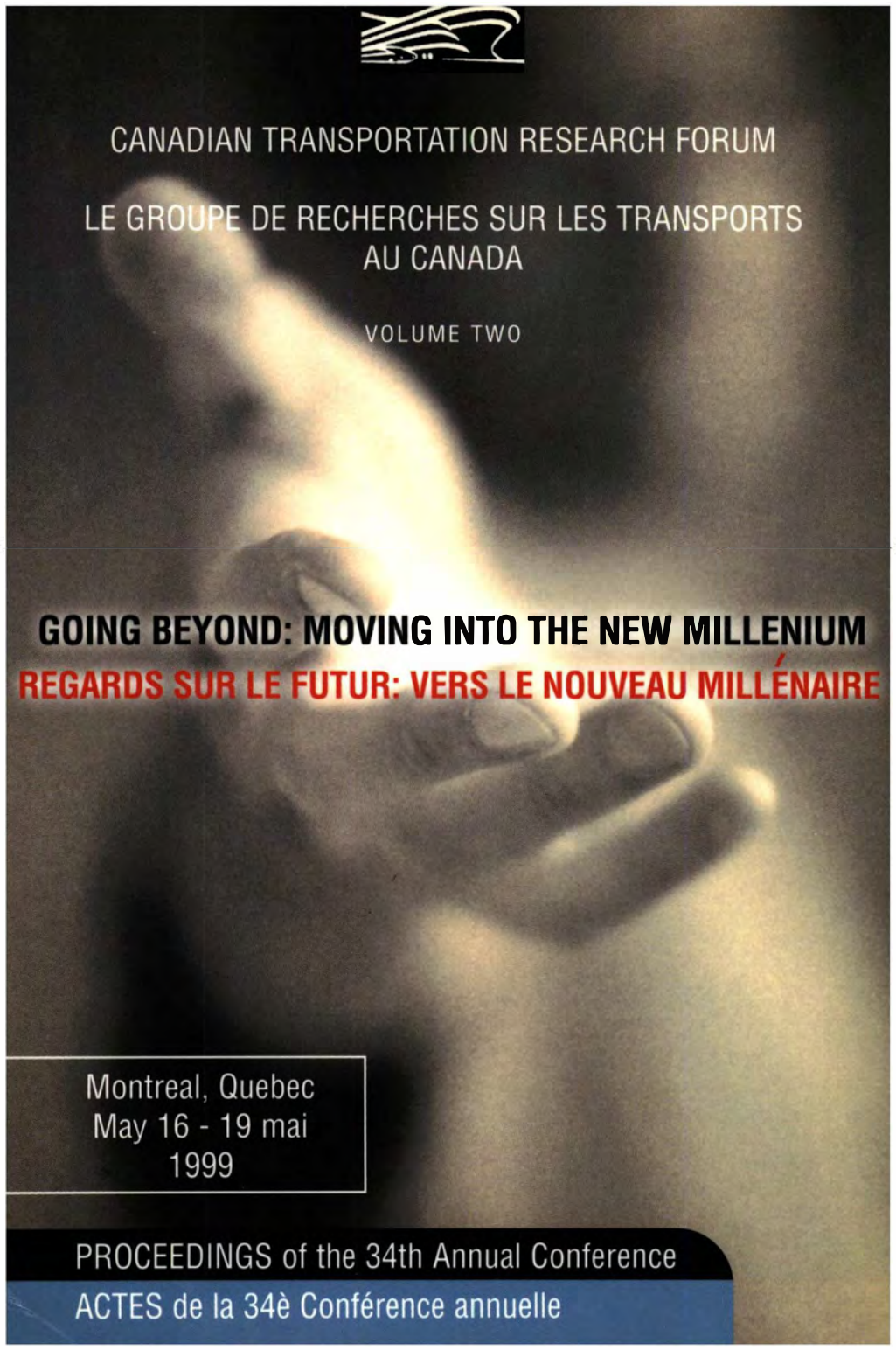


CANADIAN TRANSPORTATION RESEARCH FORUM

LE GROUPE DE RECHERCHES SUR LES TRANSPORTS AU CANADA

VOLUME TWO

GOING BEYOND: MOVING INTO THE NEW MILLENIUM

REGARDS SUR LE FUTUR: VERS LE NOUVEAU MILLÉNAIRE

Montreal, Quebec
May 16 - 19 mai
1999

PROCEEDINGS of the 34th Annual Conference

ACTES de la 34è Conférence annuelle

CANADIAN TRANSPORTATION RESEARCH FORUM
LE GROUPE DE RECHERCHES SUR LES TRANSPORTS AU CANADA

PROCEEDINGS
of the 34th Annual Conference

ACTES
de la 34è Conférence annuelle

GOING BEYOND: MOVING INTO THE NEW MILLENIUM
Regards sur le futur: vers le nouveau millénaire

Montreal. Quebec
May 16-19 mai
1999

Proceedings Printed by

University of Saskatchewan
Printing Services

The Canadian Transportation Research Forum assumes no responsibility for the content of the papers published in these Proceedings, or for any errors or omissions in the printing of this volume. These papers are published by the CTRF as a means of disseminating transportation research and to encourage discussion on a broad range of issues during the CTRF Annual Conference.

President's Message

Welcome to the CTRF's 34th Annual Conference!

The CTRF Conference Proceedings stand as a permanent record of the ideas, issues and debates that have and continue to populate Canada's transportation landscape. This year's conference title "Going Beyond: Moving Into the Next Millennium" is not so much a theme as it is a challenge. As we prepare to enter into the next millennium, conference organizers are asking us to both pause and reflect on the ideas presented and captured in previous proceedings and dare to look over the precipice and catch a glimpse of what lies ahead. This year's exploration of the environment and the potential impact of the Kyoto Agreement certainly take us to the jumping-off point for the next millennium.

This year's Montreal team lead by Ron Rice, VP Program & Publications and Gerry Kolaitis, VP Meetings, attacked the conference with abounding enthusiasm. Accepting the conference title "Going Beyond" as their mantra, the 1999 conference is marked with the introduction of CTRF's first ever Professional Development Workshop. This year's workshop on International Marketing, lead by William Spur of Bombardier Transit Systems Division, deserves a special note reflecting both the dedication of the organizing committee to expand the meaningfulness of the CTRF and the commitment of the transportation sector. CTRF thanks Mr. Spur for volunteering his time, energy and experience.

The conference Proceedings present the membership's current work and include articles from the winners of the student paper competition. The preparation and printing of the Proceedings by the University of Saskatchewan is managed by Gail Sparks, CTRF Secretariat and we are grateful to Gail and the University for their collective efforts. A summary of the keynote address, panel discussions and the Bison Transport Cup Debate not covered within the formal proceedings will be distributed subsequently in the Forumation and at our website (www.vemax.ca/ctrf).

Finally, on behalf of the Board of Directors, thanks to all the CTRF members and conference sponsors for their continuing support.

Janet M Weiss, President

MESSAGE DU PRÉSIDENT

BIENVENUE À LA 34è CONFÉRENCE ANNUELLE DU GRTC

Les Actes de la conférence du GRTC constituent un registre permanent pour les idées, les questions centrales et les débats devant continuer à occuper et à aménager le paysage des transports du Canada. Le titre retenu pour la conférence de cette année, " Regards sur le futur: vers le nouveau millénaire ", constitue moins un thème qu'un défi. Alors que nous nous préparons à entrer dans le nouveau millénaire, les organisateurs de la conférence nous demandent à la fois de réfléchir et de méditer sur les idées fortes des Actes précédents et d'oser regarder par dessus le "précipice" pour entrevoir ce que l'avenir nous réserve .Cette année, le fait d'aborder l'environnement et les conséquences possibles de l'Accord de Kyoto nous conduira certainement au point ultime du saut vers le prochain millénaire.

L'équipe de Montréal de cette année, menée par Ron Rice, vice-président Programmes et Publications et Gerry Kolaitis, vice-président Conférences, s'est attelée à la tâche avec beaucoup d'enthousiasme. Faisant du titre de la conférence "Regards vers le futur" leur mantra, les organisateurs en ont marqué la conférence par l'introduction du tout premier Atelier de formation professionnelle du GRTC. Consacré au Marketing international, cet atelier dirigé par William Spur , de la Division Systèmes de transport en commun de Bombardier, mérite une mention spéciale reflétant à la fois le dévouement du comité organisateur d'élargir le champ d'intervention du GRTC et l'engagement du secteur des transports. Le GRTC tient à remercier M. Spur d'offrir ainsi son temps, son énergie et son expérience.

Les Actes de la conférence présentent le travail actuel des membres et les articles des gagnants de la compétition des étudiants. La préparation et l'impression des Actes à l'Université de Saskatoon sont dirigées par Gail Sparks , secrétaire du GRTC; nous sommes reconnaissants à Gail et à l'université pour leur effort commun. Un résumé du discours principal, les discussions en atelier et le débat de la Coupe Bison Transport , non inclus dans les Actes, seront rapportés ultérieurement dans *Forumation* et à notre site web (www.vemax.ca/ctrf).

Finalement, au nom du Conseil d'administration, j'adresse mes remerciements à tous les membres du GRTC et aux commanditaires de la conférence pour leur appui constant.

Janet M. Weiss, Président

CONFERENCE SPONSORS
COMMANDITAIRES DE LA CONFÉRENCE

Transport Canada / Transports Canada
Gouvernement de Québec / Ministère des Transports du Québec
Industry Canada / Industrie Canada
Bombardier Inc.
AMT/ Agence Métropalitaine de Transport
Canadian Transportation Agency / Office des transports du Canada
Statistics Canada / Statistique Canada
Canadian Pacific Railway / Canadien Pacifique
Alstom Canada Transport
Canadian National Railways / Canadien National
GE Railcar Services & Leasing Canada Ltd.
National Steel Car Ltd.
Thrall Car Manufacturing Company
Trimac
TTX
Port of Montreal / Port de Montréal
CANAC Inc.
Temple Scott & Associates
PricewaterhouseCoopers
LDK Engineering Inc.
David D. Taylor & Associates Inc.
SNC Lavalin
Trinity Industries, Inc.
GPC Inc.
Carrier Transicold
CGTX Inc.
Thermal King
Mi-Jack Products
Top Lift Enterprises
RaiLink Limited
Societe des Traversiers du Québec
The Greenbrier Companies
KPMG Consulting
Bison Transport
VEMAX Management Inc.
Actran Consultants
Delcan Corporation
IBI Group
Roaduser Research Canada
The Elliott Consulting Group
Canadian Freightways Limited

DONORS TO THE CTRF SCHOLARSHIP PROGRAM
PARRAINS AU PROGRAMME DE BOURSES DU GRTC
1998-99

Algoma Central Corporation
Bombardier
Canadian Transportation Education Foundation (CTEF)
Canadian Maritime Agencies Limited
Canadian National Railways
Canadian Pacific Charitable Foundation
Government of Quebec
Marine Atlantic
plus many individual donors

1998 STUDENT PAPER COMPETITION DONORS
PARRAINS DU CONCOURS DES ÉTUDIANTS EN 1998

Air Canada
CSL Group Gold Medal (CIT)
Albert Stevens Fund
Jim Davey Trust Fund

CANADIAN TRANSPORTATION RESEARCH FORUM
LE GROUPE DE RECHERCHES SUR LES TRANSPORTS AU CANADA

EXECUTIVE - EXECUTIF
1998/1999

President
Janet Weiss
Canadian Pacific Railway

Executive Vice President
Lloyd Ash
Trimac Consulting Services Ltd.

Secretary
Gail R. Sparks
VEMAX Management Inc.

Vice President Finance & Treasurer
Jan B. Bowland
KPMG Management Consulting

Vice President External
David M. Cape
Ryerson Polytechnic University

Vice President Meetings
Ron Rice
McGill University

Vice President Programs
Gerry Kolaitis
VIA Rail Canada

Vice President Awards
Tricia Trépanier
Statistics Canada

Immediate Past President
Barry Prentice
Transport Institute, University of Manitoba

Vice President Organization and Development
Bill Raney
Ministry of Transportation Ontario

Councillors:

Professeur Yves Bussière
INRS – Urbanisation

Wade Eilliott
Halifax-Dartmouth Port Development

Eric Hildebrand
University of New Brunswick

Paul Larouche
Bombardier Transportation

Marcel Leduc
Canadian National Railway

Paul Ouimet
Intervistas Consulting Inc.

Rachid Raffa
Quebec Ministry of Transport

Barry Rempel
Canadian Airlines International Ltd.

Roger Roy
Transport Canada

Gordon Tufts
PEI Transportation and Public Works

Clarence Woudsma
University of Calgary

CTRF is ...
a broadly based network of transportation professionals with an interest in research and commentary on public policy issues. Membership is open to anyone interested in any aspect of transportation.

CTRF's objectives are ...

- to encourage transportation research in those disciplines which address themselves to the economic, managerial, technical, political, and social aspects of transportation
- to provide a common meeting ground to exchange ideas and research results
- to provide a forum for presenting and discussion transportation issues
- to bring together persons involved with Canada's transportation systems.

CTRF's program consists of ...

- a national conference with research papers, panel discussions, and invited speakers held annually in a different Canadian location
- published proceedings of the national conference
- a one-day semi-annual conference on a topic of national interest
- regional seminars promoted and co-sponsored with other organizations
- an annual CTRF student paper competition
- an annual CTRF scholarship competition
- a newsletter published five times a year.

Le GRTC est ....
un groupe de professionnels(les) en transport intéressés(ées) à la recherche et aux questions de politiques publiques. Etre membre du GRTC convient à quiconque s'intéresse aux transports.

Les objectifs de GRTC sont ...

- d'encourager la recherche dans les domaines suivants liés aux transports: économie, gestion, technologie, politique et aspect social
- de fournir un lieu de rencontre pour échanger idées et résultats de recherche
- de créer un forum pour présenter et discuter de questions de transport
- de réunir les personnes intéressées au système canadien de transport

Au programme du GRTC ....

- une conférence nationale annuelle avec site variable au Canada, qui consiste en une présentation de textes, tables rondes, conférenciers invités
- la publication des textes présentés à la conférence nationale
- une conférence semi-annuelle d'une journée sur un juget d'intérêt national
- la promotion et le parrainage de colloques régionaux avec d'autres organismes
- un coucours annuel de textes d'étudiants(es)
- un fonds permettant de décerner des bourses
- un bulletin de nouvelles publié cinq fois l'an

..... ANNOUNCING .....

2000 CTRF ANNUAL CONFERENCE TO BE HELD IN CHARLOTTETOWN, PRINCE EDWARD ISLAND

Details to be finalized

WATCH FOR CALL FOR PAPERS COMING IN SEPTEMBER 1999

For further information, contact:

Gordon Tufts
(902)368-5166
e-mail: gotufts@gov.pe.ca

Gail Sparks
(306)242-6199
e-mail: gail.sparks@vemax.ca

CTRF website: www.vemax.ca/ctrf

x

CANADIAN TRANSPORTATION RESEARCH FORUM
209 - 15 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 2X8
www.vemax.ca/ctrf

Telephone: (306) 242-6199
Fax: (306) 242-6199

INVOICE FOR 1999 CTRF MEMBERSHIP

CTRF Membership for Calendar Year 1999 ($60.00)	$_____
GST at 7% ($4.20)	$_____
Student Membership for Calendar Year 1999 ($18.00)	$_____
GST @ 7% ($1.26)	$_____
TOTAL	$_____

GST Registration No. R126274562 (If GST exempt, please indicate)

Please make cheque payable to Canadian Transportation Research Forum and mail to the address noted above. **PLEASE RETURN A COPY OF THIS INVOICE WITH PAYMENT IN ORDER THAT OUR DATABASE WILL CONTAIN ACCURATE INFORMATION RELATING TO YOUR MEMBERSHIP.**
VISA and MasterCard are also acceptable.

- ☐ **VISA**
- ☐ **MasterCard**

Card Number _____
Expiry Date _____
Name on Card _____

Please complete the following to ensure accurate membership data. The information below will appear in the next published CTRF/TRF Directory.

Name: _____ Title: _____

Company: _____

Address: _____

_____

_____

Telephone: _____ Fax: _____

e.mail: _____

Please indicate your language preference: ☐ English ☐ French

Le Groupe de Recherches sur les Transports au Canada
209 - 15 Innovation Blvd.
Saskatoon, Saskatchewan
S7N 2X8
www.vemax.ca/ctrf
Téléphone: (306) 242-6199
Télécopieur: (306) 242-6199

FACTURE 1999

Membre du GRTC pour l'année 1999 (60.00 $)	$ _____
TPS (4.20$)	$ _____
Membre étudiant du GRTC pour l'année 1999 (18.00$)	$ _____
TPS (1.26$)	$ _____
TOTAL	$ _____

Numéro d'enregistrement pour la TPS R126274562. (Si vous êtes exempté de la TPS, veuillez l'indiquer.)

Veuillez libeller votre chèque au nom du Groupe de Recherches sur les Transports au Canada et poster le tout a l'adresse ci-haut. **SVP RETOURNEZ UNE COPIE DE CETTE FACTURE AVEC VOTRE PAIEMENT AFIN QUE NOTRE BASE DE DONNÉES CONTIENNE UNE INFORMATION EXACTE SUR VOUS COMME MEMBRE DE L'ASSOCIATION.**

VISA et MasterCard sont acceptes.

- ❑ **VISA**
- ❑ **MasterCard**

Numéro de Carte _____
Date d'Expiration _____
Nom Figurant sur la Carte _____

fournir les renseignements demandée ci-dessous afin de nous permettre d'avoir une information complète sur nos membres. Cette information va apparaitre dans le prochain répertoire du GRTC.

Nom: _____ Titre: _____

Compagnie:
_____

Adresse:
_____
_____
_____

Téléphone: _____ Télécopieur: _____

Courrier électronique _____

Veuillez indiquer la langue de correspondance de votre choix.

❑ anglais ❑ français

1999 CTRF ANNUAL CONFERENCE /GRTC CONFERENCE ANNUELLE

GOING BEYOND: MOVING INTO THE NEW MILLENNIUM
REGARDS SUR LE FUTUR: VERS LE NOUVEAU MILLÉNAIRE

VOLUME I

Session/Séance 1: Opening Plenary Session/
Séance Plénière d'ouverture
Second Guessing the Third Millennium: Building on Achievements

Session/Séance 2.1: **Competitive Strategies for the Motor Carrier Industry**

- *Facteurs de compétitivité et stratégies des transporteurs routiers au Québec.* Yvon Bigras, Université du Québec à Trois-Rivières et Jacques Roy, Université du Québec à Montréal **...1**

Session/Séance 2.2: **Air Competition in the New Millennium**

- *Fee-setting in Canadian Domestic Air Navigation Services.* Raymon J. Kaduck, Government of the Northwest Territories **...16**

- *Competition and Concentration in Canadian-U.S. Transborder Aviation Markets.* Michael W. Pustay, Texas A & M University **...31**

- *Strategic Alliance and Partner Airlines' Productivity, Market Power, and Profitability.* Tae Hoon Oum and Chunyan Yu, University of British Columbia, Jong-Hun Park, City University of Hong Kong **...45**

- *Aggregate demand for Canadian Airports, 1986-1996: Literature review and preliminary results.* William Hamlin, University of Waterloo **...59**

Session/Séance 2.3: **Issues in Rail Transportation**

- *Timely Railway Data – A Leading Economic Indicator for GDP?* Harold Kohn and Yasmin Sheikh, Statistics Canada **...74**

Session/Séance 3.1: **Information Technology in the New Millennium**

Session/Séance 3.2: **Challenges of Passenger Rail in the New Era**

- *Is There Life After VIA?: Privatising Canada's Passenger Railway.* Dr. Mark Bunting, P.M. Bunting & Associates **...89**

- *L'Expérience Japonaise en matière de train à haute vitesse et de diversification commerciale des activités ferroviaires: Un modèle pour le Canada et Via Rail?* Richard Leclerc, Chercheur indépendant **...104**

Session/Séance 3.3: **Developments in Marine Transport**

- *"User Pay-User Say" and Marine Cost Recovery in Canada – Opening Pandora's Box: Evolution of the Coast Guard's Marine Navigation Services Fee.* Napier, Thompson and Frederick, Canadian Coast Guard **...117**

Session/Séance 4.1: **Logistics in a Changing Environment**

- *La PME dans la chaîne logistique: les cas du meuble de maison et de l'après-vente automobile.* C. Jacob, Y. Gregoire, Y. Bigras, R. Gelinas and M. DeSaulnier, Université du Québec à Trois Riviéres **...132**

- *The Microfoundations of Logistics: An Economist's Perspective.* Dr. Darren Prokop, University of Manitoba Transport Institute **...147**

- *Logistics Practices and Requirements of Manufacturers: A Worldwide Assessment.* Stephane Vachon, University of Western Ontario **...171**

Session/Séance 4.2: **Challenges in Passenger Transport Systems**

- *L'Impact des nouvelles technologies de communication sur la demande de transport aérien des voyageurs d'affaires.* Jacques Roy and Pierre Filiatrault, Université du Québec à Montréal **...186**

- *Competition in Surface Passenger Transport: Interpreting the British Case.* Dr. Marking Bunting, P.M. Bunting & Associates **...201**

- *Human Transportation and the Technological Changes in Communication and Information Dissemination.* Jacques Picard, Université du Québec à Montréal **...216**

- *Does Charter Chart the Way?* Francesca Thibeault and Harold M. Kohn, Statistics Canada ...221

Session/Séance 5.2: Passenger Air Travel Issues

- *Traveller Accommodation and Passenger Air Travel in Canada: The Management of Derived Demand for "Perishable" Products.* Gordon G. Baldwin, Statistics Canada ...235

- *Air Travel Decision Making, The Importance of Frequent Flyer Programs.* Edward Bruning, University of Manitoba ...245

- *The Origin, Evolution and Current Status of Cabotage.* Dr. L. Milton Glisson, North Carolina A&T State University, Dr. Michael K. Jones, University of North Carolina ...259

Session/Séance 5.3: Truck Safety and Productivity

- *Truck Safety: Assessing the Impact of the National Safety Code.* Fred P. Nix ...278

- *National Safety Code.* Darrell Richards ...291

Session/Séance 6.1: Environmental Issues in the Global Economy

- *Towards a Generalized Predictive Model for Annual Aircraft Emissions at Airports.* Judith Patterson, Concordia University ...303

- *"Green Corridors?: Meeting Kyoto Targets through Regionally Integrated Strategies to Reducing Greenhouse Gas Emissions, The Mid-Continent International Trade Corridor, A Case Study".* Dr. Adam Bronstone and Michael Butt, University of Manitoba ...312

- *A World Approach to Motorization: Structural vs Behavioural Factors at the Horizon 2025.* Yves Bussiere, INRS-Urbanisation ...334

Session/Séance 6.2: Highway Safety

- *Testing The Offset Hypothesis.* Anindya Sen, Industry Canada ...351

- *Introducing Road Safety Audits to British Columbia.* Geoffrey Ho, Insurance Corporation of British Columbia and Sany R. Zein, Hamilton Associates ...377

Session/Séance 6.3: Policy and Practice inCanada's Ports

- *External Challenges Facing Canadian Ports The Case for Reform.* Michael Ircha and Jeff Wood, University of New Brunswick ...393

- *"Adrift! – Subsidies, Economic Benefits and the Impasse in Policy Reform for B.C. Ferries.* W.G. Waters II, University of British Columbia ...408

- *A Risk-Adjustment Model for Capital Budgeting in Transportation: The Capital Asset Pricing Model Approach to Port Investment Projects.* L.A. LeBlanc, Berry College and B.C. Payne, University of SW Louisiana ...423

VOLUME II

Session/Séance 7.2: Multi-modal Issues and the Environmental Challenge

- *Just-In-Time System and Climate Change.* Javier Caceres and Darrell Richards ...430

- *Impacts of the Modern Roundabout on North American Traffic Circulation, Modal Choice, Sustainable Development and Land Use.* Tony Redington ...441

- *"Moving From Theory to Practice" The Combi-Road and Unitised Transport per Pipeline in The Netherlands as a strategy to increase transportation capacity and reduce environmental degradation.* Roger Flinterman and Hans van Ham, Delft University of Technology ...456

Session/Séance 7.3: Grain Logistics within an Evolving Context

- *Measuring the Impact of Branch Line Abandonment.* Mohammad Khakbazan, Richard Gray and James Nolan, University of Saskatchewan ...470

- *Impact of Pooling on Port Throughput and Customer Service Levels at the Port of Vancouver.* Bob Niemi, Jane Zheng and Charray Dutka, Canadian Wheat Board ...485

Session/Séance 8.1: Lessons in Environmental Responsibility

- *Greenhouse Gases – A Dilemma for Transportation Planners.* F.R. Wilson, A.M. Stevens and J.D. Innes, University of New Brunswick ...499

Session/Séance 8.2: Productivity and Innovation in the Railway Industry

- *Railway Productivity and Innovation Developments at Canadian Pacific Railway.* Malcolm Cairns ...513

- *Evaluation of the Economic Effects of Train Delays at Canadian National.* Sacha Veillette, Atum Software Inc. and Brian Abbott, Canadian National Railway ...529

Session/Séance 8.3: Logistics of Commodity Flows

- *"Grain Transportation by Truck: Changes and Outlooks for Western Canada – 1997/98".* Rene Kehoe, Transport Canada and Lloyd Ash, Trimac Consulting Services ...544

- *Manitoba's Marine Container Traffic: Trends and Developments in the 1990s.* Michael Butt and Jill Ogston, University of Manitoba Transport Institute ...553

Session/Séance 9.1: Perspectives on Western Grain Movements

- *US-Canadian System Comparison: A Grain Shipper's Perspective.* W. Drew and P. Rosher, Canadian Wheat Board ...569

- *Location and Transportation Impacts of Privatizing the Marketing of Western Canadian Oats.* Dr. Barry E. Prentice, Zhaokun Wang and Robert W.R. Morrissey, University of Manitoba ...585

- *Merging CN and CP: A Proposal for the Improvement in Grain Movement.* Rory Hart, University of Manitoba ...600

Session/Séance 9.2: Modelling Transport Demand

- *Aging, Independence and Vehicle Use in Small Towns and Rural Areas.* Irwin Bess, Statistics Canada ...617

- *The Value of Predictors on Nonresponse*. Cindy Carter, Statistics Canada ...629

- *Modelling the Travel Needs of the Elderly in the 21st Century*. Eric D. Hildebrand, University of New Brunswick ...638

- *Cross-Price Elasticities of Freight Demand: A Dynamic Approach*. Yuri V. Yevdokimov, University of Manitoba ...653

Session/Séance 9.3: Planning for Highway Infrastructure

- *The Effects of Highway Infrastructure Capital on the Cost Structure and Productivity Performance of Canadian Goods-Producing Industry*. Bilkis R. Khanam, Transport Canada ...665

- *Guidelines to Consolidate Low Volume Roads: A Case Study Approach*. Kiel Ova and Jill Hough, North Dakota State University ...680

Session/Séance 10.1: Modelling for Airport Planning and Operations

- *Optimization of Real-Time Aircraft Gate Assignment: Mathematical Model and Algorithm*. Jia-Ming Cao, Henry Fan and Soi-Hoi Lam, Nanyang Technological University ...695

- *Assessing the Socioeconomic Status of Airport Catchment Areas*. Stephen R. Ellsworth, University of New Brunswick ...710

- *Methodological Issues of Economic Impacts Studies: "The Good, The Bad and The Ugly"*. Scott J. Shurvell and Barry E. Prentice, University of Manitoba ...724

- *A Place in the Sun, or A Shelter in the Storm? A Study of Parking Services*. Victor Rueda, University of Manitoba ...739

Session/Séance 10.2: Public Policy Developments in Transport

- *Recognition of Public Objectives in the US Bus Industry as a Response to ISTEA*. J. Nolan, University of Saskatchewan, P.C. Ritchie and J.E. Rowcroft, University of New Brunswick ...751

- *Infrastructure Banks: Innovative Financing for Tapped-Out Transport Budgets*. Michael A. Crockatt and Barry E. Prentice, University of Manitoba ...764

- *The Logistics and Economics of Manitob's Marine Container Traffic.* Jake Kosior and Linda Christian, University of Manitoba ...778

AWARD WINNING STUDENT PAPERS
CTRF 1997-98 STUDENT PAPER COMPETITION

Undergraduate Category

Third Prize

An Economic Comparison of the American and Canadian Domestic Air Transport Industries Since Deregulation. Bonnie-Lynn Robertson, University of Western Ontario ... 792

Masters Category

Albert M. Stevens Award - First Prize
Air Canada Award for Best Air Transport Paper

An Examination of the Current Barriers to Effective Waste Reduction in the Airline Industry. A Case Study of Toronto's LesterB. Pearson International Airport. Jennifer K. Lynes, University of Waterloo ... 815

Second Prize

Globalization: British Airways' Vision and Prospects. Phoebe Ho, Department of Civil Engineering, University of British Columbia ... 830

Just-In-Time System and Climate Change

By Javier Caceres and Darrell Richards

Executive Summary

The purpose of this paper is to analyze recent trends in freight transportation and bring out the linkage among transportation, production and distribution. It is important to analyze the overall system so that policies can be developed to reduce greenhouse gas emissions and develop a freight transportation system that is sustainable environmentally, economically and socially.

Total logistics costs (material handling and transportation) have declined and driven down consumer prices for many products. But not all the costs are internalized in the logistics system. For example, has the saving in private warehousing costs been transferred to warehousing in transit on public highways, thereby to social costs for collisions, pollution and road infrastructure?

The changing nature of freight transportation demand may be increasing energy intensity at a time when we need to reduce it. Attempts to reduce fuel consumption in freight transportation that focus on a narrow definition of internal system efficiency (e.g. better engines, longer trucks, etc.) will fail. The production and distribution system may respond to improved transportation efficiency by increasing the demand for road transport more than anticipated.

Transportation economists state that transportation is a derived demand, just a means to an end. Experience from urban passenger transport suggests that a component of transportation demand is derived from transportation itself. Planning to accommodate perceived freight demand and mode preference induces new demand and shifts traffic to less sustainable modes. Solutions to improve the sustainability of freight transportation will fail unless this is factored into analysis.

Introduction

The purpose of this paper is to analyze recent trends in freight transportation and bring out the linkage among transportation, production and distribution. It is important to analyze the overall system so that policies can be developed to reduce greenhouse gas emissions and develop a freight transportation system that is sustainable environmentally, economically and socially.

Current Trends Not Sustainable[1]

Current trends in transportation are **not sustainable environmentally**, and the current public policy focus is on global warming. Transportation was responsible for about 27 per cent of total Canadian greenhouse gas emissions in 1995.[2] Natural Resources Canada estimates that transport will account for 28 per cent of emissions by 2010 and 37 per cent of the increase in Canadian emissions until 2010.

Federal and Provincial Ministers created the National Climate Change Process to determine how Canada can meet its commitment to reduce emissions six per cent below 1990 levels by 2010. They also struck a transportation issue table to develop options for emission reductions in transportation. Recent trends in fuel consumption are outstripping projections by Natural Resources Canada which are the foundation of the work of the National Climate Change Process. If recent trends continue, transport will account for 53 per cent of the increase in Canada's greenhouse gas emissions by 2010. Freight would be responsible for more than half of the increase in transport emissions and more than a quarter of the increase in Canadian greenhouse gas emissions.[3] Thus, while the transportation table is in the midst of its work, the goalposts have changed.

---

[1] By this we mean environmentally, economically and environmentally sustainable

[2] Natural Resources Canada, Canada's Energy Outlook 1996-2020, April 1997

[3] Centre for Sustainable Transportation, Sustainable Transportation Monitor, February 1999, p.4

Of all transport greenhouse gas emissions, commercial trucks account for 22.8 per cent, rail 3.8 per cent, and marine 3.0 per cent.[4] Thus, freight movement accounts for about 30 per cent of transport emissions, and its share appears to be growing. In the period 1990-1996, freight transportation became more efficient in its use of energy per unit of output, but overall freight energy use actually increased because there was more freight movement and because market share shifted from marine and rail to truck.[5]

Trucks account for 72.7 per cent of freight energy use, but 23.5 per cent of activity in tonne-kilometres. Rail accounts for 11.8 per cent of energy, but 45.6 per cent of activity. Marine accounts for 15.5 per cent of energy and 30.9 per cent of activity.[6] Road diesel fuel usage (mostly by trucking) increased 4.7 per cent annually between 1990 and 1996, and by 9.3 per cent in 1997 alone. In contrast, rail and marine consumption declined 1.5 per cent annually between 1990 and 1996 and grew by a more modest 0.5 per cent in 1997.[7]

There is new evidence that transportation may **not be economically sustainable**. In 1997, transport began assuming a larger share of the economy over the previous year for the first time since 1992.[8] Conventional economic analysis has always underestimated the portion of transportation in GDP because it did not incorporate externalities. For example, Transport Canada estimates transportation collision costs of $15.4 billion annually. There are also costs for noise, pollution, congestion, land degradation and social barriers.

Behind the shift in freight market from rail and marine to truck are changes in the production and distribution system, as well as the increased size and weight of trucks permitted on public highways. The just-in-time logistics system made extensive use of truck transport that could be tightly scheduled in order to reduce warehousing. In effect, the cost of warehousing was taken out of the private production and distribution network and transferred to rolling warehouses on public highways.

---

[4] Environment Canada, Trends in Canada's Greenhouse Gas Emissions, April 1997
[5] Natural Resources Canada
[6] ibid
[7] Centre for Sustainable Transportation, Monitor 1999
[8] ibid

Social sustainability in transport usually refers to the inequities in access between those with and without cars, due to income, age, or disability. Freight transport also has an impact. Retail shops used to be accessible by walking, cycling or transit. Often the new forms of retail such as "big box" stores are accessible only by car. As the suburban majority shift their shopping to this type of store, the variety of goods and shops along traditional and accessible main streets declines. This is particularly true of computers, electronics, building supplies, hardware, furniture, appliances and sporting goods.

These "big box" stores offer better selection and price. They draw from a bigger catchment area. They have sufficient scale and organization to use a just-in-time system to reduce inventory costs, for example Walmart, Price Club or CostCo. They can transfer distribution costs to the consumer who drives farther to access the store. They can externalize some of the transportation costs by developing cheap land for parking, while public authorities will pay for additional road costs due to the incremental increase in trip length for the larger catchment area.

Analogy with Passenger Transport Sustainability Issues

The prevailing ideology for urban passenger transport after the Second World War was to increase individual mobility. Well-intentioned urban planners also offered suburbs as a way for people to escape the crime, noise and pollution of the city. Traffic engineers measured the efficiency of the transportation system by the free flow of traffic, or level of service on the roadway.

Newman and Kenworthy from Australia challenged this prevailing planning ideology in a statistical correlation analysis of 32 cities worldwide first published about a decade ago. They concluded that cities with the most efficient road systems, measured by the free flow of traffic, also consumed the most fuel per capita. Those with the most congested roads consumed lesser amounts because consumers chose to walk, cycle or ride transit. Ironically, people living in cities with the most efficient road systems also spent more hours going to and from work.

Newman and Kenworthy presented an updated analysis to the Moving the Economy Conference in Toronto, July, 1998. They challenged the assumption among transport economists that there is a close link between mobility (transport consumption) and wealth. They found that large U.S. cities had 2.17 times higher car use than Metro Toronto, but were only 1.19 times higher in Gross Regional Product (GRP) per capita.[9] They had 2.41 times higher car use than the average European city, but only 0.85 times the GRP per capita. Compared to Toronto or European cities, U.S. cities spend more per capita on roads and on commuting, have far worse transit cost-recovery ratios, higher traffic deaths per capita, and higher emissions. Phoenix spends 17 per cent of its wealth on transportation, Detroit 15 per cent and Denver 15 per cent. Toronto spends seven per cent.

Rail-oriented cities are also more economically and environmentally efficient.[10] Citizens in rail-oriented cities produce about 20 per cent fewer passenger kilometres (all modes) per capita. For every passenger kilometre switched to rail, auto passenger kilometres decline by four. Thus, three-quarters of the environmental benefit comes from more efficient land use made possible by rail. This also suggests that influencing transportation mode choice could also reduce the overall transportation component per capita by its influence on efficiency of land use.[11]

Technology improvements alone are not sufficient to achieve overall sustainability. An integrated strategy is needed which simultaneously improves technology, facilities modal shifts and reduces the need for travel.[12] The O.E.C.D. also concludes that unconstrained traffic growth would overwhelm any technical fixes. It recommends a complementary strategy to influence demand.[13]

---

[9] We wonder if the GRP per capita would actually be similar or lower in the U.S. cities if the cost of externalities from transport such as accidents, pollution, noise and social barriers were subtracted from GRP

[10] Peter Newman, Sustainable Transportation – In From the Cold?, presentation to Moving the Economy Conference, Toronto, July, 1998

[11] data analyzed from Boris S. Pushkarev, Urban Rail in America, (Bloomington, Indiana: Indiana University Press, 1982). NOTE that this data is quite dated, about 20 years old. Recent work by Newman and Kenworthy published in 1998 supports the directions of this analysis.

[12] ibid, p.14

[13] O.E.C.D., Transport and the Environment, Background and Synthesis Report: Policy Measures and Their Effects, O.E.C.D. web site

The prevailing ideology in urban passenger transport was to plan to meet demand or perceived market preference. New analysis exemplified by Newman and Kenworthy and O.E.C.D suggests instead that catering to perceived demand simply made the problem bigger and less manageable. Urban passenger transportation demand management and traffic calming are now mainstream.

Contrasting Ideologies in Freight Transport Planning

Transport Canada and the Climate Change Transportation Table both recognize (urban passenger) transportation demand management as mainstream concepts that confront exponential growth in urban passenger transport consumption. But there does not seem to be a similarly sophisticated analysis in Canada for freight, which currently experiences exponential growth in trucking activity. The emphasis of potential solutions appears to be shifting traffic from one mode to another (and Transport Canada seems to consider this impractical in a just-in-time system) or technological improvements such as better engines, load matching or allowing longer trucks. Ironically, the latter technological improvements may work against attempts to shift traffic from one mode to another by altering the relative economic competitive balance.

The prevailing ideology appears to be that the trend toward a just-in-time production and distribution system is a given, and that solutions must work around that fact of life. The trucking industry probably expresses the prevailing ideology best when it describes the shift to trucking as a market preference rather than a market failure.

The transformation of the production and distribution system to just-in-time logistics has had the following impacts on the transportation market:

- Trucking gained market share because of its ability to meet just-in-time schedules reliably
- An increase in shipment distance as firms centralize production, source products from farther away, and global firms break down locally contained economies and local production
- An increase in volume of freight as firms outsource production of components
- A decrease in shipment density as products are shipped in shelf-ready packaging rather than in bulk[14]
- A shift in product distribution costs from private firms to consumers
- An increase in shipment frequency as warehousing is phased out

The benefits of these trends are a greater variety of goods and better margins for industry which are in part passed on to consumers. There is also increased employment in trucking and increased economic activity. There are, however, some downsides. What is saved in distribution and logistics costs may increase infrastructure costs, energy consumption, pollution and collision risk. Some of these costs are deferred to future generations. The shift in market from rail to truck means a less efficient use of existing infrastructure resources and potentially more land consumption and other environmental problems.

Some organizations question the just-in-time logistics system. The (Canadian) Centre for Sustainable Transportation refers to some U.K. research that finds a just-in-time system doubles transport energy consumption compared to warehousing.[15]

[14] The latest trend is cross-docking in which goods can be taken straight from the truck and put on a shelf. The timing of this is even more demanding than for a regular just-in-time system

[15] Centre for Sustainable Transportation, Sustainable Transportation Monitor, March 1998 p.14

The O.E.C.D. is analyzing sustainable consumption and production solutions. [16] It finds that advances in technology will not be sufficient to overcome increased environmental impacts.[17] Andreas Pastowski of the Wuppertal Institut in Germany suggests that the marginal benefits of freight transport are less than the marginal costs due to congestion and externalities such as pollution and noise. Freight transport volumes can increase even when marginal costs exceed benefits if these other costs are not internalized in the production and shipping system. If external costs are not factored into business decisions, then profits can be made shipping goods between regions with marginal differences in cost of production.[18]

Will electronic communications reduce the amount of freight transport? While there no doubt have been reductions of certain types of products, overall freight traffic continues to grow. Truck traffic is growing faster than population, despite several years of intense computerization, fax machines and the internet. The economical increase in long-distance communications made possible by the internet and telephone deregulation appears to have increased the long distance freight market rather than having reduced it. The long-haul just-in-time logistics system may not have been as effective or even possible without increased communications and computing power.

Just-in-time logistics squeezes out redundancy of supply. But it also increases the risk to security of supply as inventories are reduced. A just-in-time system is very fragile and more vulnerable to unforeseen disruptions. Recent examples are the ice storm and GM strike in 1998. Logistics can help the response to a natural disaster, but it may also leave some people stranded without a backup. The demanding schedules leave little room for unforeseen traffic problems or the human condition of drivers.

---

[16] O.E.C.D., Sustainable Consumption and Production, web site
[17] O.E.C.D., Project on Environmentally Sustainable Transportation, web site
[18] Andreas Pastowski, Decoupling Economic Development and Freight for Reducing its Negative Impacts, Wuppertal Papers, No 79, Sept, 1997, p. 15,16,18

Possible Solutions

Transportation is said to be a derived demand, but urban passenger transportation research shows that catering transportation supply to meet perceived demand can actually induce new demand that was not forecast, thereby making the problem worse. Improving transportation efficiency stimulates dispersal of economic activity and land use, which increases per capita consumption of transportation.

There is a parallel risk to policy makers of assuming that the current trends in freight transportation are a given and with which not to tamper. If their response to climate change or the sustainability challenge is limited to trying to make the vehicles more efficient, they may create perverse and unintended effects. The market could respond to the increased internal transport efficiency by increasing average trip distance and reducing product density. Not only would this increase transport activity, but it could also shift some existing traffic from more sustainable modes to truck.

There are two ways to seek a solution. One option would be to restructure the overall industry organization and its link to transportation and the economy. There is great resistance to this type of restructuring from both transportation and production. Restructuring along these lines would also confront the globalization process that thrives on long distance trade, sourcing and distribution.

The path of less resistance for many policy makers is to find a way to delay or avoid restructuring; for example, by using unlimited greenhouse gas emissions trading. This would target emission reductions where it is most economically efficient. Under this scheme, transport would not be restructured from a sustainable viewpoint. Emission reductions and restructuring would be shifted to other sectors of the economy that use lower priced fuels. This may not lead to a sustainable, or even a least-cost solution. Because emissions trading does not internalize the externalities of collisions, land degradation, noise and congestion, the total transportation costs will not be reduced under emissions trading. Additional policies would be required to achieve sustainable transportation.

Internalizing external costs is the preferred solution from economic theory, because price signals would be used to change behaviour of consumers and shippers. The appended diagram illustrates the concept of internalizing costs in the logistics system. It would be a political challenge for one country, in a global free-trade economy, to do this. The voting public may not understand the direct benefits of reducing the cost of externalities. The externalities would also tend to shift across the border, and some of the problems such as air pollution would drift back home.

A scheme to internalize costs could potentially involve trading credits for collisions, emissions, road damage, and congestion. This is an expansion of the international emissions trading concept, which is already complex.

Another option would be government charges and rebates/shadow tolls. Freight activity with larger environmental/safety impacts would pay a fee, which would be rebated through shadow tolls to modes that are more sustainable. The charges and rebates would be based on environmental and safety performance. Impacts on Canadian competitiveness in continental and international markets would be mitigated if the total charges were offset by total rebates/shadow tolls in a revenue neutral system. The overall price of transportation would not change, but the competitive position of the most environmentally and safe modes of transport would be relatively improved.

Another option would be to level the playing field in terms of safety regulations and infrastructure subsidies between the modes. This would improve the situation, but some of the relative difference in external costs between modes would continue to be hidden from consumers and shippers.

Conclusion

Transportation economists state that transportation is a derived demand, just a means to an end. Experience from urban passenger transport suggests that a component of transportation demand is derived from transportation itself. Planning to accommodate perceived demand and mode preference induces new demand and shifts traffic to less sustainable modes. Solutions to improve the sustainability of freight transportation will fail unless this induced demand is factored into analysis. An overall approach is needed that considers technological solutions, mode shift to sustainable modes, and linkage to the overall production and distribution system.

copied from Hansson April 1990

IMPACTS OF THE MODERN ROUNDABOUT ON NORTH AMERICAN TRAFFIC CIRCULATION, MODAL CHOICE, SUSTAINABLE DEVELOPMENT AND LAND USE

EXECUTIVE SUMMARY

The thesis of this paper is that the modern roundabout significantly alters for the better the traditional access equation that determines development densities, so that both current and planned land use densities can naturally increase in urban areas. The roundabout enables this through two features: (1) providing up to a third greater capacity for motor vehicles and other users while simultaneously decreasing delay mostly to a few seconds for all users; and (2) enabling and enhancing bicycle and pedestrian transportation that alters both the extent and character of these modes in a given location, thereby shifting modal choice toward nonmotorized modes and, secondarily, to transit. The combination of these two forces--greater intersection capacities with reduced delays for all users and facilitating the expansion of the bicycle and pedestrian modes--establishes the roundabout as central to strategies for moving urban development toward greater density. Greater urban densities mean less intensive resource use and reduced motor vehicle travel. The roundabout facilitates traffic circulation, expands the horizon of nonmotorized modes and modal choice, assists directly and indirectly in the movement of urban areas to sustainable consumption, and catalyzes mixed land uses emphasizing reduction of automotive intensive transportation. The roundabout also directly aids in reducing global warming gases and improving air quality.

After a discussion of the principle of transportation access and urban density, a brief overview of the modern roundabout is followed by a discussion of the thesis in the context of : (1) a case study of a roundabout and impacts on traffic circulation and a nearby traffic signal; (2) modal choice; (3) sustainable development; and (4) the land use transportation linkage.

TRANSPORTATION ACCESS: THE TRIP TIME AND URBAN DENSITY RELATIONSHIP

The emphasis in North American transportation during the last half of the 20th century centered on car mobility built on massive motor vehicle subsidies. The motor age, symbolized by interstates and freeways, resulted in suburbanization and massive low density urban growth areas, a phenomenon popularly called sprawl. Like the trolley lines at the beginning of the century,

the freeways increased access to land areas distant from central cities. Unlike the trolley lines fed by users primarily on foot or bicycle, the highway arterial expansion in turn connected by car to land areas many kilometers in all directions compared to the typical trolley line corridor of a kilometer or two in width. As the highway age matured after World War II In the US one metropolis began to overlap with another, and the melding of many entities led to the megalopolis, an overlapping metropolises extending hundreds of kilometers in one or more directions.

North American growth and urban density directly connects to transportation, and can best be described in terms of the principle of access. Huang (1997) defines access as average trip times--a measure of cost--for a given location compared to a reference location Huang (1997). Average trip times are average travel times for all household trips weighted by mode and purpose. In Huang's study access measurement directly predicts development density both in theory and in actual application to areas adjacent to Washington, DC.

The basic equation determining that determines degree of density (Huang, p 17) is:

Accessibility = Difference between Average Trip Time at Location i and at Reference Location o

Where average trip time is the weighted sum of average trip times by modes and purposes

In applying this equation, Huang adjusted for demographic factors, such as income and housing type. Those locations with higher accessibility--that is, lower average trip times--naturally tend to experience greater trip frequencies--and therefore density of development. This tendency reflects attempts of households to minimize the combined costs of housing and transportation, thereby seeking locations with higher access, that is, with relatively lower transportation costs. It is important to emphasize that land use elements (housing, employment, etc.) in relation to transportation do influence densities, but only as those aspects relate to access. Traditional discussion of access to a great extent did not identify the density/access relationship (Burns, 1979 p 10). In the metropolitan context, traditional urban transportation texts also lacked an understanding of the land use density as defined by transportation access (Meyer, Kain, Wohl, 1965, pp 48-55). The role of the roundabout is its impact on

access--and therefore the density--in the built and developing environment.

ROUNDABOUT BACKGROUND

The modern roundabout era began in 1966 when Britain adopted the yield-at-entry rule for vehicles entering roundabouts. This rule at roundabouts resulted in substantial increase in capacity and sharply reduced collision and injury rates. The typical roundabout has a diameter of 30-60 m with a central island of at least 9 m. The mini-roundabout features no central island and instead has a traversable central raised central area. It is again a British invention dating from the early 1970's, and arose from the need to serve severely constrained intersections where "normal" roundabouts cannot fit, a situation most often found in older urban areas.

Modern roundabouts quickly spread to many British influenced countries in the 1970's (particularly Australia and New Zealand), continental Europe and finally in 1990 to the United States. By 1995, 19 North American roundabouts were enumerated, a figure that rose to about 100 in early 1999 with several more hundred under development at that time.

Roundabouts are considered a significant contributor to highway safety. Safety data shows the United Kingdom the leader with the lowest highway fatality rates worldwide and European countries with significant roundabout populations approaching or surpassing the United States fatality rate which held second position to Britain until recently (Pucher and Lefevre, 1996. p. 26). France embraced roundabouts in part as a measure to address high road fatality rates, and now leads the world with a 1998 estimated 15,000 roundabouts, a figure increasing about 1,000 annually (Jacquemart, 1998, p 4).

TRAFFIC CIRCULATION--A CASE STUDY

Too many vehicles for roads and intersections to handle constitutes traffic congestion. Traffic congestion constitutes a major problem for urban transportation in industrialized nations with the costs of delay and pollution measured in billions of dollars even for a single large metropolitan area (Pucher and Lefevre, 1996, p 73). Delay and lack of capacity to move traffic at intersections contributes substantially to overall congestion. While roundabouts do possess finite capacity, their capacity is generally greater than that of other intersection control devices, traffic signals or sign control (Garder, 1997, p 79-80). Roundabouts decrease delay for all users--vehicles, bicycles and pedestrians. Moreover, the greater the traffic levels, the greater the reduction in

delay provided by the roundabout versus the traffic signal. The Montpelier, VT case study here provides an example of comparative roundabout and traffic signal performance in an almost side-by-side location with approximately equal entry volumes. More important, it shows the roundabout impact on overall traffic and circulation.

Analyzing delay at intersections by traffic engineers utilizes a "level of service" hierarchy outlined in Table 1. There are two major forms of delay measurement, stopped delay discussed here, and geometric delay. Geometric delay addresses the lower overall speed and greater time it takes to go around the circle compared to a straight through movement. Increased geometric delay is not considered a significant factor for policy analysis since roundabout performance measures generally exceed alternatives, particularly for such factors as air pollution and emissions, stop delay, and ease of pedestrian crossing.

Table 1

Level of Service for Motor Vehicles--Signalized Intersections

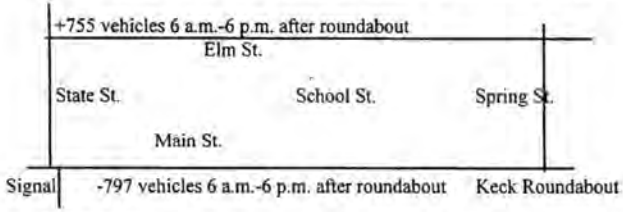
Level of Service	Seconds of Stop Delay
A	0-5
B	>5-15
C	>15-25
D	>25-40
E	>40-60
F	Over 60

Source: Transportation Research Board, *Highway Capacity Manual*

A measurement of 8 US roundabouts revealed an average 77 percent decline in a.m. and p.m. peak hour delay, from about 14 seconds to 3 seconds (Jacquemart, p 30). This is the equivalent in terms of "level of service" (LOS) of increasing the performance of the surveyed intersections from just below LOS C to near the midpoint of LOS A. LOS measures "peak hour" delay that occurs normally during the morning or afternoon drive times. The LOS concept also applies to pedestrians and bicyclists. Pedestrians at traffic signals also experience delay either waiting for a separate pedestrian walk phase or the common crossing practice of pedestrian movements parallel to the current flow of intersection traffic. At a roundabout pedestrians utilize crosswalks about one

Figure 1

Montpelier North-South Downtown Circulation Grid



Other Intersection Information (current):

East State/State/Main (on demand pedestrian phase)	4 Phase Traffic Signal
State/Elm	One way stop (Elm)
Elm/School	4 way stop
Elm/Spring	2 way stop (Spring)
Main/School	2 way stop

vehicle distant from entry lines into the circulating travel way. These crosswalks provide a pedestrian refuge midway within the roundabout "splitter" island so that pedestrians only have to deal with one direction of traffic at a time (see Figure 2).

Montpelier Case Study

The following describes impacts of the roundabout in improving traffic and circulation in a busy mixed use city center. The identification and documentation of the traffic circulation improvement in Montpelier following a roundabout installation was accidental. The summer 1995 installation of the 19th roundabout in the US coincided with a demonstration changing a three phase to a four phase traffic signal cycle two blocks away at the Main and State Streets intersection, considered the worst intersection in the City (see Figure 1). The fourth phase created separate phases for East State and State Streets in order to address disjointed movements at these offset streets operating in a single phase. An examination of the standard engineering analysis in 1995 for the proposed split phasing of State Street and an unrelated study of the same intersection in 1997 revealed conditions improved rather than deteriorating as had been predicted. The roundabout provides the only plausible cause of the before-and-after improvements, mostly caused by vehicle using Elm Street instead of Main

Street as shown in Table 2.

Main and State Streets intersection has approximately 14,000 entering cars daily and about 6,000 pedestrians. This intersection is the crossroads for this 8,000 population US State Capital City. The Montpelier north-south downtown circulation is comprised of mainly two parallel streets, Main and Elm. The major east-west connectors along Main and Elm Streets are State Street and Spring Street at either extreme and School Street (not shown) that has small vehicular volume and is left out for analysis purposes. Traffic volumes in 1996 were approximately 9,000 on Main Street at State Street, 6,000 on Spring Street, 8,000 on State Street, and 5,000 along Elm Street.

The roundabout introduction at the former stop-controlled intersection did drop delay by more than half at Main and Spring Streets--from 6.3 seconds to 2.7 seconds at peak hour (Gamble, 1996, p 6). But, the impact at the two-block distant signalized intersection was far greater. With the roundabout in place, about 800 vehicles shifted during the day from Main Street to parallel Elm Street (Gamble, 1996, p 9). This shift amounted to an average increase of a car every 20 seconds on Elm Street during the 6 a.m. to 6 p.m. period, and conversely one less every 20 seconds on Main Street. The reason for the shift in traffic centers on the prior difficulty in making left hand turns from Spring Street north onto Main Street, a problem erased by the roundabout resulting in decrease in stress and travel times for drivers choosing the Elm Street routing compared to Main Street even in face of the lower delay at Main and State Streets traffic signal.

Most important are the delay figures--actual and predicted--for the new phasing at State and Main Street, a demonstration now made permanent. Table 2 shows that counter to the anticipated increase in delay of 17.2 seconds, delay declined 12.7 seconds. The traffic shift from Main Street to Elm Street facilitated by the roundabout represents the proximate cause of the circulation improvement and reduced delay at the Main and State Streets intersection.

A rockslide closed Elm Street for several months during winter of 1997-1998 and roundabout traffic volume increased 13 percent to 1,260 vehicles peak hour over a 1996 measurement (Gamble, 1998, p 2). Roundabout stop delay at peak hour remained unchanged at 2.7 seconds, although peak hour traffic of 1,260 there was 19 percent higher than the peak hour traffic in 1997. Roundabout traffic during that period increased to approximately the same volume as the Main and State intersection prior to the Elm Street shutdown.

Table 2

Montpelier Main and State Street Signalized Intersection Peak Hour Delay

Year	Average Vehicle Delay (seconds)	Level of Service (LOS)
1994 Before Roundabout 3-Phase	39.6	D
1995 Projected with 4-Phase	56.8	E
1997 Post Roundabout	26.9	C

SOURCES: "Intersection Analysis," Project 7180, September 2, 1997 and "Main, State and East State Intersection Evaluation of Split Signal Phasing," January 31, 1995 (City of Montpelier, VT, Pinkham Engineering Co.).

Modal Choice

Modal choice simply means one or more types of transportation selected by the consumer for a trip. Modal choice, for example, for home to work trips depends on such factors as average speeds, costs, convenience, and comfort. In the case of the home to work trip, modal choice is often complicated by needs to fulfill other household needs--taking children to daycare, handling household needs and the like. Stops during a home-to-work or any other trip is termed "trip chaining."

Representative figures for European and North American urban modal splits are provided in Table 3. The disparity of North American and European modal share is striking, particularly in regard to the bicycle mode, 1 percent in North America compared to a minimum of 5 percent in European countries. A sample of ten European countries revealed a range of bicycle modal share of 5 to 30 percent, a median of 9.5 percent (Pucher, 1997, p 32).

Table 3

Urban Area Modal Percentage Split for Canada, France, United Kingdom, and United States (1990 or Latest Available)

Country / Mode	Canada	France	United Kingdom	United States
Walk	10	30	12	9
Bicycle	1	5	8	1
Transit	14	12	14	3
Car	74	54	62	84
Other	1	0	4	2

SOURCE: Pucher, 1996, p 16.

While car share trends of trips are generally upward in Europe, non-motorized and transit trips will continue a major factor in transportation compared current North American conditions. Europe and North America subsidize the car travel, but European countries generally do recover the cost of motor vehicle base costs from users while US motor vehicle users pay only 59 percent of direct public highway expenditures (Pucher and Lefevre, 1996, p 28), (Federal Highway Administration, p. IV-9). Further, gasoline taxes are five to ten times higher in Europe than in the US and about three times higher in Canada (Pucher and Lefevre, 1996, p 28, 172).

The US, Canada, and the UK possess the most car oriented travel

among North American and European nations. But for various reasons--taxation, land use practice, degree of segregation of population by income, and government policy, for examples--car share of urban trips is 10 percent less in Canada than the US and 22 percent less in the UK (Table 3).

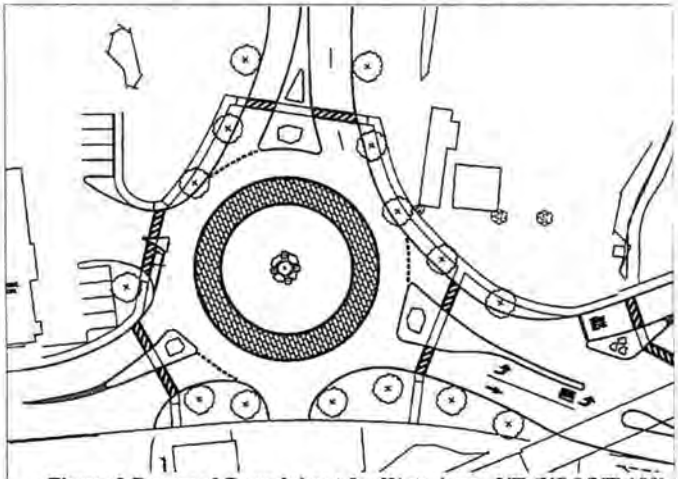


Figure 2 Proposed Roundabout for Waterbury, VT (US 2/VT 100) Courtesy of Pinkham Engineering Co., Burlington

Governmental policy influences modal choice independent of other factors, such as income, population growth, and employment levels. The Netherlands with 48 percent of urban trips by bicycle and walking has long supported investments in these modes and stands second only to Sweden among ten European nations surveyed (Pucher, 1997, p 34). Even during a period of car growth in Germany, the share of bicycle travel in selected German cities increased an average 50 percent in data from the 1976-1995 period (Pucher, p 35). The German policies have fostered investment in car free space and networks of car free paths for bicycle and pedestrians in urban areas. A US study of land use design that includes pedestrian friendly facilities shows household vehicle miles decrease 10 percent per household (1000 Friends of Oregon, 1997, Vol 7, p 16). New or retrofitting older areas to pedestrian friendly status primarily means ensuring ease of intersection negotiation that the roundabout enables and a connected network of sidewalks (1000 Friends of Oregon, 1993, Vol 4A, p 5).

Another factor currently separating North America and Europe--although this separation is beginning a narrowing process--is the increased relative penetration of large numbers of roundabouts that work to preserve and enhance nonmotorized modes. Even in North America where nonmotorized trips are minimal data, indicating the potential for increasing bicycling and walking is found in the 1990 National Personal Transportation Survey, the statistic that 59 percent of all US person trips in motor vehicles were under 8 km (5 miles) (FHWA, 1993). Also, Jacquemart (1998, pp 25-29) and Garder (1997, pp 49-68) found numerous studies showing the roundabout--even when compared to the traffic signal--is far safer for car occupants and pedestrians. Generally, roundabouts reduce collisions involving pedestrians and motor vehicles in half, cut injuries up to 70 percent injuries and reduce injury severity. Bicyclists safety data shows slight improvement at roundabouts, while providing the other advantages for bicyclists, such as reduced injury severity and decreased delay..

The principle of transportation access and urban densities relates directly to time as a substitute for cost of travel. Since bicycling and walking are lower cost modes and trip times are reduced with the presence of roundabouts, the access of any area is enhanced--and therefore density increase forces exerted--when modal shifts occur to nonmotorized modes.

The roundabout plays a key factor in modal choice, since effective and efficient pedestrian facilities depend on intersections that are pedestrian friendly and relatively delay free, a basic feature of roundabouts.

Sustainable Development

Sustainable growth and development emerged as a concern in the environmental movement during the 1970's and moved to the forefront in the 1990's with the increasing public awareness of global warming, its causes and consequences. Both the threat of a leveling off of oil production within a decade or two as well as the consequences of current levels of petroleum consumption in terms of global warming emissions give cause to less consumptive land use designs, i.e., less sprawl and more higher density land use arrangements that less resource consumptive.

A less technical definition of sustainable is that of development meeting the needs of this generation without compromising future generations meeting their needs (World Resources Institute, 1997, p 3). Daley (1991, p 17) defines sustainable growth as maintenance of a pool of resources, replenished in

equal amount as resources are drained from the available pool. Nonrenewable resources, particularly coal and petroleum, would require considerable reductions in use from current levels to meet either of the definitions provided. To supply energy demands short term renewables (solar, water, etc.) and medium term (trees, plants, etc.) provide the most available substitute energy sources. Transportation comprises two-thirds of all US petroleum demand (World Resource Institute, 1997, p 129). Global oil production is anticipated to peak early in the new century while demands continue to grow (World Resource Institute, 1997, p 130-132).

An environmental problem of even larger proportions, global warming, also relates directly to petroleum consumption. The US is first in the world in CO_2 emissions (Canada is eighth), the key global warming gas. One third of US global warming gases are in transportation (World Resources Institute, 1993, pp 319-320). Continued and expanded petroleum as the primary source of global warming gases, equates to catastrophic future costs in the form of radically altered weather, agricultural damage, ecosystem failures, and flooding of lowland areas.

Clearly there are a number of obvious--but unpopular--methods to decrease nonrenewable resource use, including raising prices, mandates for land use density, etc. Technology may provide some relief--high mileage hybrid vehicles, emission control improvements, and provision of more efficient public transport (high speed ground transport as a replacement for air, for example) are examples. The first US first global warming policy, *Climate Change Action Plan* (United States, 1993) contains a central feature, cashing out the employee parking space subsidy, that is, giving a worker a choice of a subsidized parking place or the value of the subsidy as a cash employee benefit. This market approach relies on incentives benefitting all involved--the business, the employee, and the community. The World Resources Institute (1997, pp 167-182) outlines this and other policy options ranging from population control and intelligent vehicle systems to transportation pricing incentives and urban design and density increase strategies.

The roundabout can contribute a modest direct short term and more substantial long term contribution to any sustainable development, global warming, and air quality improvement strategies. At busy intersections it provides direct reduction in nonrenewable energy use contributing to sustainability and reducing global warming emissions, about a third less than for signalized intersections (Mustafa, A and Vougias S , 1993, pp 237-238). However, potentially even more importantly over the long term, the roundabout

through the principal of access--reduced travel times in a given geographic area for nonmotorized and motorized users alike--can have immediate and long term positive environmental impacts through increasing nonmotorized trips and facilitating higher development densities.

In the short term, there is the opportunity to employ the roundabout in conjunction with other nonmotorized facilities improvements to shift modal choice from the car to non-motorized and transit. Second, there is the long term impact of enabling increased densities in existing developed areas with further relative decrease in motorized activity.

Land Use Transportation Linkage

Land use and transportation are inextricably linked through the principle of access. Huang (1997) points out that the impact of transportation on land use and land use density can be readily measured using an access formulation. Practically all urban and metropolitan planning organizations have employed models for determining transportation demand for decades, most all involving travel time between urban sectors adjusted for actual empirical demand information to predict future demands. Yet in the early 1990's there was not a single integrated land use and transportation model in North America and few models used at that time addressed nonmotorized modes (1000 Friends of Oregon, 1991, Vol. 1, pp 53-54).

The 1000 Friends of Oregon project (1997, Vol 7) represented the first US integrated land use and transportation modeling analysis examining a highway oriented versus transit and non-motorized alternative scenarios for Portland, OR, metropolitan growth. In this study even in the case of the Land Use, Transportation, and Air Quality (LUTRAQ) Alternative area wide modal share for nonmotorized increased only from 5.1 percent to 5.6 percent for all trips, transit 9.3 percent to 12.9 percent and auto 85.6 percent to 81.4 percent. However, In the "transit oriented design" areas total transit and nonmotorized reaches 29.9 percent of all home-based trips (1000 Friends of Oregon, 1997, Vol 8, p 8). This prediction fits with the actual German experience of increasing nonmotorized modal share through investing in and establishing positive nonmotorized environments. Implicit in the LUTRAQ positive projection is increased density, mixed use land use design, and incentives for commuters to forego solo driving. While not stated, the LUTRAQ positive predictive design reflects in great part the access principle, that is, by creating up front a positive nonmotorized and transit design along with higher densities in a mixed use fashion, modal shares can be adjusted and will reflect the conditions that the

increased access supports. Certainly other factors play an important role in the 1000 Friends of Oregon design, particularly provision of efficient transit and the minimizing road access expansion.

This paper does not address the important contributions of various initiatives of planners and architects in the design of community space and town centers minimizing motor vehicle invasion that historically date from the British new town movement led by Howard (1965) at the turn of this century and more recently those advocating and providing design for a less car centered environments, such as Jacobs (1961), and Duany and Plater-Zyberk (1992).

The roundabout role in the land use equation is again two-fold, providing first a tool to establish a positive non-motorized and motorized facilities and capacity. Second, through the reduction in transportation travel time and thereby cost, enabling greater land use densities than otherwise would be possible. The roundabout also enhances transit efficiency and access for all users. In summary, in the context of access, roundabouts enhance land use practices designed to minimize transportation costs and increase densities.

Conclusions

This paper evaluates the role of the roundabout in the context of the interconnection of land use and transportation as described by the principle of access.

First, the principle of access defines development densities, that is, increased access provided by transportation results in higher density development. Since the roundabout increases access in capacity and reduced delay for all users, it enables and facilitates increased densities. Second, a case study shows that traffic and circulation efficiency is sharply increased and enhanced--including a two-block distant traffic signal--through installation of a single roundabout. Third, modal choice in modern industrial countries except in North America reveal substantial nonmotorized modal shares, shares that can be increased by initiatives in expanding these modes in urban areas. The roundabout promises to be an ally in maintaining and expanding modal choice for nonmotorized and transit.

Fourth, in terms of a sustainable community and economy, the roundabout can play a key role, because the roundabout itself can reduce motor vehicle emissions and global warming gases as well as fostering increased modal share for nonmotorized transportation. In addition the roundabout enables

increased densities because of both the capacity it provides for vehicles but also for the reduced costs of transportation in the forms of reduced delay for all users and increased use of less expensive nonmotorized modes.

Fifth, integrated land use and transportation models confirm the principles of access improvements tied to increased densities, and the promise of the roundabout in both nonmotorized modes enhancement and accommodation of transit-friendly development.

References:

Burns L (1979) *Transportation, Temporal, and Spatial Components of Accessibility.* (Lexington Books, Washington, DC).

Daly, H (1991) *Steady-State Economics.* 297 pp. (Island Press, Washington, DC).

Duany A and Plater-Zyberk E (1992) The second coming of the American small town. *Wilson Quarterly, 16(1).*

Gamble A (1996) Montpelier roundabout Main Street/Spring Street. (Vermont Agency of Transportation, Montpelier, VT).

Gamble A (1998) Montpelier roundabout delay study with Elm Street closure. 4 pp. (Vermont Agency of Transportation, Montpelier VT)

Garder P (1997) The modern roundabout, the sensible alternative for Maine. 141 pp. (Maine Department of Transportation, Augusta, ME).

Huang Y (1997) Identifying the link between transportation and land use density with accessibility. *76th Annual Meeting, Transportation Research Board Report 970293,* 27 pp. (TRB, Washington, DC).

Federal Highway Administration (1998) *Highway Statistics 1997.* (FHWA, Washington, DC).

Federal Highway Administration (1993) *1990 National Personal Transportation Survey Databook.* p 4-88. (FHWA, Washington, DC).

Howard E (1965) *Garden Cities of To-Morrow.* 168 pp. (The M.I.T. Press, Cambridge, MA).

Jacobs J. (1961) *The Life and Death of Great American Cities.* 458 pp. (Random House, Toronto).

Jacquemart G (1998) *Modern Roundabout Practice in the United States. Transportation Research Board, National Cooperative Highway Research Program Synthesis 264,* 73 pp. (National Academy Press, DC).

Mustafa, A and Vougias S (1993) Analysis of pollutant emissions and concentrations at urban intersections. *ITE 1993 Compendium of Technical Papers* (Institute for Transportation Engineers, Washington, DC) pp 234-238.

1000 Friends of Oregon (1991) Modeling practices. Vol 1, 76 pp. (1000 FOO, +Portland, OR).

1000 Friends of Oregon (1993) The pedestrian environment. Vol 4A, 76 pp. (1000 FOO, Portland, OR).

1000 Friends of Oregon (1997) Making the connections--a summary of the land use, transportation, air quality project. Vol 7, 35 pp. (1000 FOO, Portland, OR).

1000 Friends of Oregon (1997) Making the connections technical report. Vol 8, 76 pp. (1000 FOO, Portland, OR).

Pucher J (1997) Bicycling boom in Germany: a revival engineered by public policy. pp. 31-45. *Transportation Quarterly 51/ 4.*

Pucher J and Lefevre C (1996) *The Urban Transport Crisis in Europe and North America.* 226 pp. (MacMillan Press, London).

Transportation Research Board (1994) *Highway Capacity Manual.* p. 9.6. (TRB, Washington, DC).

US Office of the President (1993) Climate change action plan. 29 pp. (Office of the President, Washington, DC).

World Resources Institute (1993) *Environmental Almanac.* p. 319. (Houghton Mifflin, Boston).

World Resources Institute (1997) *Frontiers of Sustainability.* 367 pp. (Island Press, Washington, DC).

"MOVING FROM THEORY TO PRACTICE"

The Combi-Road and Unitised Transport per Pipeline in The Netherlands as a strategy to increase transportation capacity and reduce environmental degradation.

By
Roger Flinterman and Hans van Ham

Delft University of Technology
Faculty of Technology, Policy, and Management
The Netherlands

Introduction

Contrary to Canada, the Netherlands is a small country with a high population density. Moreover, its often considered to be the gateway to the North-western part of Europe. Analyses carried out at the end of the eighties indicated a large number of problems facing the Dutch transport system over the years to come. These problems were considered so urgent that the Government suggested radical changes in transport policy. Background of the new policy is the agreement among political parties on the concept of sustainable society, defined as a society that meets the present generation's needs without jeopardising future generation's ability to meet theirs.

In general, the purpose of transport policy is to ensure accessibility. However, as economic growth brings about an even more rapid increase in (road) transport, the accessibility of industrial and commercial centres is threatened. In addition, the competitive position of the transport sector is endangered by congestion problems. For the Netherlands, where international transport and distribution plays an important role in the economy, this is a hot issue. Other than causing congestion problems, transport may damage the environment in three ways: air pollution, noise nuisance and fragmentation of the countryside. Also, the decline in safety is one of the resulting problems. Typically, the goal of a sustainable society implies setting limits on the environmental effects of the transport system, which may conflict with economic growth.

In 1990, the Dutch Government published a policy statement on transport called the Second Transport Structure Plan (also called the *SVV II*, which is its Dutch acronym). Quite uniquely, the SVV II policy has been fleshed out in terms of specific measurable targets with respect to (1) environment and amenity (e.g. by 2010 emissions of NO_x and unburned hydrocarbons by road vehicles will be 75% lower than in 1986), (2) managing and restraining mobility (e.g. major residential developments will be served by public transport) and (3) accessibility (e.g. high quality rail links for freight transport will be established between the main seaport areas and their hinterland). In order to achieve the defined targets, the SVV II formulates a large number of policy measures (Second Chamber of the States-General, 1990).

To monitor the actual developments and move step by step along the desired route, the Government constantly reviews the progress made and reports on it annually in the so-called Policy Assessment Report. This report contains information about the actual development in terms of the defined targets. After describing and explaining the actual developments, a forecast is made in regard to the target in 2010. This enables the Government, in case it seems that the targets are not going to be met, to adjust, intensify or renew the policy measures and their development in light of the results achieved. Since 1993 the formal policy assessments and additional analyses of the developments in transport show, on average, a poor performance on congestion and environmental indicators and good results in relation to the transport sector.

An evaluation carried out a few years ago suggested that intensifying the existing policy and putting more emphasis on technology could deal with the above mentioned problems (Ministry of Transport, 1996). Unitised Transport per Pipeline and Combi-Road are considered promising new transport modes for freight. Meanwhile, the Ministry of Transport published a policy paper on underground transportation (Ministry of Transport, 1998).

This paper outlines, first of all, underground infrastructure for point-to-point good flows, usually for a limited number of commodities. These pipeline systems are scrutinised at the moment. Secondly, the paper describes Unitised Transport Systems for Urban Goods Distribution, suitable for distributing various commodities from the outskirts of a city to the city centre. In the next paragraph attempts are made to integrate 'stand alone' urban goods distribution systems in a national network by means of Combi-Road. The possible impacts of such a innovative concept will be discussed in the paragraph 'Future Logistic Chains'. In addition, the crucial role of a Logistical City Park will be explained. Furthermore, the implementation phase will be dealt with in 'Moving from Theory to Practice'. Finally, the Dutch experiences are put in a North American perspective.

Underground Logistic System (OLS)

In The Netherlands two main ports are located namely Rotterdam (the biggest port in the world) and Amsterdam Airport Schiphol.
The last couple of years transport research in The Netherlands has mainly been focused on the development of new concepts for marine container transportation to and from the hinterland. Erroneously, because 28 per cent of the total transport volume (tonnage) and only 11 per cent of the transport sector's turnover is realised in this segment. Hence, the focus on domestic transportation research has been underexposed in relation to its importance.

One of the opportunities to improve the national transportation is developing underground freight infrastructure for general cargo. However, investing in pipeline transportation is really expensive. How expensive pipeline transport is, depends for a big part on the tube's diameter. Roughly, the total cost of the system will be 50 per cent more with a diameter of 5 meters than with a diameter of 3.5 meters. Therefore, pipeline transportation will only be profitable when a high volume of goods is transported through the pipelines. High volume transportation can be found to and from city centres between cargo generating locations and terminals.
The serious interest in underground transportation can be reflected in a growing number of plans for implementation of underground transport. The first underground system is supposed to operate in 2002. It is called OLS (Underground Logistic System). The OLS is a initiative of the Amsterdam Airport Schiphol (AAS) and the United Flower-auction Aalsmeer (VBA). This system has been set up for high volume transportation of time-critical goods, mostly flowers, because the traditional way of transportation (road transport) is getting too unreliable.

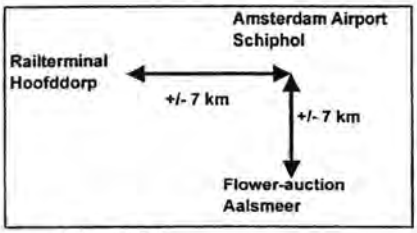


Figure 1: Route OLS

The OLS will connect the flower-auction Aalsmeer with Amsterdam Airport and, at a later stage, a new rail terminal in Hoofddorp (see figure 1). After completion, freight transport will be non-congested and connected to air- and rail networks on a (inter)national level.

A similar project like the OLS is developed for the companies DSM and Nedcar in the South of The Netherlands (OLS-Zuid Limburg). Those two companies will be connected to a rail/barge terminal in the area. The main goal of such a project is the learning experience of connecting pipeline transportation with other modes.

Besides the business goals, OLS tries to contribute social goals such as reducing road congestion and negative environmental impacts, improving safety and using space effectively.
Two comments can be made about the OLS in relation to conventional public infrastructure. First of all, the OLS is only focused on a few commodities. Secondly, the route of the OLS is just from one point to another. So the question is if this kind of system will be used more and more or for this project only.

Pipeline Transport for Urban Goods Distribution

If it is profitable to operate a concept, such as pipeline transport for urban goods distribution, several companies and several commodities can use this system. This will be a big advantage compared to the limited range of possibilities the OLS has.
The problem with Urban Goods Distribution is that the origins and destinations of the goods are all spread throughout the region. Hence grouping is the leading logistical framework used for urban goods distribution. The study 'Pipeline Transport for Urban Goods Distribution' tries to set up a logistical concept from the logistical framework 'grouping', as mentioned before (DTO, 1997).

Three kinds of grouping can be discerned:
1. The grouping of the flow of goods;
2. The grouping of destinations, for example into interchanges, making combined transport possible;
3. The grouping of routes;

Goods are received just outside the city at an interchange referred to as a Logistical City Park (LCP). From the LCP the goods are transported along a central pipeline transport system (PTS) to district distribution shops (DDS). From here the goods are distributed to shops, consumers, offices, and businesses.

These district interchanges can be used not only for distribution but also for reverse logistics (see figure 2).

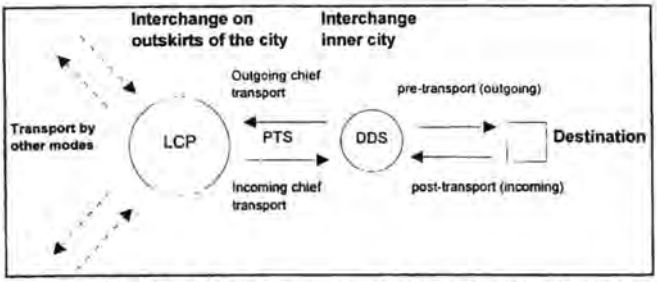


Figure 2: Principle behind the concept of pipeline transport for urban goods distribution
(Source: DTO, 1997)

Urban Goods Distribution in combination with Combi-Road

A lot of retailers, who supply their shops at the inner cities, want to use only one supply chain to supply their shops. The biggest food retailer in The Netherlands, Albert Heijn, stated that they will never use a logistical plan that differs for every region. To achieve a logistical plan on a higher level- so big retailers will use urban pipeline distribution- the concept will have to be placed into a network. Optimising only one part of the chain is not effective enough in most cases. Therefore, research is done to optimise the whole chain, from producer to consumer. The idea is connecting Logistical City Parks on specific routes where a lot of goods are moved. Those routes are called corridors[1]. Most corridors are focused on the transportation of goods to and from the port of Rotterdam. Those goods are called 'maritime' because a part of the route is by sea-ship. Continental goods, which have origins and destinations on the continent, are as mentioned before really important too. But the question is if those continental goods will be moved via the corridor. Therefore a corridor analysis has been done (Flinterman, 1999). The corridor used in figure 3, is the south-east corridor which starts at the

[1] A corridor is defined as a spatial zone between the Port of Rotterdam and one or more regions, that are more or less each others extensenions, on which concentrated flow of goods take place (Buck Consultants, 1997)

Port of Rotterdam and ends in the industrial Ruhr area in Germany. This corridor is one of the most important corridors The Netherlands has, especially for marine containers (20 and 40 feet).

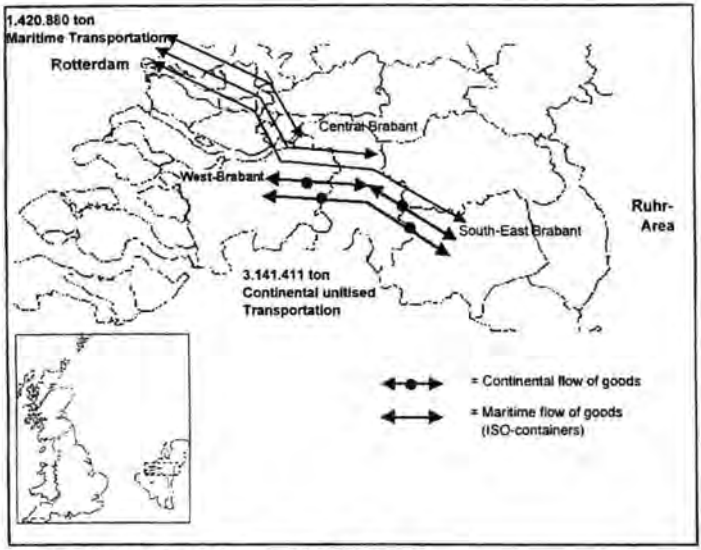


Figure 3: Maritime versus Continental flow of goods
(Source: Flinterman, 1999)

Figure 3 shows that the continental flow of goods on the corridor are twice as important as the maritime flow of goods. But the maritime flow of goods, mostly 20 and 40 feet containers, should not be underestimated, especially because of the ongoing growth of container flows via the port of Rotterdam. That is why a concept has to be developed in which maritime as well as continental goods can be moved.

Combi-Road is a new mode that is in its developing phase. Combi-Road is unmanned transportation of goods on a separate highway to and from the hinterland. The vehicles drive at a speed of 50 km/h and 12 seconds behind each other. The vehicles are electronically powered and drive on rubber tyres to

reduce noise to a minimum. Because the vehicles can drive 12 seconds behind each other, a high volume of containers can be moved (see figure 4).

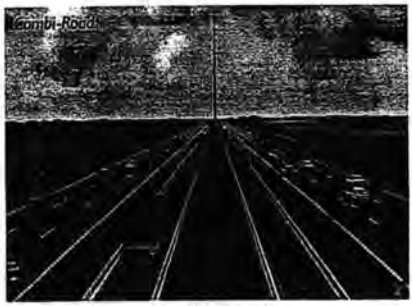


Figure 4: Combi-Road impression

Container Shipping Lines like Maersk, try to offer their customers a reliable door-to-door haulage. On the sea-side reliability of arrival is not a problem at all, but at the land-side it is. In order to control the hinterland transportation and the necessary reliability themselves, shipping lines need a new mode of transport.

Combi-Road can offer this reliability, because the mode does not have any congestion problems and the system offers a good tracking and tracing system. Combi-Road vehicles are detected by infra-red cameras, which measure position, speed, acceleration and deceleration. Arrival time can be measured continuously, which can be communicated towards other (chain-) parties.
A two hundred meters long test-side was realised in 1996. The government is deciding if the construction of a new test-side with a length of about four kilometres, which should be realised in 2002, can go through.

Maritime goods which are transported on the corridor don't have a direct destination in the inner city (Flinterman, 1999). On the other hand continental goods do have a destination in the inner city. So, a combination of Combi-Road and unitised transport per pipeline for urban goods distribution in one logistic chain is only possible for continental goods. The most important characteristics of both concepts are that the haulage has a high frequency and that goods can be send in smaller batches.

Future Logistic Chains

In the current situation producers supply the Distribution Centres (DC) which are mostly owned by the retailers. Then the retailer supplies his shops from the DC's.

At the DC's the goods are distributed by cross-docking[2] more and more. In the new situation the LCP can offer the same functions as a DC (see paragraph 'Logistical City Park').

In the new situation the producer will deliver the goods directly at the LCP. From there other LCP's can be supplied by Combi-Road. From the LCP's the goods will be moved through pipelines to their destinations. In this situation DC's will not be necessary anymore.

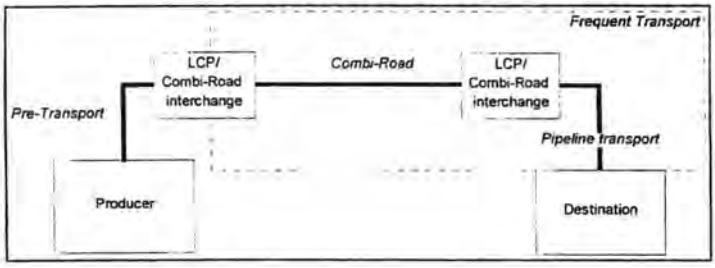


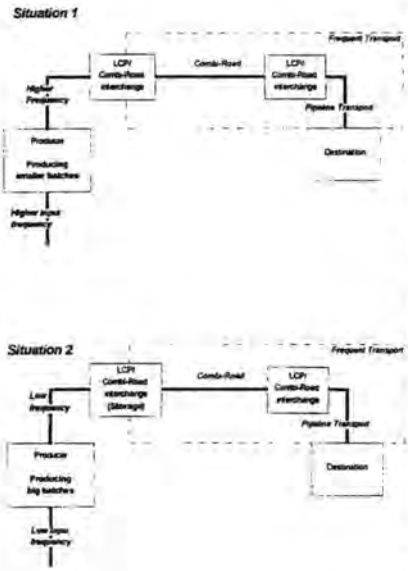
Figure 5: Concept of Combi-Road and Pipeline transportation

Figure 5 shows that not the whole chain has a high frequency nor transports in small loads. This is only the case from the LCP to the destination. It depends on a couple of factors how the chain from the producer to the LCP is organised. Primarily, the power of the actors in the chain is crucial. More often it is seen that the power is moving from the producers' side towards the retailers'. Retailers have already taken over the wholesaler's function to gain more power and control in the chain. That is why the Dutch retailers have a lot of power. The retailer is mainly focused on customer-demands. Consumer behaviour is getting more unpredictable. The consumer is not focused on special brands or stores anymore. The consumer is changing its preferences all the time. Therefore the retailer tries to use a logistical chain that fits with these rapidly changing and unpredictable customer-demands (CTT, 1998). The retailer needs a reliable logistical chain of a high quality to perform at a profitable level. That is why the

[2] Cross-docking is a transport-concept in which goods from different origins come together at a central point. At this central point the goods are sorted and bundled for transport to the receiver without any storage in between.

retailer wants the producer to deliver a high frequency and in small batches at the LCP.

Producing in small batches is too expensive for a lot of producers. Adjusting the machines after a batch-production for an other batch causes time loss and therefore increases production costs. Producing in large batches and storage afterwards, is often cheaper.
So two different situations can be distinghuised, when Combi-Road and pipeline transport for urban goods distribution operate in the same logistical chain (see figure 6).



In the first situation the retailer forces the producer to produce in small batches. The producer has to change his delivering strategy from a low frequency into high frequency. In this scenario inventories are almost totally eliminated from the logistical chain. The control on the (flow of) goods in the chain play a crucial part. The logistical costs will shift from the retailer towards the producer.
In the second situation the producer does not change his way of production, purchasing, and logistical approach. The producer only uses the storage possibility at the LCP.

Figure 6: Conceptual situations Combi-Road and urban pipeline transportation

Companies evaluate new logistical concepts by means of performance indicators. Performance indicators should include integrated logistical costs (per product), delivery frequency, level of stock, lead time, delivery reliability,

service level, number of kilometres travelled, etc. The criteria set for performance indicators differ per company. For example retailer Albert Heijn wants goods to be delivered from producer to the shops within eighteen hours. Other retailers operate successfully with more than thirty hours of lead time.

Every company has to decide if a new concept fits into their own business strategy. Sometimes firms are forced to change their concept, because of new regulations; for example, time windows and environmental demands set up by the government. Time windows can cause delivery problems, because vehicles are not allowed to enter inner cities at certain hours.

However, before companies decide to go for a whole new concept of for example pipeline transport for urban goods distribution and Combi-Road, lots of tests will have to be done. In this test-phase the performance indicators can be measured (partially). To minimise investments an LCP will only do basic tasks in the testing-phase.

Logistical City Park

The interchange point at the outskirts of the city plays a crucial role in the whole chain. But as noticed before, especially in the beginning, only primary functions can be performed.
A Logistical City Park operates as a serving-hatch between transhipment centres of producers and consumers (DTO, 1997).

To operate an LCP, there is a need for activities, businesses, and connections to transportation networks. Primarily an LCP must offer cross-docking, direct distribution[3], and rolling stock possibilities. A facility operator or logistics service provider will manage and operate these activities.

To provide the LCP with goods, the site must be accessible for various modes. First of all road transportation must be linked with an LCP. Also connection with new modes such as Combi-Road and unitised transport per pipeline is a requirement in the newly supposed situation. To offer a Combi-Road connection a so-called Combi-Road exchange station is needed. The exchange station is a

[3] direct distribution is the distribution of group delivered commodities to their destinations on a short term within a DC. Usually a short-time buffer is used.

place where goods change their transportation mode. It can offer exchange between Combi-Road, sea shipping, inland shipping, road and/or rail. On the long term an LCP can be developed as a multifunctional industrial area, with more different activities, such as simple Value Added Logistics[4] (VAL) and storage. More modes will be linked to an LCP, like inland shipping or rail transportation. More businesses will settle in this area, such as forwarders, logistics service providers, carriers, industrial companies, and assembly plants. An LCP will develop itself as a multifunctional and multi-modal industrial area. Another criterion for the LCP build-up is the necessity of physical separation of activities, businesses and mode linkages. An LCP must be designed in such a way that no activities will be hampered by any other activities, businesses, or modes (see figure 7). The following can be concluded from figure 7, Activities, businesses, and modes have to be built up in layers in time. Those layers have to be physically separated, because of the necessary independence of activities. The primary process should not be affected by other non-critical processes.

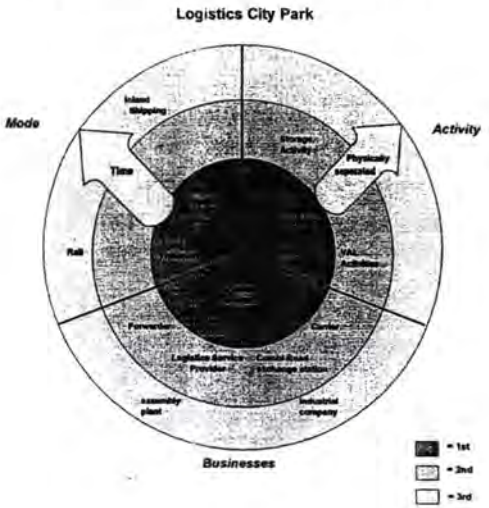


Figure 7: Possible set up for a Logistic City Park (source: Flinterman, 1999)

[4] VAL activities like labelling, packaging, bar-coding, etc.

Moving from Theory to Practice

At the beginning of a new millennium new transport concepts have to be developed, because the pressure on space, environment, and infrastructure is getting too high. Although some plans may sound 'to good to be true', a few small scale plans will be realised in the near future. However, to move on towards underground networks and Combi-Road, big steps will have to be made and problems will have to be overcome.

One critical criterion to the success of new logistical systems on land is standardisation of load units. In maritime transport load-units are well known; the ISO maritime container is a very good example of international standardisation. Although successful, this container does not fulfil the needs of inland (and especially short distance) load-units: it is too heavy and too narrow. Numerous attempts have been undertaken to find an optimal load-unit for 'continental' transport. The three main issues in which the use of load-units can play a role are:

- Reduction of transhipment costs and/or time in (intermodal) transport;
- Reduction of handling costs of cargo in distribution centres;
- Reduction of loading and unloading costs at points of origin and destination;

(Binsbergen van A.J. et al, 1998)

Eventually, the integrated overall costs are the most important performance indicator on which companies will base their decisions. New concepts must cut costs, or else they will not be accepted by the 'market'. Research as mentioned in this paper seems to be driven by technology. This must change into a more market oriented approach. Concepts must provide what the market needs, which is why the costs are the most important factor.
So, good communication between government, researchers and potential users is a requirement. Other stumbling blocks which should be overcome, are (chain)organisation, legislation (for example no rules about underground constructions are made yet), infrastructure ownership (public or private) and liability.

A North American Perspective

The studies carried out in the Netherlands cannot be marked as ad hoc anymore. The first underground, unmanned systems will operate in the beginning of the

next decade. The pressure on new concept development is high, because goals set by the government must be achieved.

Concepts in The Netherlands are mostly developed for areas with a lot of congestion. In North-America congestion can be found in and around major urban centres. But most major Canadian urban centres have only undertaken sporadic studies of goods movement, with a primary emphasis on trucking activity. Also urban air quality has been of particular focus in large metropolitan centres like Toronto, Vancouver and Montreal (Woudsma, 1998).

Usually, the focus of these 'sporadic' studies is on trucking. Will this approach be adequate for the next century or must (totally) new technologies and systems taken into account. May be Unitised Transport per Pipeline and Combi-Road are not optimal from a North American point of view but rethinking the existing transport systems is inevitable.

Bibliography

Binsbergen van, A.J. et al., **Load-Units for Urban Freight Distribution**, Delft, December 1998;

Buck Consultants International, **Mainport Rotterdam, a corridor-perspective**, Nijmegen, March 1997;

Centrum Transport Technologie (CTT), **Venster op 2015, toekomstschets van de ontwikkeling van logistieke knooppunten**, Rotterdam, 1998;

DTO , **Buisleidingentransport (BLT) voor stedelijk goederenvervoer**, deel A, Interdepartementaal Onderzoeksprogramma Duurzame Technologische Ontwikkeling, Delft, August 1997;

Flinterman, R. , **Combinatie van Combi-Road en Ondergronds Transport over de corridor Brabantse Stedenring**, April 1999, Amersfoort;

Ministry of Transport, **Transport in Balans**, The Hague, 1996;

Ministry of Transport, **Ondergronds Transport en Buisleidingen**, The Hague, 1998;

Nederlands Economisch Instituut (NEI), **De Economische Betekenis van de Transport & Distributiefunctie voor de Nederlandse Industrie en Dienstverlening (Eindrapport Rolgoed III)**, Rotterdam, November 1995;

Second Chamber of the States-General, **Second Transport Structure Plan, part d (Government Decision)**, 1990;

Woudsma, C. , **Urban Goods Movement Revisited**, Calgary, May 1998.

MEASURING THE IMPACT OF BRANCH LINE ABANDONMENT

Mohammad Khakbazan, Research Assistant, Department of Agricultural Economics, University of Saskatchewan.
Richard Gray, Associate Professor, Department of Agricultural Economics, University of Saskatchewan.
James Nolan, Assistant Professor, Transportation Chair, Department of Agricultural Economics, University of Saskatchewan.

Introduction

On February 27, 1995, the Government of Canada announced a reform of operating rules and gave new powers to railways that allowed for more rapid abandonment of (low-volume) branch lines. Under this regime, the railways fell under regulation of the recently passed CTA (Canada Transport Act). Most importantly, this meant: 1) maximum freight rates are set until the year 1999 by the CTA (this is intended to give captive and small shippers a transition period to look for alternative means of transport), and 2) "grain dependent" branch lines will no longer be protected from abandonment. These policy changes will certainly affect the behavior of railways and, in turn, the economic efficiency of the grain marketing system. This paper examines the incentives and consequences of the railways abandoning low volume branch lines. In particular, we develop a model to examine the optimal railway branch line configuration under the existing elevator system.

Objectives

The focus of this research is to develop a model to analyze the costs of alternative branch line configurations under the current system and under a regulatory framework (Bill C-101) where maximum cap rates are in place. We first use the model to explore the optimal configuration of a railway branch line system under the existing elevator system, and then we analyze the subsequent impacts on railways, farmers, grain companies and roads in a region of interest in Western Canada.

The Model

This study utilizes a spatial equilibrium model to describe part of the Western Canadian grain market. The spatial model incorporates cost characteristics of various elements of the grain transportation industry. A simulation model solves for the behavior of farmers and the railways through the interaction of their cost relationships.

The model incorporates seven major assumptions, all intended to make the analysis tractable. These are:

1. Grain production cost functions are quadratic and have non-zero fixed costs.

2. Trucking costs are a linear function of distance.
3. Farmers and the railway are each rational profit maximizers.
4. Commercial trucking rates for various truck types and distances were averaged to calculate the per tonne-kilometer of trucking cost in the model. This averaging may slightly bias the trucking costs, but it would not change the overall optimal configuration of railway branch lines.
5. It is assumed that elevator companies have no market power. They play a passive role in the grain handling and transportation system and charge a tariff irrespective of changes in branch line configuration and volumes handled. In effect, there are only two active sectors in our model, the farmers and the railways. When a line is abandoned, all the grain elevators located in that line will be closed. The grain is redirected to open elevators in other lines.
6. Rail freight rates are regulated.
7. A fixed proportion of grain production is hauled to elevators. Farmers respond to a grain price change by producing less or more grain. But a fixed proportion of this grain volume is shipped to export destination.

The solution of the model is derived as follows. First, the total number of elevators and farms (townships) in the region is identified. Second, the distance between each farm (center of township) to all the elevators is estimated. The trucking cost equation (Equation 4) allows us to compute the trucking cost for each farm to different elevators. To begin with, it is assumed that the elevation charge (*EC*) is the same for all elevators, and farmers deliver their grain to the nearest elevators. The predicted catchment area for each elevator and its respective delivered output can now be found. Comparison of the predicted delivered output with the actual output received by the elevator yields a residual. By changing *EC* for each elevator, this residual can be minimized and the catchment area for the elevator can be estimated. The basic catchment area computed in this manner is then used to analyze the impact of various transportation policies.

Grain Production Costs

We used a quadratic functional form to describe the grain production cost equation:

$$C_G = a + bt^2 \tag{1}$$

This yields the following well-known average and marginal cost results:

$$AC_G = \frac{(a + bt^2)}{t} \tag{2}$$

$$MC_G = 2bt \tag{3}$$

where C_G is the total cost per square kilometer of grain production, AC_G is the average cost of grain production per tonne, MC_G is the marginal cost of grain production per tonne and t is the yield in tonnes per square kilometer. Given this cost function, the grain supply curve is illustrated in Figure 1. For any price less than $\overline{p}$, production would be zero.

Figure 1. Grain Supply Curve.

Trucking Costs

The equation for the cost of trucking is given as follows:

$$AC_T = EC + VC_T = EC + gd \tag{4}$$

where AC_T is average cost per tonne to transport grain by truck; EC is the elevation costs; VC_T is the variable cost per tonne; g is cost per tonne-kilometer; and d is the distance between the farm and the country elevator in kilometers.

The cost of grain delivered at the elevator depends on the farmer's distance from the elevator, elevation cost, freight rates, and on the grain yields (t). Individual farmers will choose their grain yields so that, the following relationship between yield and distance is satisfied;

$$t(d) = \frac{(P_w - f_r - EC - gd)}{2b} \tag{5}$$

where P_W is the world price of grain, f_r is the freight rate, and $t(d)$ is the yield in tonnes per square kilometer of the profit-maximizing farmer located d kilometers from the elevator. By assumption, $t(d)$ must be greater than or equal t^*_{min}. A farmer receiving P_W per tonne must pay f_r, the trucking cost of EC and gd (variable with distance). Farmers will increase yields until:

$$P_w - f_r = MC_G + EC + gd \tag{6}$$

or, by rearranging Equation (6),

$$P_F = P_w - f_r - EC_i - gd$$

where P_F is the farm price. Individual producers will choose their grain production so that $P_F = MC_G$.

Modeling Elevator Decisions

In general, there are two arguments given to justify elevator closure. The first is that elevators are competing for business and they will reduce the rate of consolidation to maintain market shares, but at greater cost. Therefore, a forced consolidation will lead to greater cost savings. The alternative argument is that grain companies can currently choose to rationalize their system. They will do so in the least cost manner. If they are constrained by branch line abandonment, then the costs cannot fall as much. A higher cost is associated with the first case because a higher number of elevators operate in this scenario. A lower cost obtains in the second case because fewer elevators operate under this scenario. Clearly, these two lines of reasoning result in opposite cost effects. Since the magnitude and direction of elevator decisions within our modeling framework is not clear, grain elevator decisions were assumed to have zero effect in this model.

Railway Total Branch Line and Main Line Costs

The average cost of transporting a tonne of grain from the country elevator to the port is the sum of three separate costs: mainline cost, volume-related branch line costs, and line-related branch line costs. Volume-related costs vary with the volume of traffic and consist of two main components: (i) service units, defined as measures of the amount of work done; and, (ii) unit costs, which are determinations of the standard dollar amounts to be applied to each unit of work performed. Volume costs are calculated by multiplying service units by unit costs. Volume-related costs are derived from train-related and car-related workloads. These have been incorporated into the movement of cars being costed. Line-related costs are fixed and are present on branch lines regardless of traffic level and can be avoided only if the line is abandoned. These costs consist of track and roadway maintenance, depreciation and cost of capital (i.e. ownership), and property taxes associated with the line.

Total railway branch line costs (TRBC) and total railway main line costs (TRMC) are computed as follows.

$$TRBC = i(L_{NW}) + \nu \sum_{m=1}^{M} \sum_{j=1}^{n} D_{jm} Q_{jm} \tag{7}$$

$$TRMC = \varphi \sum_{m=1}^{M} L_m^p Z_m \tag{8}$$

where φ is the mainline volume-related cost of transporting grain per tonne; i is the branch line line-related maintenance cost per kilometer of grain-dependent branch line; ν is the average volume-related cost of transporting a tonne of grain over a kilometer of grain-dependent branch line; D_{jm} is the distance of branch line from elevator j to connection point m; Q_{jm} is grain for movement from elevator j to connection point m; L_m^p is length of main line from connection point m to the port; L_{NW} is the total length of the branch line network; and Z_m is grain shipped on the main line from connection point m to the port. Together, these two costs comprise the total railway cost (TRC);

$$TRC = TRBC + TRMC = i(L_{NW}) + \nu \sum_{m=1}^{M} \sum_{j=1}^{n} D_{jm} Q_{jm} + \varphi \sum_{m=1}^{M} L_m^p Z_m \tag{9}$$

where:

$i L_{NW}$ is the total fixed cost (TFC), and

$\nu \sum_{m=1}^{M} \sum_{j=1}^{n} D_{jm} Q_{jm} + \varphi \sum_{m=1}^{M} L_m^p Z_m$ is the total variable cost (TVC).

Looking at this cost function, we note that any adjustment in the length of branch line could affect the railway costs and consequently market equilibrium. Even though the form of the cost function is simple, we believe it provides an effective means to examine the consequences of changes in the branch line network.

The Study Region

The region we utilize for the simulation analysis is located in the west-central portion of Saskatchewan. It contains about a quarter of the province's farmland. This region is surrounded by the North and South Saskatchewan Rivers in such a way that movement into or out of the region is confined to a few bridges in the area. Hence, inter regional shipments are ignored except for the areas close to the bridges. The region produces approximately 4,360,000 tonnes per year of grain and historically, about 75 percent of the production has been destined for export markets (Saskatchewan Highways and Transportation). The rest stays in the region for processing and other usage. The crop districts 7, 7A and 7B, and parts of crop districts 3B, 6B and 9B are

located in this area. All three major soil zones - Brown Soil Zone, Dark Brown Soil Zone and Black Soil Zone - are found from the bottom of the region to the top (Saskatchewan Highways and Transportation).

There are 540 townships and 90 delivery points located in this region. Boundary adjustments have been made for those townships located on the far side of the region. Farmers produce grain and ship it to the delivery points for export. In this part of Canada, we can safely assume that all export grain is routed to Vancouver.

Rail is the dominant mode of transportation used by farmers to ship their grain to the export destination. The two major Canadian railways serve the study region. The main lines belonging to both railways cross the northern part of the region in an east-west direction. A network of branch lines connects the country elevators to these mainlines. In general, the Canadian National system serves the northern part of the area and the Canadian Pacific system serves the south.

A sub-set of thirteen branch line segments were identified for consideration in this work. These thirteen segments serve a total of 2,194,900 tonnes of grain products (1995), at a total of 62 delivery points.

The Data

The data used in this analysis came from different sources. These include Saskatchewan Highways and Transportation, Crop Insurance and data from various grain industry officials. However, the majority of the data used in this study were obtained from the Geographic Information System (GIS) database maintained by Saskatchewan Highways and Transportation.

Saskatchewan Highways suggests the annual maintenance cost for grain movement averages out to 5 cents per tonne mile or 3 cents per tonne kilometer for the province. We use this estimate to compute the road damage costs. The 3 cents per tonne kilometer cost multiplied by the distance from the center of the township to the delivery point multiplied by its production volume is the road cost for a particular township. This paper also assumes a $10.89/tonne elevation cost for each delivery point[1].

---

[1] This tariff is what AgPro Grain charged for wheat shipped in the 1995-1996 crop year.

Empirical Results

The first step in the modeling process calibrated the catchment area for the delivery points located in the study region. Comparison of the elevator's received volume in 1994-95 with the model output indicates that less than 10% of differences exist between the actual delivered volumes (1994-1995) and the delivered volumes yielded by the model. Our model is accurate; it is more accurate than the unadjusted minimum transport cost model used by Saskatchewan Highways and Transportation (Saskatchewan Transportation Model, General Information).

To facilitate analysis of branch line abandonment in the next sections of the paper, the Conquest branch line (CN line) was further divided into two segments: Conquest from *Beechy* to *Macrorie*, which was about 88 kilometers long, and Conquest (top) from *Macrorie* to *Delisle*, about 73 kilometers long (this is a logical configuration from the railway's perspective).

In all cases, the quantity shipped on a particular branch line can significantly affect the magnitude of this cost for that line. Our estimated per tonne-kilometer costs for the rail network considered here are very close to the per tonne-kilometer cost provided by CP Rail. For example, CP Rail estimated the *Lloydminster* subdivision per tonne-kilometer cost to be equal to $0.074, which is very close to the $0.079 estimated by the model. Similarly, the reported cost of $0.35 for the Dodsland subdivision is very close to the estimate of $0.37.

Scenario 1: Branch Line Abandonment (Bill C-101 with no Penalty)

Combinations of the branch lines were "abandoned" in the simulation to analyze the impacts of removing various branch lines on supply response.

There was a relatively small decrease in grain export attributable either to the decrease in farm prices or the increase in transport costs as a result of branch line abandonment. In general, we observe that the change in production is not very significant. Rational responses would include a shift away from lower valued crops to higher valued commodities. It should be noted here that in calculating this response, we assumed freight rates were regulated.

Of all the cases we simulated with the model, two particular scenarios are worth further consideration: 1) the extreme situation where all branch lines are abandoned, and 2) a more realistic scenario where all branch lines except *Kerrobert* subdivision, *Maclin* subdivision, and *Rosetown* subdivision are abandoned.

In the first scenario, farmers' total transportation and handling costs increase by 6.67%. Road costs increase by 253.9%, and railways' costs decrease by 24.39%. The overall cost saving in this case is $2.27 million. In the second scenario, farmers' total transportation and handling costs increase by 1.38%. Road costs increase only by 70.76% and railways' costs decrease by

11.19%. The overall cost saving in the second scenario is $5.24 million. Even though the railways gain the greatest saving in first scenario, a socially optimal situation obtains where the *Rosetown* branch line of the CN and *Kerrobert* and *Macklin* branch lines of the CP stay open. Clearly, the cost saving under the two scenarios is small, but from a social welfare perspective the second scenario is a Pareto improvement.

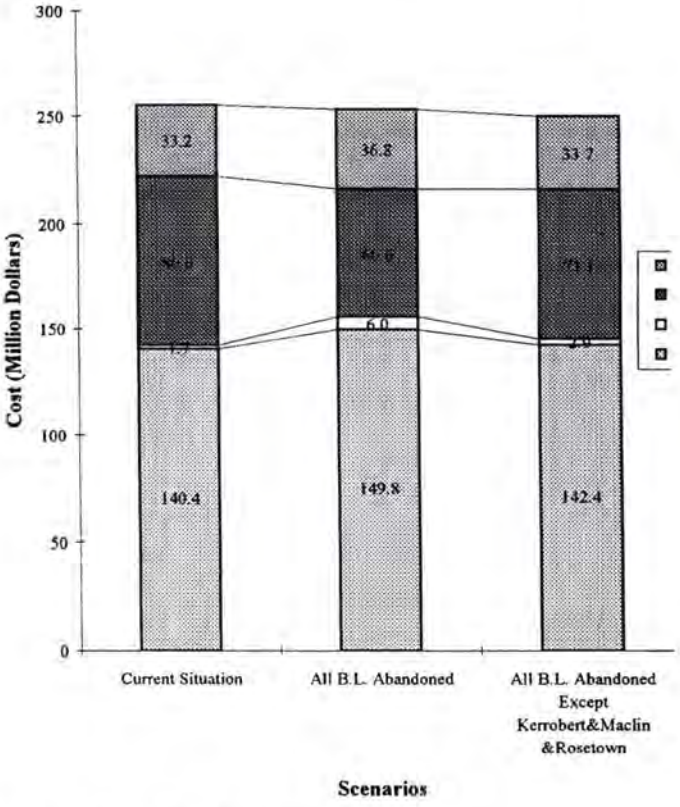


Figure 2. Cost Analysis of Branch Line Abandonment.

Elevator costs increase in some abandonment scenarios (Figure 2) though reason suggests it should be the other way around. When the catchment areas were calibrated, elevation charges were adjusted in the model to minimize the differences between the actual and predicted grain volume in the region. This adjustment caused charges to increase for some of the elevators. Adjusted rates were kept fixed even with branch line abandonment. When a branch line is abandoned the grain volume transferred to remaining elevators should create some economies of size and more intense competition among grain handlers. If in the calibrating process, the elevation charges of elevators in new lines have increased, this generates higher elevation costs.

This outcome is contrary to what is likely to happen in reality. If elevator consolidation occurs at the same time of branch line closure, elevation costs would be expected to decline rather than to increase, with additional cost saving to the system. We therefore acknowledge that this study of optimal branch line configuration is slightly compromised by our assumptions concerning changes in costs of the existing elevator system with branch line abandonment, but we believe that the basic results are correct.

The last issue left to examine is how the two railways might abandon the branch lines in the region. In effect, this is the question of market arrangement (Figure 3). Under the current scenario, CP earns $5,587,564 in profits and CN earns $3,843,249 of profit from the branch lines in the region. They also extract $8,854,393 and $13,871,299 profits on both the main and branch lines respectively.

On the part of the railways, two outcomes are possible when branch line abandonment takes place:

Non-cooperative Case: One rail company abandons its own branch lines, allowing the profits of the other rail company to increase or remain the same. We studied a few scenarios representing this case - for instance, when the *Bodo* subdivision of CN was abandoned, or when the *Smiley* subdivision of CP was abandoned. The extreme example of this could occur if CN decided to abandon the subdivision of *Bodo* and CP decided to abandon the subdivisions of *Smiley*, *Kerrobert*, *Major*, *Reford*, *Maclin* and *Lloydminster*. This leads to another important issue: why would one rail company let the other company benefit more from its decision toward abandonment?

Cooperative Case: The two companies, CP and CN, act together to maximize profits. The most obvious example of this situation is where both firms decide to abandon all the branch lines in the region. We conclude that for some areas in the study region, one rail company can increase its own profits or its rival's profits by abandoning its own branch lines. However, the

profits of each railway are maximized when all the branch lines in the region are abandoned.

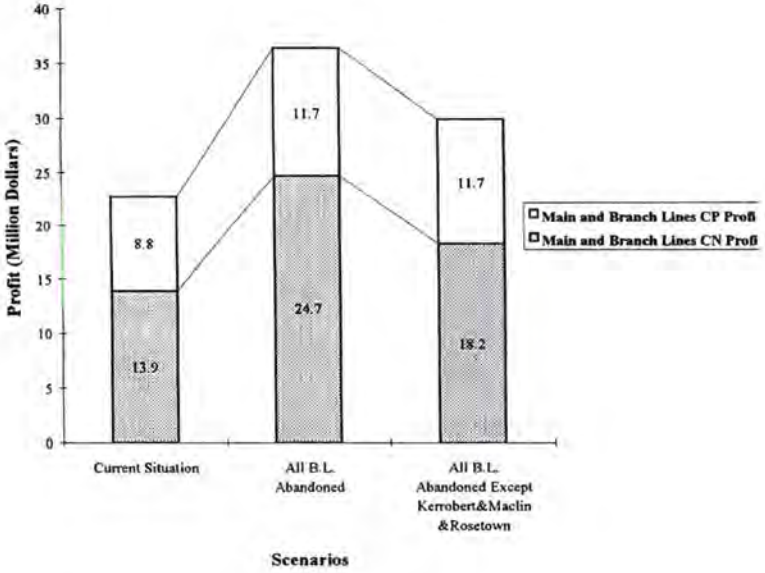


Figure 3. Distribution of Branch line Profits with No Penalty.

Scenario 2: Branch Line Abandonment (Bill C-101 with Penalty)

Figure 4 shows branch line profits in the case where the railway is given the power to abandon the lines with a penalty. We assume the railway has to pay a fee of $6000 per kilometer of line abandoned (an amount close to that originally suggested by CP).

The general conclusions made in previous section can be extended to this case. In the scenario where the railways separately maximize profits, all the branch lines except *Kerrobert* subdivision, *Maclin* subdivision, and

Rosetown subdivision were abandoned. However if the two railways cooperate to maximize their joint profits, all branch lines will be abandoned.

When the railways do not act together, imposition of the penalty on abandonment results in the least cost (socially optimal) branch line configuration. However, if the railways collude to maximize their joint profits, then complete (and excessive) abandonment takes place. Given this result, it is somewhat unclear as to whether or not the proposed penalties through Bill C-101 could result in maximization of social welfare. As might be expected, this depends on the strategic behavior of the railways regarding their abandonment policy.

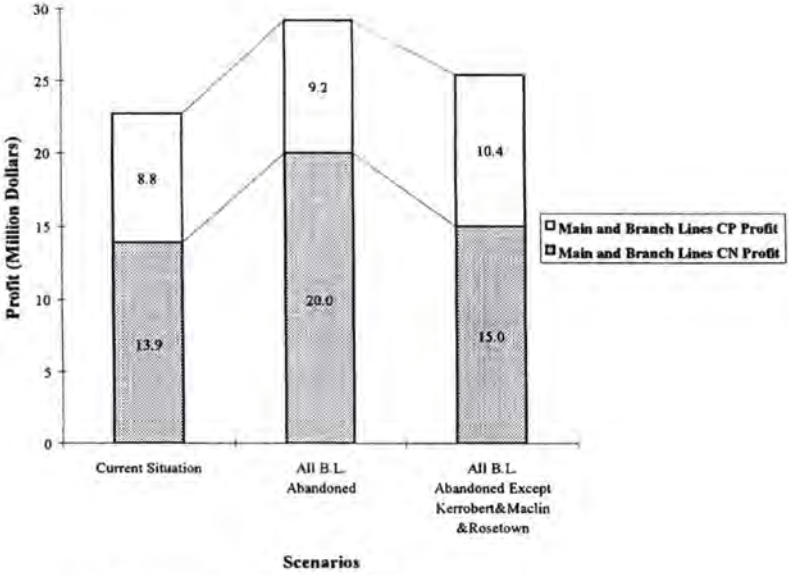


Figure 4. Distribution of Branch line Profits with Penalty.

Sensitivity Analysis

We chose two variables to study in our sensitivity analysis. These variables are trucking cost and railway volume-related cost. We chose the latter because foreseeable technological improvement in the railway industry will be reflected in lower volume-related cost, line-related costs are very unlikely to be affected in near future. The results are discussed below.

a) Change in the Trucking Costs

Recall from the trucking cost function that trucking cost was assumed to be eight cents per tonne/kilometer on average. We now examine the overall impact on the grain handling and transportation system of lowering the trucking cost from eight cents to six cents. Our results suggest that a reduction in trucking cost generates more grain production and more export, though not significantly. We also find that, as a result of reductions in trucking cost, the change in the distribution of delivered grain is quite significant.

As trucking costs decrease, the average cost of branch lines receiving more grain will decrease. This indicates that lowering trucking cost from eight cents to six cents causes abandonment of higher cost branch lines and creates more traffic on lower cost branch lines. These figures also indicate that a reduction in trucking cost reduces the socially optimal number of branch lines and facilitates more elevator consolidation.

Formally, our computations show that a reduction of two cents per tonne/kilometer in trucking cost reduces farmers' costs from $140.4 million to $139.3 million, reduces railway costs from $80 million to $78.8 million, and reduces elevation costs from $33.2 million to $32.1 million. Road costs increase from $1.7 million to $2.3 million. These results are obtained under the assumption that road costs remain the same at three cents per tonne/kilometer and that road use increases.

As trucking cost falls, it causes the distribution of profit on branch lines to change for both railways.

b) Change in Elevation Charges and Trucking Costs

In this scenario, the trucking cost was lowered from 8 cents to 6 cents per tonne/kilometer and was combined with a ten percent reduction in the elevation rates. The total volume of export increases to 3,211,621 tonnes compared to 3,189,823 tonnes in the current situation, a change of 21,798 tonnes. The configuration of branch lines was similar to the case where trucking cost was lowered from 8 cents to 6 cents, but the distribution of received volume changed slightly among the delivery points. The branch line average costs declined for the lines that received more grain.

There is a $4.7 million cost saving under this scenario compared to current situation. Farmers, railways, and elevators all benefit as a result of this change. The only "losers" are taxpayers.

c) Change in the Railway Volume-Related Cost

During the WGTA era, some authors argued that the railways received about half of their cost savings from technological advancements and productivity gains in grain transportation (Vercammen, 1996). On the other hand, with the elimination of the WGTA, the railways now capture a much larger share of the productivity benefits (Vercammen, 1996). In the present policy environment, the railways are far more likely to aggressively seek out cost-efficient technologies.

We represent technological gain by a lower railway volume-related cost. For the scenarios studied here, the railways' volume-related cost was assumed to be 1.2 cents and 1.8 cents per tonne-kilometer for the main and branch lines respectively. These costs were lowered to 1.0 cent for the main line and 1.5 cents for the branch lines in the productivity analysis. The other variables were assumed to be the same in the model.

Under the new *Canadian Transportation Act* (CTA), the railways will receive close to one half of the annual productivity benefits, both in the short run and in the long run (Vercammen, 1996). If this is true, then we find that the railways gain $6.11 million annually as a productivity benefit in the study region. Such a substantial benefit gives strong incentives to the railways to seek out more cost-efficient technologies and improve the overall performance of their grain transportation system.

Conclusion

We examined the impacts of branch line abandonment in Western Canada on supply response and costs for railways, farmers, elevators, and roads. The increase in transport costs as a result of line abandonment caused a relatively small decrease in grain production. The overall impact of abandonment is a loss to social welfare, more road costs, and large gain to the railways.

Specifically, we found that the least-cost rail configuration occurs when the *Rosetown* branch line of the CN rail and the *Kerrobert* and *Macklin* subdivisions of the CP rail stay open. As expected, the socially optimal configuration was different from the scenarios representing the railways' best interests. Railway profits are maximized with a complete abandonment of branch lines. However, the difference in efficiency gains between a complete abandonment as compared to a partial abandonment was relatively small. Furthermore, a $6,000/km abandonment penalty does reduce the railways' incentive for abandonment. We found that if railways do not abandon lines

acting together, this penalty would result in the socially optimal level of abandonment. If the railways were to collude and maximize joint profits, it would be in their interest to abandon all branch lines, even with the penalty in place.

In sum, the model shows that moderate changes in trucking and rail costs yield a range of results. Any technological advancement in the trucking industry leads to significant redistribution of benefits among the parties involved in the grain industry. A cost reducing technological improvement in the railway industry leads to significant benefits to all parties if railway freight rates decrease. As expected, railways will benefit most from technological improvements in the rail industry.

References

Canadian Grain Council., 1995. Canadian Grain Industry: Statistical Handbook.

Canadian Wheat Board., 1994., Grain Transportation / Car Allocation: What Are the Options?

Elliott, A., 1994. Deregulating Grain Transportation. A report prepared for Transport Canada.

-----., 1995. Modernizing The Grain Car Allocation System In Canada. A report to Saskatchewan Grain Car Corporation. R.L Banks & Associates, Inc.

Fulton, M., and R. Gray, 1997. Railways, Competition and the Hold-Up Problem. Working paper, Department of Agricultural Economics, University of Saskatchewan.

Fulton, M., 1997. The Economics of Freight Rate Determination. Working paper, Department of Agricultural Economics, University of Saskatchewan.

Government of Saskatchewan, 1997. Grain Freight Rates Under Competition and Regulation: A Case Study. Regina.

Karadininis, K., 1985. Economic Analysis of the Impact of Variable Freight Rates on the Western Canadian Grain Handling and Transportation System: Area Study. MSc. Thesis, University of Saskatchewan.

Karwandy, T.L., 1992. Grain Transportation Policy in Western Canada. MSc. Thesis, University of Saskatchewan.

Nagy, J.G., W.H. Furtan, and S.N. Kulshreshtha, 1984. The Implications of a Change in the Crowsnest Pass Freight Rate on the Canadian Prairie Wheat Economy. *The Logistics and Trans. Review*. 15: 574-566.

Tyrchniewicz, E.W., 1984. Western Grain Transportation Initiatives: Where Do We Go From Here? *Can. J. Agri. Econ.* 32: 253-268.

Vercammen, J., 1996., Productivity Sharing and Car Ownership Western Grain Transportation. Van Vliet Chair Report. Department of Agricultural Economics. University of Saskatchewan.

IMPACT OF POOLING ON PORT THROUGHPUT AND CUSTOMER SERVICE LEVELS AT THE PORT OF VANCOUVER

Bob Niemi, Jane Zheng, and Charray Dutka
Canadian Wheat Board

EXECUTIVE SUMMARY

Capacity utilization at Vancouver will continue to be an issue for Canada's grain handling and transportation industry. Vancouver tends to be the preferred port for shippers due to its close proximity to high return markets and low inbound rail shipping costs. However, the ability of the Port of Vancouver to handle the throughput necessary to serve this customer demand is continuously being debated.

Recent reports undertaken for the review of Canada's grain handling and transportation system, have recommended changing the car placement mechanism at ports from partial pooling to full terminal specific ordering (TSO) as a way to improve system performance.

Using queuing theory, this analysis models vessel and car arrivals at the port of Vancouver to determine the overall impact of these car placement mechanisms on waiting times and queue lengths. Furthermore, this analysis identifies the impacts of changing vessel and train sizes on waiting times and queue lengths.

This analysis raises serious concerns about the recommendations contained in the McKinsey and Estey reports in that both TSO and increased train size, which are being touted as ways to increase overall system performance. The analysis reveals that TSO will result in decreased throughput and customer service levels, and increased car cycle times. For these reasons, the industry must be careful in implementing solutions that will increase efficiencies in specific areas of the system and for certain system participants, while imposing costs on other areas of the system and other system participants.

IMPACT OF POOLING ON PORT THROUGHPUT AND CUSTOMER SERVICE LEVELS AT THE PORT OF VANCOUVER

Bob Niemi, Jane Zheng, and Charray Dutka
Canadian Wheat Board

INTRODUCTION

Effective utilization of available port capacity at Vancouver has and will continue to be an issue for Canada's grain handling and transportation industry. Generally, Vancouver tends to be favored over the Canadian ports due to its close proximity to premium markets and low inbound rail shipping costs. However, the ability of the Port of Vancouver to handle the grain necessary to satisfy customer demand off the West Coast is continuously being questioned.

The port of Vancouver accounts for roughly 45% of Canadian grain exports and 75% of the West Coast movement. The port of Vancouver handled over 15 million tonnes of grain in 1991-92, establishing an all time record. Since that time, throughput has dropped off considerably due mainly to lower production and supplies. In 1997-98, the five port terminals shipped only 12.1 million tonnes of all grains.

Many studies have analyzed the port of Vancouver in an attempt to determine how to maximize throughput through the port. Numerous solutions have been proposed, ranging from building new terminals and joint management of all terminals to terminal specialization, continuous port operations and the pooling of rail cars.

Pooling of railcars was implemented to reduce railway switching and facilitate the movement of large export programs. While consigning cars to specific terminals for unload worked reasonably well at low volumes, better car placement mechanisms were required to handle larger volumes at the ports. After implementation of pooling at the West Coast, it was estimated that port capacity increased by 15 to 25 percent.

Recent reports have rejected the notion of car pooling at Canada's ports. The 1998 McKinsey report recommended terminal specific replenishment as one way to increase system performance. This included order assignment to specific terminals, terminal specific trains and the elimination of car pooling. In essence,

they proposed assigning vessels to specific terminals and allocating trains in the country to meet the vessels.

In addition, the recently released Estey report, commissioned by Transport Canada for the review of the grain handling and transportation system, recommended that the industry move to full tendering for CWB grains from port position. This particular recommendation would, in essence, preclude the pooling of CWB grains as grain companies would be unwilling to assume the risk of unloading another company's grain that does not meet its tender specifications.

Given the recommendations to end car pooling, this analysis will attempt to answer the following questions in an attempt to determine whether it is worthwhile to continue car pooling at port.

(1) What effect will car placement mechanisms, such as Terminal Specific Ordering (TSO) and pooling, have on the industry's ability to maximize throughput at Vancouver?

(2) What effect will increasing train and vessel sizes have on port performance?

(3) How will the car placement policies, such as TSO and pooling, affect Canada's ability to serve its customers?

To answer these questions the analysis assumes a simple queuing model of the port system configuration to determine the impacts of car pooling versus TSO on port operations at Vancouver. Specifically, the model will identify the impacts of changes in car placement mechanisms and vessel and train sizes on waiting times and queue lengths.

CAR POOLING

History

Prior to the adoption of car pooling the early 1970s, all grain arriving at Vancouver (and Thunder Bay) was consigned to a specific terminal. In most cases, cars were consigned to the terminal that was affiliated with the primary elevator in the country. This required a significant amount of rail car switching between terminals, which contributed to increased port congestion, lower port

throughput and greater demand on railway resources when a terminal was unable to immediately unload cars destined for its facility.

Upon adoption of car pooling by the grain companies with terminals at Vancouver (and Thunder Bay), rail cars were queued and placed for unload at the first available terminal. While companies were guaranteed their share of country originations (using an unload formula), the grain company did not necessarily unload the same cars that they loaded in the country. This change in car placement resulted in increased port throughput and improved utilization of rail cars and rail yards at port.

Adoption of the rail car pooling agreement was strongly advocated by the railways as they knew that pooling of unloads would significantly decrease railway switching, thereby reducing port congestion and demands on railway resources (ie. rail cars and rail yard capacity). Although the railways were not signatories to this agreement at the time (and are not currently), they have significant control over the placement of rail cars upon arrival at port.

Efficiencies

The organization that most directly dealt with measuring system performance was the Western Grain Transportation Office (formerly the Grain Transportation Agency). While the WGTO and GTA acknowledged that benefits did accrue to the grain handling and transportation system as a result of pooling, they admitted that it was difficult to put a number on these benefits. However, one way in which they were to estimate partial benefits was through cycle time measurements.

In its last analysis on cycle times, the GTA concluded that:

(1) Cycle times for pooled grains (wheat, barley and canola) were lower than non-pooled commodities (oats, flax, rye, etc.). ie. For Vancouver, wheat, barley and canola were found to have car cycle times of 17.5, 21.5 and 20.6 days in 1992. Other non-pooled commodities, oats (29.4), rye (25.2), flax (24.8) and all other commodities (31.2) had significantly higher cycle times (GTA Analysis of 1992 Car Cycle Times).

(2) Time for pooled grains at port were lower than the non-pooled commodities (same study). For Vancouver, wheat, barley and canola

were on-hand 1.1, 1.4 and 1.4 days respectively. Oats (3.0), rye (2.2) and flax (2.5) were again significantly higher.

The Pacific Coast Study (Canada Grains Council 1976) also acknowledged the benefits of car pooling. It reported that "the pooling of cars makes it possible to have grain placed on terminal elevator tracks a few hours after their arrival at Coquitlam or Port Mann." Furthermore, it also reported that "the pooling of cars of Board grains being delivered to the terminals has bee responsible for a considerable reduction in car sorting and has resulted in improved rail service to terminal elevators."

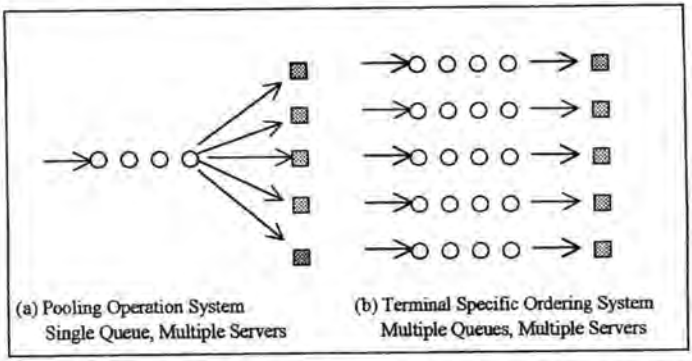
These studies show that pooling of grain car unloads at Vancouver has obvious operational benefits, especially on railway resources. The most significant of which are reduced switching and unload of the rail cars upon arrival at port, leading to improved port operations and throughput.

QUEUING THEORY

Queuing models have been used for evaluating a system's performance since the early 1970s (Tang 1991). Much of the work has been done in the areas of manufacturing, computer network, and production management systems. These studies found that waiting times for multiple servers with a single queue are lower than for multiple servers with independent queues. (Kleinrock 1976, Lee 1966). These findings are equally relevant to the modeling problem at hand, in that they are consistent with the change in port performance that the grain industry experienced when it moved to car pooling in the 1970s.

Evaluating port performance with regards to grain loading and unloading can be approximated by queuing theory in terms of how long a vessel (or a rail car) is likely to spend at the port. The car placement mechanism for car pooling and terminal specific ordering systems at the port of Vancouver can be modeled as per figure 1. Part (a) of figure 1 illustrates how pooling would operate, where arriving rail cars would be queued together and placed for unload at the first available terminal that is idle. Whereas, part (b) shows that under TSO, arriving cars would be put into one of five queues depending on which terminal it is destined for unload. As can be seen from the illustration, rail cars are not able to move between queues for unload at a terminal that might be idle. Finally, figure 1 can also represent the outward loading side of terminal operations in that the queues can also represent vessel lineups for loading.

Figure 1: System configurations of pooling and terminal specific ordering.



To put queuing theory into a context that is readily understandable, think of the check-in lines at an airport. Generally, passengers will stand in one line, waiting to be processed at the first available ticket counter. This would be consistent with the pooling of rail cars at port.

However, now think of passengers lining up to check-in at specific ticket counters. Once in line, passengers would be unable to switch lines even if another ticket counter is free or another line is moving more quickly. From experience, we know that lineups would lengthen and less passengers would be processed as they would not be able to take advantage of faster moving lineups. This would be very similar to what would be experienced in a TSO environment at port. Overall, less throughput would be available for loading onto vessels as faster moving terminals would not be fully utilized due to the fact that rail cars would be unable to move between terminal queues. Furthermore, port performance would be further restricted as a queue must be chosen over three weeks in advance of when the rail car would arrive.

MODEL

This section describes the various modeling scenarios and the assumptions used in this analysis.

Data used in the queuing model is based on actual observations. These data are the number of vessel arrivals, vessel tonnage, number of terminals, and vessel

days in port. Vessel and car data for the port of Vancouver for the most recent crop year (1997-98) is selected for analysis. The full year of data allows for the incorporation of the seasonal variation of vessel and car arrivals and comparison to other years. This period is also selected as no major disruptions to system performance occurred in this time frame.

From these observations, vessel arrival rates, average vessel size, average load rate per busy terminal, average service time per vessel and service rate are calculated. The vessel arrival rate dictates the arrival rate of cars, assuming that terminal stocks are constant.

The queuing formula assumes a Poisson arrival rate. The data in the peak shipping months (October to April) fit this assumption quite well.

Vessel Pooling

Several assumptions are made to solve the problem using queuing theory. Most importantly, car placement mechanisms will determine how vessels are assigned to terminals for loading. ie. Pooling of rail cars facilitates vessel pooling, whereas TSO will preclude vessel pooling. Vessels arrive randomly in port to be served by terminals on a first-come, first-serve (FCFS) order sequence. All five terminals are assumed to be identical and stocks are adequate.

In 1997-98, CWB vessels (net of malting barley) accounted for 79 percent of all vessels. Adjustments were necessary to account for terminal preference of canola vessels, non-pooling of cleaned canola, and partial pooling of some of the smaller CWB grains[1]. The best-fit calculation used in weighting the formula for the baseline pooling value is 72 percent. Terminal utilization, which is the proportion of time that terminals spend loading vessels, is estimated to be 82.6 percent.

Car Pooling

Pooling of rail cars is more difficult to model than vessel pooling due to various combinations of inbound rail and terminal yard structures. To simplify the modeling process and a number of problems related to the number of railways, yards, interchanges, terminal distribution and sequencing, the following assumptions are made:

---

[1] Smaller volume grains tend to be consigned to one or two terminals due to the inefficient utilization of bin space that would result if these small volume grains are pooled

(1) one arrival queue for all five terminals;
(2) arrival queues at port encompass all yard and track structures;
(3) unloads occur on a FCFS basis at the five terminals;
(4) terminal space is not limited;
(5) unloading capabilities are identical for all terminals; and
(6) unload utilization rate is identical to vessel loading utilization rate.

Scenarios
Scenarios are modeled to determine the effects of:

(1) TSO (0% pooling), partial pooling (72% pooling) and full pooling (100% pooling) on vessel loading and rail car unloading;

(2) Changing sizes of arriving units on system performance (assuming constant throughput);

Effects are measured for each scenario based on days in port, number of units in port, and service times.

RESULTS

Regardless of the system of pooling utilized, grain handling at Vancouver must to go through the same process – the terminal unloading the rail car and loading the grain into the vessel. The analytical results reflect both the queuing analysis of vessel loading and car unloading processes as these operations simultaneously affect port performance. While car and vessel arrival queues represent inter-dependent queues on either side of the terminals, the following section discusses the results of the scenarios from the two activities separately.

(1) System Performance Comparison

(a) Vessel Loading
Table 1 shows the effects on days in port and number of arrivals under TSO, full pooling and partial pooling. Vessels arriving under the current system of partial pooling spend an average of 8.7 days in port, of which 5.6 days are spent waiting and 3.0 days are spent loading. The average vessel time in port is calculated from arrival and departure dates. However, under TSO the number of vessel days in port per vessel would more than double, to 17.7 days. This is a

surprisingly large increase that is mostly due to the sensitivity of waiting time to car placement mechanisms.

The number of vessels in port reflects the difference between the two car placement mechanisms. Under partial pooling, the estimated vessels in port would be 11.8 vessels, whereas the number of vessels in port under TSO would more than double to just over 24 vessels. Again this reflects the sensitivity of waiting times.

Vessel service levels are indicative of customer service, reflecting the number of vessels waiting and loading. In many industries, a 98 percent customer service level is targeted, with a trade-off occurring between the level of service and the cost of providing the service. At service levels higher than 98 percent despatch tends to be earned, whereas below 98 percent demurrage is incurred. Assuming an average of 12 vessels in port, of which 4 are in some stage of loading and that one-half the vessels loading are loaded, this would result in an average of 10 vessel equivalents of unsatisfied demand. With 500 vessel arrivals per year, this would represent two percent unsatisfied demand or 98 percent satisfied demand for customers.

Table 1: Vessel queuing configurations on Vancouver

Scenarios	Days			Number of Vessels			Service Level (%)	
	Wtg	Ldg	Total days	Wtg	Ldg	Total number	Estimated	Observed
Pure Pooling	2.2	3.0	5.2	2.9	4.1	7.1	99.0	
Actual	5.6	3.0	8.7	7.7	4.1	11.8	98.0	98.3
TSO	14.7	3.0	17.7	20.0	4.1	24.2	95.6	
TSO/Actual	2.6	1.0	2.1	2.6	1.0	2.1		

At constant arrival rates, service levels decrease as the number of vessels and days in port increase as a result of a decrease in pooling. Note that the 95.6 percent service level reported for TSO is somewhat lower than the 97.4 percent service level for Vancouver in 1996-97 when system performance resulted in low customer service levels. This analysis shows that if TSO had been in place in 1997-98, waiting times and customer service levels would have been lower than what was actually experienced in 1996-97. Furthermore, this refutes the claims that the system is simply not working and requires major restructuring as the 1997-98 customer service levels matched the targeted 98 percent service level.

This degree of service level sensitivity is more evident in figure 2, which shows that longer days in port per vessel will result in a lower level of customer service. Assuming a utilization level of 82.6 percent at the port, vessel days in port under the current system are 8.7 days. This corresponds to the 98.0 percent customer service level. However, vessel days in port under TSO would double to 17.7 days with only 95.6 percent of the customer's service level being attained. As can be seen from figure 2, there is a direct trade-off between vessel days in port and customer service levels.

Figure 2. Relationship between days in port and customer service levels.

(b) Car Unloading

Table 2 shows that a train spends on average about 3.0 days in port under the current pooling system compared to 6.2 days in port under TSO. In addition to time in port, the number of trains or cars in port also doubles under TSO. The difference between the two car placement mechanisms is 12.4 trains or 1236 cars. Based on the results, the 24 trains or 2415 cars in port would well exceed the terminal yard capacity or at least the current level of cars on hand (1179) at the port. Anymore cars would result in reduced port performance due to congestion.

Adjusting the TSO cars on-hand to the partial pooling level of 1179 cars to reflect the assumed terminal yard capacity, will require a 15.2 percent reduction in the rail car arrival rate. However, this reduction would equate to a reduction in throughput of more than 1.8 million tonnes from the 1997-98 tonnage. At the same time, this reduction in tonnage would result in a drop in the car days at port from 6.2 days to 3.6 days. This is 0.5 days or 17.8 percent higher than the number of days in port under the partial pooling scenario. Finally, this reduction in unload tonnage would also affect the vessel tonnage by the same 15.2% reduction. The vessel days in port would drop to 10.2 days (from 17.7), which is 1.6 days or 15.3 percent higher than the 8.7 days that would occur under partial pooling.

Table 2: Rail car queuing configurations on Vancouver

Scenarios	Days in Port	Trains in Port	Cars in port
Pure Pooling	2.9	7.1	708
Actual	3.0	11.8	1179*
TSO	6.2	24.2	2415
TSO / Actual	2.1	2.1	2.1

Note: 85 tonnes per car or 8500 tonnes per train

* *Actual estimated to be around 1100 cars*

(2) The Effect of Changing Size of Arrival Units

(a) Vessel Size

Assuming constant throughput at port, a 10 percent increase in vessel size at port would lead to a decrease the number of vessels (to 452 vessels), but an increase in the number of days in port (9.5 days). Conversely, decreasing the vessel size would result in an increase in vessel number (to 552 vessels) and decreasing days in port (to 7.8 days). Table 3 shows the impact of a 10 percent change in vessel size.

Table 3: Change in size of arriving vessels

	Vessel Size	Arrivals	DIP	DIP/10,000 Tonnes	Number in Port
Actual	24254.7	497.0	8.7	3.6	11.8
+ 10%	26680.2	451.8	9.5	3.6	11.8
- 10%	21829.2	552.2	7.8	3.6	11.8

From the customer's point of view, there is a trade-off between cost and service in chartering a large vessel to load grain due to lower freight costs per tonne. A smaller vessel may receive better service when there are stock availability and terminal loading constraints, such as draft and berth length, which can exist at either the port of loading or unloading.

(b) Car/Train Size

Table 4 shows that a ten percent increase in the number of cars for each train is expected to increase the number of days in port per train (to 3.3) and cars queued at the terminal yard (to 1297 cars) compared to the base scenario. A ten percent decrease of the cars for each train is expected to result in fewer days in port per train and less cars queued in the terminal yards (2.7 days in port per train and 1061 cars in port respectively).

To equalize queue size values, either the service rate needs to be increased or the arrival rate decreased. Holding the service rate constant, the arrival rate would need to decrease from 3.5 trains to 3.4 trains in order to bring the cars at port down to 1179 cars. This would amount to a 2.0 percent reduction in throughput or about 236,000 tonnes annually. Furthermore, the time in port would increase by ten percent or 0.2 days for all cars. For these reasons, lowering the number of cars in port to maintain current on-hand averages would require a reduction in the train size or an increase in yard capacity.

Table 4: Change in Size of Train/Car Units

	Cars/Train	Trains/Day	DIP/Train	DIP/10,000 tonnes	Trains in Port	Cars
Actual	100	3.9	3.0	2.9	11.8	1179
+ 10%	110	3.5	3.3	2.9	11.8	1297
- 10%	90	4.3	2.7	2.9	11.8	1061

Increased train and rail car size means higher on-hands at port. If trackage (or number of cars in port) is a constraint, throughput will suffer and the gain in rail efficiency will be offset by port inefficiencies and therefore lower customer service. The trade-off is that the pursuit of local or individual efficiency may not be beneficial for overall system efficiency. This may explain why the port performance improvements in the past have not been measurable or present to the degree expected.

System capacity is limited by the most constraining element. If line capacity (number of trains per day) is limited in total or by commodity, then increasing the train size is to be expected in order to maintain or increase throughput. However, if Vancouver yard capacity is limited in total or by commodity in conjunction with line capacity, then the result of two system constraints related to train-size means that system throughput will be sacrificed. Inbound flow rather than outbound flow appears to be where the port constraint is centered.

CONCLUSION

Queuing theory provides a simple, but effective method of analysis to quantify the effects of changes in car placement policies, as well as indicating the direction and the magnitude of change on waiting times and service levels.

Comparison of pure pooling versus terminal specific ordering (TSO) reveals that the number of days in port and the number of vessels increases dramatically under TSO. This increase is due solely to the reduced flexibility of terminal operations under TSO. As the industry continues to move away from car pooling to TSO, we would expect to see not only a reduced ability to serve customers of Canadian grains, but also a decrease in throughput. This analysis raises serious concerns about the recommendations contained in the McKinsey and Estey reports.

The analysis also shows that increasing vessel and train size would lead to a reduction in the number of units of arrival and an increase in days in port. Larger train sizes may have negative implications on port performance, particularly if yard capacity is an area of concern. The analysis also indicates that smaller and more frequent vessel and train arrivals tend to improve port performance.

Ultimately, this analysis reveals that both TSO and increased train size, which are being touted as ways to increase system efficiencies, will actually lead to decreased system efficiencies through decreased port performance and increased car cycle times. However, while the analysis provides users with an understanding of areas where potential changes can be made to increase port throughput and customer service, it is not without limitations. Due to the limited scope of this analysis, there was no attempt to model the impact of all factors that affect port operations.

REFERENCES

Cook, T. M. and R. A. Russell. 1971. "Introduction to Management Science." Prentice-Hall Inc: New York.

Estey, W. 1998. Grain Handling and Transportation Review: Final Report.

Grain Handling and Transportation Committee. 1976. Pacific Coast Study. Canada Grains Council.

Grain Transportation Agency. 1991. Grain Handling and Transportation Requirements at the West Coast in 1995-96 and 2000-01 – Technical Report.

Grain Transportation Agency. 1992. Analysis of 1992 Cycle Times.

Heads, J., Wilson, A. and J. Eisler. 1995. Potential Changes in Grain Traffic Through British Columbia Ports. University of Manitoba Transport Institute.

Kleinrock, L. 1976. "Queuing Systems, Volume 2: Computer Applications." John Wiley & Son, Inc: New York.

Lee, A. M. 1966. "Applied Queuing Theory – Studies in Management." St Martin's Press Inc.: New York.

McKinsey and Company. 1998. Improving the Western grain logistics system.

Tang, C. and S. Yoo. 1991. "System planning and configuration problems for optimal system design." European Journal of Operational Research, vol. 54 (163-75).

GREENHOUSE GASES - A DILEMMA FOR TRANSPORTATION PLANNERS

Prof. F.R. Wilson, P.Eng.
Prof. A.M. Stevens, P.Eng.
Prof. J.D. Innes, P.Eng.
Transportation Group
University of New Brunswick
Fredericton, N.B. E3B 5A3

ABSTRACT

The mission of sustainable development has been embraced with enthusiasm and zeal, but often in a vacuum of rational planning and analyses. Many in the transportation sector see the sustainability concept in terms of sustainable transportation development.

The 1992 Rio Earth Summit and the 1997 Kyoto Protocol have provided an added impetus, horizon dates, and target achievement levels that all sectors contributing to the green house gas "problem" should meet. Transportation planners, engineers and economists must now move to define a sustainability developed transportation system that can meet the needs of society while achieving the required transportation sector's contribution to the green house gas issue which could be as high a reduction as 32% if the current envisioned targets are to be achieved.

This paper examines some of the traditional rationales that have driven mankind in its search for better conditions for existence. It compares these initiatives with those which may be required to produce a sustainable transportation development strategy for the future. Particular attention will be given to the Canadian and North American scene and their relation to world conditions. These are further focused on Canadian transportation and its energy requirements and maintenance of national competitiveness.

1.0 INTRODUCTION

This paper addresses a dilemma facing Canadians and others throughout the world. Specifically, how should transportation planners and operators respond to the Kyoto proposition to reduce greenhouse gas emissions while continuing to plan, design and operate a transportation system that meets the essential needs of society. The focus of the discussion is on carbon dioxide emissions produced by the transportation system. These emissions are the by-product of the transportation activity and alleged to be of major importance to the future climatic conditions.

Developing acceptable strategies for reduction of Green House Gases (GHG) involves convincing the general public that a crisis is indeed pending. Global and climate changes are not new and have been largely uncontrollable if natural history evidence is accepted. Many tend to assume that the current conditions and weather patterns are the norm yet there exists much historical, prehistoric and scientific evidence that gradual and sudden climate change takes place. An excellent treatment of the climate change process can be found in the work by H. Petersson[1].

A major challenge is convincing the world's population, especially in under-developed nations that a crisis of sufficient magnitude exists to warrant curtailment of production of GHG's. This challenge will be especially difficult when it relates to transportation - a factor seen as essential to a higher level of prosperity and betterment of society in these nations. Why should they not reach the level of mobility which Canadians enjoy? For Canada to reduce a few percentage points in the production of GHC's or maintain existing levels will not make an impression in the under-developed and developing Nations. Without commitments from these populous Nations, Canada's contribution will be negligible at best - hence one of the dilemmas.

2.0 THE CANADIAN CHALLENGE

Transportation systems exert a certain amount of stress on the environment. It has been estimated that Canadian transportation is responsible for 62% of the nitrous oxide (NOX), 42% of the volatile organic carbons (VOC) and 27% of the carbon dioxide (CO_2) being produced in the country (Green Plan, 1990)[2]. This pollution of course contributes to the greenhouse effect as well as to problems related to ozone having both local and global environmental significance. Transportation can also be the source of a variety of pollutants in which the dispersion is more confined and problems are considered to be local or site specific.

Transportation uses significant amounts of energy, specifically petroleum products. It has been estimated that transportation is responsible for the use of 65% of the petroleum refined in Canada and that 70% of this amount is used by the highway mode (Hijazi, 1992)[3].

A comparison of Canada with the G-7 Nations is presented in Figure 1. (Bureau of Transportation Statistics, 1995). This graph illustrates the Per Capita CO_2 emissions related to transportation for the G-7 countries. It can be seen that the per capita CO_2 emissions related to transportation is very high in North America and has grown considerably over the past two decades. Figure 2 taken from the same paper illustrates the share of total CO_2 emissions that are due to transportation at two points in time, 1965 and 1992. It is noted in this diagram that the share of transportation related emissions would appear to be in the order of 25% of the total in North America and approaching those values across many G-7 nations. The impact of climate on these numbers must be taken into consideration. France appears to have the distinction of exhibiting the highest share.

Figure 3 taken from the 1995 estimates by Environment Canada places transportation's contribution to the GHG emissions in CO_2 equivalents. The data displayed in Figure 4, from the same source, shows that the CO_2 emissions from transportation are relatively balanced between passenger travel (52%) and freight transport (48%). The automobile portion will prove the most difficult to address due largely to the large number of motor units used and the wide geographical distribution of travel. Considering these statistics it is clear that in meeting the targets established by the Kyoto Protocol that carbon dioxide (CO_2) will be the focus for the transportation sector.

The Kyoto Protocol when fully implemented commit Canada to reducing its GHC emissions by 6% below 1990 levels within the time frame 2008-2010. The 6% figure is misleading and can project a false dimension of the problem. Since 1990 Canada's total GHG emissions have risen by approximately 9% which means that if Canada is to reach the Koyto target a reduction of approximately 15% below today's levels is required over the next 9 to 13 years.

In the transportation sector the challenge is even greater because of its share of CO_2 production. The transportation sector emissions are expected to increase by approximately 26% from 1990 levels by the year 2010 and by 42% by 2020. This means that a reduction of 32% (26 + 6) in transport-related emissions is required by the Koyto target period.

This situation presents major challenges to all sectors of the economy and to Canadians current way-of-life. The number of people in the Nation that take part in the reduction will be larger than now, but it will still mean that each must reduce their average GHG production in the transportation sector by approximately a third of their current levels - a dilemma of major proportions.

3.0 SUSTAINABLE DEVELOPMENT - THE TRANSPORTATION SECTOR

A conventional wisdom widely discussed is that the GHG problem in the transportation sector can be solved if all those involved in transportation planning, design, and operation adopt the concept of "sustainable transportation development" or "sustainable transportation systems". Like many terms and/or concepts, the term contains huge measures of variability and can be made to fit any current problem or fad.

3.1 DEFINING SUSTAINABILITY

The idea of sustainability, while being almost universally attractive, can be somewhat vague and this vagueness can result in the terminology being ineffectual and misunderstood. This in turn can prevent its translation into positive action.

The essence of sustainability and sustainable development is captured in a number of definitions in the literature including "human well-being within ecosystem well-being, extending through time" (Howatson, 1994)[4] or as stated by the Brundtland Commission in 1986[5] "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". According to Holmberg and Sandbrook [6] seventy definitions of sustainability are now current.

This Brundtland definition has been interpreted to mean that sustainable development provides for intragenerational and intergenerational equity. Intergenerational equity provides for future generations having equal access to resources necessary for social, economic and ecological stability. Given that much of history and politics and even war has revolved about the issue of the perception of intragenerational equity and fairness, its inclusion into the discussion may not assist in resolving environmental issues.

One view of the concept of sustainable development as proposed by the Conference Board of Canada takes a broad view of the issue and appears to be generally intergenerational in its focus. It is proposed that sustainable development can include three aspects. These are:

- economic sustainability - wherein wealth is sustained over time;
- ecological sustainability - or environmental protection wherein critical life support and ecological systems are sustained over time;
- sociocultural sustainability - wherein social and cultural systems are sustained over time.

It can be seen that environmental protection or ecological sustainability is part of the concept of sustainable development. It can also be seen that environmental protection consists of two components, these being: the prevention of pollution, and conservation.

In this case, pollution prevention is defined as the prevention of the release of harmful substances into the natural environment whereas conservation would extend these activities into those associated with the conservation of specific species and materials such as soil. The potential for ambiguity can be seen here as the objective of most pollution prevention activities might well be related to conservation.

Given such level of ambiguity it is difficult to envision solutions to the GHG coming solely through reliance on the application of the sustainability concept. However, the sustainable transportation system should be addressed.

3.2 A BALANCED TRANSPORTATION SYSTEM

The concept of a balanced transportation system may be a more logical approach than becoming immersed in the sustainability argument.

At this point in history, Canada has a relatively mature transport technology which has evolved over time but which at the present remains relatively stable. The use of particular modes has evolved in response to individual and community social and commercial needs and affordability. The utility of the modes is a collective expression of the response of the marketplace to the choices available. Current North American thinking is supportive of the existence of alternative choices in transportation although in some of the more remote areas, alternative choices are not necessarily available or practical.

Traffic has grown significantly over the period 1950 to 1994, but the largest growth has been in the share of the traffic handled by road vehicles particularly trucks. In terms of revenue passenger miles, air freight is a relatively small proportion of the total traffic. Growth in this aspect of the traffic has been very significant in recent years with the explosion in couriers and small parcel movement worldwide.

Canada may be typical in the evolution of the modes. Here, the modes of travel have become rather specialized. Air transportation is the dominant form of long-haul passengar travel. A trip longer than a few hundred kilometers will generally be made by aircraft. For shorter distance travel, the road is used almost extensively. Intercity rail passenger services are generally not highly used in Canada.

For the movement of goods the modes have taken on a relatively high level of specialization. Rail transport has been significantly replaced in recent years by the use of trucks for non-bulk movements. Currently trucks offer a reasonably flexible form of transport and a very high level of service to the user. Trucks have been widely adopted when the choice was available in competition to railroads. The flexibility of the trucking firms were often a contrast to the lack of flexibility of the railroads. Expansion of inter-modal transport will occur.

In any discussion of transportation and sustainability, most of the discussion tends to focus entirely on the use of road transport. This may be due to many factors. It is often suggested that road transport is the most inefficient mode of transport and the most polluting. In fact, people and goods can often be moved very efficiently both economically and environmentally on highways in comparison to the other modes. The highway mode has often been vilified as wasteful and inefficient and indeed the use of the motor vehicle is very often less than optimal but tends to be the most convenient. This results in alleged negative environmental impacts. It must be recognized, however, that the mode has an important function within current land use objectives.

At this time, the highway system can be considered to be reasonably mature and our primary means of transportation of people and goods. The almost universal adoption of the automobile for personal mobility has had a profound impact on the nature of commerce and development patterns within and between cities in many developed nations.

It would seem that once the individual has a motor vehicle available, then he or she will adopt a lifestyle which is consistent with that mobility. The individual may and often does choose to live in a suburban or rural area and work in a dense land

use area. The commercial activities become dependant upon their ability to accommodate the automobile. The successful business is often the one with good parking space available. This then extends to have a substantial impact on the shape of urban North America which becomes a set of living and working and commercial areas that are generally not accessible to each other except by automobile. The result is substantial driving for relatively short trips.

This has been recognized as a problem by planners, designers, social scientists and others for many years and a good deal of progressive thinking has evolved in more recent years to change the urban form and reduce the need for private vehicle trips. Still, it is often very difficult if not impossible to effect this change. The experience of many parts of North America would suggest simply that the traffic will increase to use the available capacity. Demand management initiatives have been popular in more recent years as an alternative to increasing the supply of street capacity.

Highway investments, once made, have impacts financially and on the demand for such facilities. If the highway system is overdeveloped, reducing the use of motor vehicles has been shown to be a difficult task. Developing nations may have an advantage of having an opportunity to plan and design more balanced transport systems which avoid some of the mistakes made in other areas where the downstream impacts were not fully understood when the systems were built.

It is quite clear that vehicle ownership is strongly related to national wealth. As the wealth of a nation improves it is almost certain that vehicle ownership and utilization will increase. The adoption of the automobile for personal transportation and mobility appears to be a universal phenomenon and is not confined to North America.

It is apparent that it will be a huge challenge to develop a sustainable Canadian transportation system that maintains current levels of personal mobility. Other strategies must be found.

4.0 ADDRESSING THE DILEMMA

Whether it is possible, using strategies suggested in this Section and others, to provide a transportation system that is "sustainable" for several generations is a very open question at this time. It will, in the authors' opinion, be very difficult for Canadians to meet by 2010 the challenges posed by the Kyoto Protocol.

Choices are available with respect to how to reducing CO_2 emissions. The real challenge is whether Canadians, and others in the developed nations, and their governments are prepared to invoke and accept the regulations required. Further are the governments and people prepared to accept the economic and societal consequences of this regulations.

The dilemma arises because:

- There is no easily apprehended crisis to overcome;
- Canada is a very small player in global affairs even if we are considered to be one of the largest per capita producer's of GHG;
- Canada's neighbor, the United States will probably not go along with the Kyoto Protocol in the final analysis. The US is a big player in world affairs and accounts for over 25% of world consumption, etc.;
- The US tends to set standards which Canada tries to emulate in terms of consumption. To a large extent the US sets the pattern that much of the world would like to achieve;
- It is uncertain how many countries will accept the Kyoto protocol or how successful they will be in meeting the targets;
- The effect of natural climate change is uncertain;
- The precise effects of the GHG remains uncertain despite the discussions surrounding Kyoto;
- There is no proof that meeting the targets will have the desired effect. The desired effects vary from region to region around the globe;
- It is not known whether the world can sustain a level of GHG emission that will stabilize climate change;
- The current free enterprise ideas oppose control of GHG emission;
- There is no easily apprehended reason for an individual to make sacrifices to control GHG emissions.

Notwithstanding the strong forces influencing reduction strategies, there are some initiatives which transportation planners and policy architects should be implementing. The basic premise is that a lowering of CO_2 production means a lowering of fuel consumption. Some moves to lower petroleum-based transport fuels through use of alternates must be treated by considering the total cycle. For example, the often promoted use of electric vehicles can result in limited GHG production.

Electric power for transport usually requires the production of the power "off-site" or removed from the transport function. This strategy in the near future will require consumption of carbon products in one for or another. Natural gas as the feed stock to combined cycle units will reduce the production of LO_2 and CO_2 but

will increase significantly other undesirables such as NOX, a major smog providing agent.

Hydro-electric utilities are promoted as one solution. Increasing environmental restrictions and advocacy groups will oppose further development of hydro-electric sites even those in remote Northern regions. The anti-nuclear lobby will oppose the future expansion of this power source at least through the Kyoto target period.

Strategies that could lower CO_2 production by transport vehicles include:

a) Technology Based -
- Mandatory controls/regulations on non-transport vehicle engine use (engine use restricted to movement function - targets are idling of vehicles by truckers, emergency vehicles, etc.);
- Use of fuels with higher hydrogen content (associated problem is increase in hydrogen production without increase in CO_2 production);
- Improved vehicle and engine fuel efficiency (low emission high efficiency engines will require dedicated fuel types - increasing costs and possibly decreasing flexibility);
- Fuel cell utilization depending on mass production of an efficient and dependable cell which produces a net reduction in CO_2;
- Improved traffic signal timing, geometric design standards, etc.

b) Regulatory/Policy Based -
- Fuel rationing;
- More restrictive and enforceable standards for acceptable fuel emissions;
- Permissible fuel consumptions for vehicles used for specific missions (local delivery, commuting, long-haul transport, urban transit, etc.)
- Speed limits (The US experience under the Carter Administration regulations provide a bench mark);
- Limits on military exercises, government vehicle use etc.;
- Full cost pricing of urban transportation that includes the reduction of CO_2 and other GHG emissions.

c) Longer Term -
- Review of urban design standards to improve journey distance standards;
- Limitations on rural sprawl;
- Development of smaller block engines;
- Development of on-board fuel cells;
- Extend the life of transport infrastructure.

The foregoing is not an all-inclusive list of potential strategies for reducing emission of GHG's by the transportation sector. Very few cited are strategies that will be readily accepted by Canadians or their politicians.

5.0 SUMMARY

The authors have not attempted to belittle or paint a pessimistic picture of the challenges associated with reducing transportation's contribution of GHG's. The objective is to raise questions and obstacles facing transportation planners, designers, operators, and in particular policy makers who are tasked with the challenge.

There are a few reasons to be encouraged that Canadians can meet the target. The Nation can produce the technology if users and the balance of society are prepared to pay the costs. The danger is that the transportation sector will plunge headlong, because of the relative short timeframe, into finding a solution to a problem that was crafted by policy-makers and politicians without any major input by those who will be tasked with finding the solution. Possibly more would be achieved by developing thoughtful strategies to the long-term problem without being stampeded by target dates and reduction levels. Do we want to repeat the errors made in the 1970's when transportation users were herded in varying directions by policy makers bent on solving the alleged oil-based energy problem - a problem that disappeared in the next decade. The major difference is that the CO_2 problem won't go away when and if oil prices change. The measures taken have to persist and there can be no going back to the old ways.

There is no painless magic bullet that will produce the Kyoto targets for transportation. We cannot be sure that the world can or will afford the socio-economic price required to stabilize GHG emissions.

The scepticism of many persons is captured in the following quote from John Goddard, a noted world traveler and lecturer. (many share the sentiment)

> *"I think the most appalling thing I see is the chronic indifference of the world leaders to our critical problems of overpopulation and pollution. I'm not thinking of any individual leader, because they're all guilty of concentrating on profit and economic development."*

The major difficulty of meeting the GHG emission standards is that a fundamental shift in motivation and attitude is required. Canadians are not conditioned to think in terms of the kind of conservation and restraint that will be necessary - they are

conditioned to be competitive and to measure success in terms of comparative status. They have also been conditioned to believe that improved technology will solve any problem Maybe it will but there will be significant delays to develop and distribute the technological changes that may become available. Meanwhile the only sure hope for success lies in making the attitudinal changes necessary to set up the measures that can confidently be foreseen.

Meeting the Kyoto targets has many of the same characteristics as 'unilateral disarmament'. You have to have faith that your competitors, (i.e. the enemy) will not take advantage of your weakness. This has to be considered as an underlying reason the Kyoto agreement may fail. Even with the threat of mutual annihilation from nuclear and other weapons of mass destruction, society cannot overcome their suspicions of groups and cultures that don't parallel their's. One has only to witness the many destructive conflicts, and ideologies that persist in the world today to wonder if the fundamental changes required to achieve the Kyoto target has any chance of success. Canadians have been moderately successful in reducing smoking. One has only to travel to almost anywhere else in the world to find out that there are not many others who view smoking the same as we do in this country. One must assume that any reduction in CO_2 emissions will be worthwhile for society to make the required changes and sacrifices.

The reduction of CO_2 omissions is similar to personal efforts to improve and maintain health. The hope might be for a better and longer life - it is not to achieve immortality.

REFERENCES

1. Petersson, H. "Exploring the Ocean Floor", Scientific American, August 1950.
2. Government of Canada, "The Green Plan", Minister of Supply and Services, Catalogue EN-21-94/1990E.
3. Hijozi, N. "Transportation and the Canadian Environment, Establishing the R&D Priorities", TP11471-5, Canada 1994.
4. Howatson, Allan. "Reforming Public Policies for Sustainability", the Conference Board of Canada Report, 129-194, Canada, 1994.
5. The Brundtlant Commission, World Commission of Environment and Development, 1987.
6. Holmberg, J. and Sandbrook, R. "Sustainable Development: What is to be Done", Policies for a Small Planet, London, U.K., 1992.

Figure 1

Per Capita CO_2 Emissions by G-7 Nations

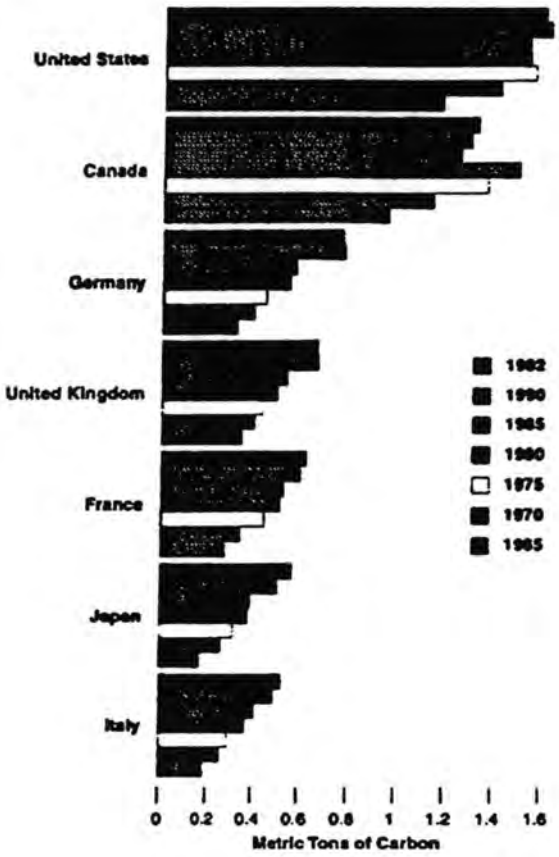
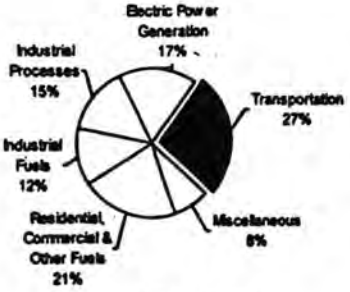


Figure 2

Share of CO_2 Emissions due to Transportation by G-7 Nations



Figure 3
GHG Emissions by Sector
(In CO_2 equivalents)



Total = 619 megatonnes

Source: from 1995 estimates by Environment Canada

Figure 4
CO_2 Emissions from Transportation



Total = 150 megatonnes

Source: from 1995 estimates by Environment Canada

RAILWAY PRODUCTIVITY AND INNOVATION
Developments at Canadian Pacific Railway

In the modern high-tech economy, the railway industry is sometimes viewed as unresponsive and lacking in innovation. In order to shed light on this issue, this paper provides a summary of the historical productivity performance of Canadian Pacific Railway (CPR) at the aggregate level, its implications for shippers, and a broader context for its assessment. Aggregate measures are however no substitute for a detailed review of developments that generate productivity, and the second part of the paper outlines recent innovations at CPR and new innovations that will be the source of future productivity gains.

I HISTORICAL RAIL PRODUCTIVITY AT CPR

The most recent and extensive analysis of Canadian railway productivity[1] covered the period 1956 to 1991 and was updated to 1995, and the results summarized here are for CPR (Canada) only. Total factor productivity (TFP) was measured as the ratio of an output quantity index and an input quantity index:

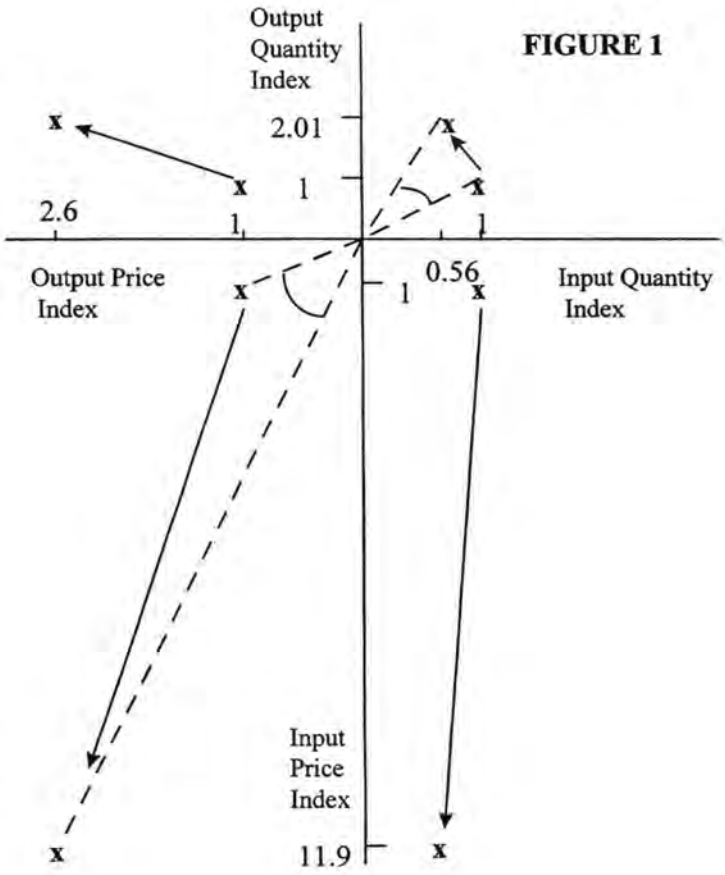
- the output quantity index is an aggregate of both freight and passenger outputs;
- the input quantity index is an aggregate of labour, fuel, materials, and capital[2].

In Figure 1 is presented a visual representation of the findings[3]. From 1956 to 1995 the output quantity index increased two-fold from 1 to 2.01 while the input quantity index decreased by some 40 percent from 1 to 0.56. The TFP ratio is in fact the angle between the two slopes and equal to 2.01/0.56 = 3.59 and this represents a 3.3 percent average annual increase over the entire 39 year period. The more detailed findings indicate that the average annual increase in TFP was 3.5 percent between 1956 and 1981 and 2.8 percent between 1981 and 1995.

---

[1] Measuring Productivity Performance and Financial Returns for CN and CPR 1956-1991, Michael Tretheway, W G Waters II, Andy Fok, Centre for Transportation Studies UBC, March 1994.
[2] Details of the extensive methodology are provided in the original study.
[3] This graphical representation was first presented at the 1998 CTRF by W. G. Waters.

FIGURE 1


Output
Quantity
Index
2.01
1
2.6
1
1
1
0.56
Output Price
Index
Input Quantity
Index
Input
Price
Index
11.9

Note that this feature of a decline in productivity in the more recent past relative to earlier is also a feature of the Canadian economy in general:

> "Canada has not kept pace on several accounts over the 1990s: total factor productivity has not increased and instead has declined, an experience which is shared with no other country (in the OECD)"[4]

The earlier study also introduced the concept of total price productivity (TPP) which is the ratio of an input price index and an output price index. These additional indices have also been represented in Figure 1 in the opposing quadrant and with the numerical signs reversed. From 1956 to 1995 the input price index increased 12-fold from 1 to 11.9 while the output price index increased somewhat less than 3-fold from 1 to 2.6. The TPP ratio is again the angle between the two slopes and equal to 11.9/2.6 = 4.58 and this represents a 4.0 percent average annual increase over the 39 year period. This time the more detailed findings indicate that the average annual increase in TPP was 3.4 percent between 1956 and 1981 and 4.9 percent between 1981 and 1995[5].

Productivity - increased output relative to inputs - allows output prices to grow more slowly than the prices paid for inputs. In a competitive industry in the long run, total factor productivity is expected to equal total price productivity. In other words, competitive forces would drive down prices and pass productivity gains through to shippers, and by comparing TFP and TPP trends it reveals the sharing of productivity gains over time. The conclusions of the earlier study are illuminating:

> "Over the years TFP and TPP track one another fairly closely, but starting in the early 1980s the trends diverge, TPP growing much faster than TFP. That is, on average, revenues realized for rail outputs have not kept pace with rising prices paid for inputs (TPP was averaging 4.9 percent annually) and the difference exceeds the rate of productivity growth (TFP was averaging 2.8 percent annually). Expressed another way, on average, productivity gains have more than been passed through as lower prices for services provided. Expressed still another

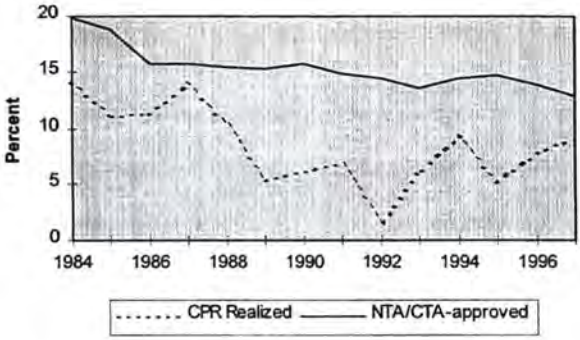
[4] OECD Economic Surveys 1997-1998, Canada, page 47.

[5] An additional observation from Figure 1 is that on the cost side, the nearly 12-fold increase in input price has been accompanied by a 40 percent decrease in input quantity. CPR has clearly responded over the years to significant inflation in input prices by reducing input usage and now transports twice the volume with 40 percent less factor inputs.

way, revenues are not keeping pace with costs and the financial position of the railways has deteriorated (between 1981 and 1995)"

The financial performance during the more recent period can be confirmed by examination of the rates of return of CPR. In Figure 2 is presented a comparison between the NTA/CTA-approved cost of capital rates between 1984 and 1997 and the corresponding CPR realized return on capital. The gap throughout the period confirms the fact that CPR has not been revenue adequate over an extended period and that there was a deterioration in financial position following passage of the 1987 National Transportation Act.

FIGURE 2 : CPR Realized Return on Capital versus NTA/CTA-approved Cost of Capital



An update of the productivity analysis from 1995 to 1998 is not straightforward but an attempt has been made to approximate the results as follows:

- an output quantity index was calculated as the increase in revenue-ton-miles (RTMs) of freight traffic;
- an output price index was calculated as the corresponding increase in revenues per ton-mile;
- an input price index was calculated as a weighted average of component input price changes of labour, fuel, materials and capital using as weights the cost shares from 1995. The capital price index was simply the product of the change in net investment and the change in cost of capital rates; and

- an input quantity index was calculated as a weighted average of component input quantity changes of labour (hours), fuel (litres of diesel consumed), materials (material expenditures deflated by the material price index) and capital (depreciation deflated by the capital price index).

The results are summarized in Table 1. Input quantities have grown in excess of

TABLE 1 : Average Annual Changes in TFP and TPP 1995 - 1998

Output quantities	+0.2%	Input prices	+0.2%
Input quantities	+0.8%	Output prices	+0.9%
TFP	-0.6%	TPP	-0.7%

output quantities due to the significant capital investment over the period as indicated in Figure 3 later in the paper. As a result measured TFP is -0.6 percent which highlights the need to conduct any productivity analysis over a multi-year period to smooth fluctuations, since the benefits of the investment will manifest themselves in later years. Input prices have increased modestly due to increases in labour and material prices while output prices have increased at a slightly higher rate. As a result TPP is -0.7 percent and is slightly more negative than TFP which suggests that CPR has begun to reverse the trends of the earlier period. Overall, these results are consistent with the improving financial performance of CPR also indicated in Figure 2 following passage of the 1996 Canada Transportation Act.

When analyzing at a disaggregate level to determine the sources of productivity there are a number of traditional measures in the rail industry some of which appear in Table 2 for CPR over the period 1981 to 1998.

The following points may be noted:

- labour: the number of employees declined between 1981 and 1995 and has continued to decline between 1995 and 1998. Labour productivity as measured by RTMs per employee has correspondingly increased significantly, but largely from restructuring and less from growth;
- fuel: diesel consumption increased marginally between 1981 and 1995 but significantly less than corresponding GTMs. Since 1995, consumption has declined dramatically despite increasing GTMs due in part to the increased fuel efficiency of newly acquired locomotives;

TABLE 2				Annual Average Percent Change	
	1981	1995	1998	1981-1995	1995-1998
Average number of employees	100	53.7	47.5	-4.3	-4.0
Fuel Consumption	100	103.8	95.4	0.3	-2.8
Miles of Road - year end	100	75.1	67.3	-2.0	-3.6
Number of Freight Cars - year end	100	57.3	56.2	-3.9	-0.7
Number of Locomotives - year end	100	93.0	92.5	-0.5	-0.2
GTMs	100	116.6	116.8	1.1	0.1
RTMs	100	127.1	128.0	1.7	0.2
Labour Productivity - RTMs per employee	100	236.5	269.2	6.3	4.4
Traffic Density - GTMs per Mile of Road	100	155.2	173.5	3.2	3.8

- infrastructure: the miles of road declined by 2.0 percent annually between 1981 and 1995, and the decline has accelerated between 1995 and 1998 following passage of the Canada Transportation Act. The accelerated decrease is largely a consequence of the creation of shortlines - 65 percent - rather than discontinuance - 35 percent. Traffic density as measured by GTMs per mile of road has increased significantly, but again largely from line rationalization rather than traffic growth;
- equipment: both the numbers of locomotives and freight cars have declined between 1981 and 1995, but the decline is much more pronounced in the number of freight cars. Since 1995 the number of locomotives has continued to decline, despite the large renewal program, as the older locomotives are retired.

In order to provide a broader context to view the CPR productivity performance, manufacturing in Canada generated 2.1 percent labour productivity growth over the period 1990 to 1997 in contrast to corresponding US growth of 3.4 percent[6]. This suggests an above average productivity growth for CPR but this was achieved from a lower absolute level.

A more meaningful comparison can however be made directly with the US railroad industry. From the earlier study, using a simple RTM index of output quantity, TFP between 1981 and 1988 increased by an annual average 3.5 percent at CPR while the annual average for US Class I railroads was 5.2 percent. As indicated in the earlier study:

[6] Conference Board of Canada, February 1999.

> "the TFP growth of the Canadian railways appears to be behind the US average. If the Canadian railways were more productive than US railways in an absolute sense, then lagging growth rates would not necessarily be a high concern. However, the partial productivity performance measures suggest that US railroad's absolute level of performance is near or exceeds CN or CP"

Overall, therefore, the productivity performance of CPR continues to remain vital for future competitive purposes. In a further comparison between railways in Canada and the US, the findings that productivity savings are passed on through to shippers in Canada has also been confirmed in the US[7]. Over the period 1965 to 1995 productivity improvements in the US rail industry produced annual savings approaching US$25 billion, with most of the savings achieved after 1983 following deregulation. However, competitive pressures from deregulation resulted in declining real prices and:

> "the US$19 billion in price cuts from 1983 to 1995 and the US$22 billion for the entire period are equivalent to the costs savings - the cost savings were almost entirely passed on to the customers. Despite the very impressive gains in productivity, especially over the 1983 to 1995 period, the net effect for the rail industry was simply to reduce the size of the industry by 50 percent, without any increase at all in profitability. The industry was unable to retain the savings that it worked so hard to gain through productivity improvements"

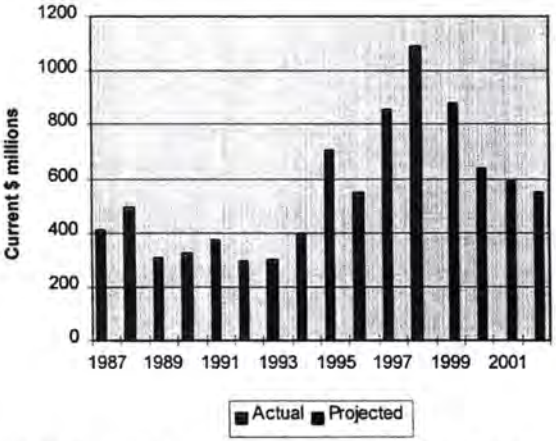
In the face of this collective evidence of the rail industries in Canada and the US over the long term it is difficult to sustain the view that railways overall are unresponsive and uncompetitive, this despite complaints from some shipper groups to the contrary. What is not at issue however is the need to generate future productivity gains.

II INNOVATION AT CPR

As indicated in part I, much of the productivity between 1981 and 1995 arose from railway restructuring rather than revenue and traffic growth. This arose in part as a consequence of the partial re-regulation in 1987 which put a chill on new investment and shows up in the level of capital investments undertaken by CPR as indicated in Figure 3. The Rogers Pass project investment shows up in

[7] Productivity and Prices in the US Rail Industry: Experience from 1965 to 1995 and Prospects for the Future, Carl D Martland, MIT. Journal of the Transportation Research Forum, 1997.

FIGURE 3 : CPR Capital Investments 1987-2002



part in the years 1987 and 1988, and thereafter until 1995 investment is below the ongoing plant renewal requirement of some $450 to $550 million annually.

From 1995 onwards CPR has made and will continue to make catch-up investment which is focused to some extent on traditional railway technology, but has also made investments in new technologies with a view to innovation. Innovation has been increasingly recognized[8] as the key to technological progress which in turn is seen as the dominant driver of economic growth. As such, individual firms in many sectors now use innovative activities as one of the main instruments of competitive behaviour - recognizing that they lose out to the competition not because of price or because they built too much or too little capacity, but because they fail to develop new products, services or processes as quickly as their competitors.

Recent studies[9] support the view that the dramatic improvement in computing power and communication, and information technology, are the major force

[8] See for example the extensive research work of the Economic Growth Program of the Canadian Institute for Advanced Research.

[9] The Emerging Digital Economy, US Department of Commerce, 1998.

behind innovation and the higher productivity growth generally in the US. It is also worth noting that Canada ranked number two in 1997 in corporate R&D spending as a percent of sales[10].

The balance of this paper will therefore focus on developments at CPR both traditional and innovative directed towards generating future productivity.

2.1 Locomotives

A key productivity-enhancing program at CPR has been the very significant acquisition of new AC traction locomotives as detailed in Table 3 and the corresponding retiring of older portions of the fleet. CPR is the only railway in Canada to adopt AC technology and the locomotives are ideal for winter conditions and challenging geography.

TABLE 3	1995	1996	1997	1998	1999	2000	2001	Total
GE 4400 hp	83		90	92				
GM 4300 hp				12	49			
GM 6000 hp					4	8	8	
Total	**83**	**0**	**90**	**104**	**53**	**8**	**8**	**346**

AC traction motors employ micro-chip technology, are super-sensitive to wheel slippage, and deliver split-second commands that reduce or increase wheel rotation in response to traction. When no slippage is detected they deliver the optimum power required to maintain or increase speed without inducing wheel slip. As a result of these and other features, AC locomotives have a hauling capacity that on some trains is almost twice that of standard DC locomotives. The locomotive's dynamic braking system uses the traction motors instead of air brakes to control speed, helping to reduce in-train push-and-pull forces for safer train handling and smoother freight movement particularly over mountainous terrain. Economic benefits also arise from reduced maintenance while fuel consumption and greenhouse gas emissions will decrease by about 20 percent on a total fleet basis.

Another locomotive development at CPR is the commissioning and testing of a new electronically controlled pneumatic braking system. The traditional air brake systems with a single brake pipe down the length of a train to charge reservoirs and apply the brakes is being augmented by a hard wire down the

[10] Survey of Innovation in Industry, The Economist, February 1999.

length of the train. This wire is used to send an electronic signal to apply the brakes instead. The advantages of such a system include the following:

- the reservoirs can be charged continuously reducing the possibility of run-aways and providing for safer train operations;
- the increased speed of brake application reduces the stopping distance and provides for potential higher track speeds and increased line capacity;
- reduced slack action provides for maintenance savings on wheels and couplers;
- the ability to manage a graduated release provides potential fuel savings and also reduces the possibility of run-aways.

The simplicity of the system is also expected to reduce the skill level required for locomotive engineers and thereby reduce crew training costs. Overall economic benefits are currently being evaluated with the results anticipated within the next 6 to 12 months.

CPR has also been implementing a program of remote control of yard locomotives at the principal locations across the network. CPR uses locomotives modified with the Beltpack remote-control systems developed by CANAC. The Beltpack unit is different from other radio-based systems in that it is based on automatic speed control rather than the more typical throttle-and-brake control. Economic benefits from this program include reduced labour costs, reduced locomotive maintenance, as well as increased job enhancement and safety for yard employees.

2.2 Freight Cars

The benefits from a new generation of railcars used in bulk service can be seen from Table 4. The new technologies result in shorter, lighter cars with higher volume contents. More cars per train and higher trailing tonnages per train will result in a significant increase in annual capacity over the high density CPR route from western Canada to tidewater in BC.

Another development in freight car design is the cornerstone of a new intermodal service - Iron Highway. The Iron Highway concept was developed in 1986 in response to the AARs research program into high productivity trains, and a prototype was successfully tested in 1993.

TABLE 4 : Productivity improvements from new bulk railcar technology

	Coal Cars		Grain Cars	
	Current	Future	Current	Future
Length	58' 7"	53' 1"	59' 0"	55' 8"
Tare weight - tons	27.5	21.5	30.8	29.7
Content weight - tons	115.5	122.0	100.0	113.0
Gross weight on rail	143.0	143.5	130.8	142.7
Capacity - cu ft	4,100-4,760	>4,800	4,550	5,300
Outlet gates	rotary dump	rotary dump	4	3
Cars per train	114	120	112	120
Trailing tonnage per train	16,302	17,220	14,650	17,124
Annual capacity increase - tons		2.6 million		2.5 million

Designed to transport any truck trailer, including the over 90 percent of truck trailers that are not reinforced for rail service, characteristics of the short-haul service, which operates in partnership with trucking, include:

- freight cars that are actually continuous flexible-platform elements, eliminating the push-pull action of conventional couplers for better ride quality. Each 1,200' element made up of 40 articulating units divides into a unique split ramp configuration which provides two drive-on/drive-off surfaces. The capacity of each element is 20 53' trailers or up to 40 trailers of shorter length;
- line haul operations that are reliable, have average transit times comparable to truck transit times, use dedicated crews with preferred labour agreements, and provide a market-driven scheduled service with two train starts per day in each direction for a given city-pair. The current service between Montreal and Toronto with a transit time of under 8 hours permits equipment turn-around in 12 hours so that each train set makes two runs a day and this efficient asset utilization is important for the economics;
- terminal operations that use independent, dedicated, minimal-facility terminals close to markets and the highway system, and which use simplified operating procedures and hand-held computers that guarantee a 15 minute turnaround of tractor and driver. Hostler trucks can load or unload a full train in less than two hours; and
- information systems developed specifically for Iron Highway that permit the electronic transfer of all processing information between CPR and truckers. Full automation means that customers use a reservation system by Internet, phone or fax to guarantee a slot on a train, and shipment data

gathered by the system drives the efficiency of business and terminal procedures[11].

Iron Highway will expand into the Toronto-Detroit market soon and into other eastern short-haul markets in Canada and the US over the next few years.

Another intermodal innovation is the development of a 286,000 lb high-capacity double stack flat car for the movement of international containers to and from the Port of Montreal. In response to a 1994 CPR request, National Steel Car has designed and constructed a double stack car with greatly improved loading capability:

- capable of handling 20' marine containers in the top well;
- capable of handling four heavy marine containers of 55,500 lbs each; and
- able to safely allow for unrestricted loading - heavy container over light - through a car design stable at a centre of gravity up to 106".

It is anticipated that the high capacity double stack car will increase equipment utilization for CPR, and will address the needs of the Port Of Montreal for more double stack cars to ease congestion resulting from vessel discharge patterns and limited track and ground storage at terminals.

Furthermore, CPR has been a leader in introducing the first 53' reefer containers in North America in 1998 in order to satisfy trends in the grocery industry. These new units have improved insulation resulting in a substantial reduction in heat loss. Moreover, CPR is beginning to monitor the ride quality of multi-level flat cars in automotive service, using a device which continuously monitors the motion of the car and sends a signal via satellite to a recording centre whenever the motion exceeds pre-specified thresholds.

2.3 Infrastructure

CPR continues to make considerable capital investment in ongoing renewal of track and roadway infrastructure - of particular note is the replacement of jointed rail by continuous welded rail on the lengthy corridor from Moose Jaw to Chicago which will be completed over the next five years. Productivity enhancements of a more incremental nature include the following:

---

[11] CPR won the Best of Category award in Organizational Transformation for this pioneering work on data systems at the sixth annual Canadian Information Productivity Awards, 1998.

- better grades of steel are being tested on curves in mountainous terrain to improve wearability. Improved rail/tie fastening systems are also being installed on these curves to improve the strength of the track structure;
- computer systems are being replaced on track evaluation cars to upgrade their capabilities to measure track geometry and rail wear. In addition a new vehicle is being acquired in 1999, consisting of a gauge restraint measuring system, which will significantly improve the methods of measuring the strength of track structures and evaluating tie requirements;
- nine trackside wheel impact load detectors were installed across the CPR network in 1998 which measure the impacts of wheel anomalies and parallel the role of hot box detectors in improving rail safety;
- continued investment in high-rail vehicles and more productive work equipment will continue to control costs at a time when increased rail traffic results in pressure on available track blocks for scheduling track maintenance and renewal.

The Signals and Communications trackside infrastructure at CPR remains to a significant degree based upon physical track circuits and electro-mechanical technologies. Over the medium term it will migrate to an infrastructure based upon advanced communications and micro-processor based technologies. The first stage, currently under way, is the elimination of the aging pole line and transferring the services it carries to radio code line and electronic track circuits. The establishment of a fibre optics communications network stretching the length of the core railway will both facilitate this transfer and establish a platform upon which to launch future developments.

CPR is also engaged in significant intermodal terminal expansion. There are four major projects involving increased working trackage and more advanced lift technology with a combined capital investment of nearly $100 million:

- Vaughan terminal in Toronto underwent a major expansion in 1998 with capacity being increased by 60% to 225,000 handlings per year;
- Lachine terminal in Montreal is undergoing a two year expansion that will be completed in 1999.Capacity will be increased by 45% to 205,000 handlings a year;
- a new Calgary terminal was built on a greenfield site and completed in 1998 and with the transfer from the old to the new facility, capacity has increased to 105,000 handlings per year; and
- a new Vancouver terminal is being built on a greenfield site at Pitt Meadows and scheduled for completion in 1999. With the transfer from the

old Mayfair terminal to the new Pitt Meadows terminal, capacity will increase to 120,000 handlings per year.

2.4 Operations Planning

A significant new project at CPR is "Service Excellence" which will implement new business processes, operating systems and performance measurements in order to improve reliability of shipment delivery on a dock-to-dock basis, and improve asset utilization. This five year project with implementation beginning in 1999 and a capital budget of over $150 million will result in:

- the operation of the railway using an integrated operating plan;
- the management of shipments from end-to-end with integrated processes;
- a customer focus including aligned performance measures.

Major components of the project are as follows:

- an integrated operating plan: this will provide CPR with enhanced connectivity of linehaul and yard operations, shipments with a dock-to-dock trip plan, accurate arrival times available to customers, scheduled engineering work programs and mechanical repairs, and more flexibility for the Network Management Centre to respond to emergent situations. Anticipated benefits are the enabling of end-to-end shipment delivery with improved reliability, increased productivity of engineering and mechanical functions, and improved asset utilization;
- improved yard and terminal throughput: a new state-of-the-art yard management system is being developed for handling cars through classification yards. An advanced intermodal terminal system already in use by other railroads for managing intermodal terminal operations is being adapted for implementation at CPR in 1999. Improved yard management practices are also being implemented with a view to reducing overall car cycle times;
- end-to-end car and shipment management: an Integrated Transportation Management System (ITMS) will create trip plans for both loaded and empty cars with corresponding arrival times. New analytical tools will provide algorithmic blocking and classification and generate lowest cost routings for a given origin-destination pair. In addition, a new freight car equipment operating system will be purchased to optimize the use of these assets while reducing costs. These systems will be integrated with new Customer Order Management systems and the new yard management system to provide customers with improved shipment information.

These developments will be underpinned by information technology that recognizes that quality data is a valuable asset and that creates the necessary supporting databases, the data warehouse and software. The importance of performance measurement to improve customer satisfaction has also been recognized, and metrics are being developed at a variety of corporate levels to assist management and provide an ongoing scorecard for customers.

2.5 Electronic Commerce and Internal Business

The CPR Internet site (www.cpr.ca) was recently cited[12] for its ease of navigation, and its balance between providing reference and statistical information and offering an Internet service to customers. Highlights include:

- how to establish direct contact and obtain a freight rate;
- a transit schedule, similar to a shipping schedule, confirming when and where calls to intermodal terminals can be made;
- the ability to monitor equipment through an equipment tracing program;
- submission of bills of lading via EDI;
- secure access to customized fleet reports;

and the site also identifies a customer service team available 24 hours a day 365 days a year. CPR has recognized that electronic commerce is an important channel for future income growth, encouraging customer loyalty while enabling cost reductions. Efforts are continuing to embed elements of electronic commerce in functional areas of the railway and to improve the capture and analysis of data on customer choice.

Improved customer interfaces have also been augmented with significant improvements in internal business systems related to financial reporting. CPR has adopted the R/3 client/server business management software from SAP to improve its business processes and protect its computerized data through a key project called APEX (Applications and Processes for Enterprise Excellence). By mid 1999 CPR employees across all departments will be using SAP software to maintain the company's books of records, produce month and quarter-end financial reports, do budgeting, manage assets and access monthly management reports. In all SAP software will replace some 40 legacy systems and is anticipated to generate more than $30 million in annual cost savings.

[12] Containerisation International, February 1999.

CPR has also adopted Lotus Notes as the preferred means of internal communication and will be phasing out the legacy MERLIN system for many employees over the next year.

2.6 Labour Agreements

Lastly, it is not only in real assets and business technology that innovation has played a renewal role but also in human capital. CPR has negotiated innovative new labour agreements with its unionized workforce and is the first Class I railway in North America to implement incentive-based compensation (IBC) on a system-wide basis.

The purpose of IBC is to engage CPR employees in the business to improve financial performance to mutual benefit - productivity is enhanced by a knowledgeable, informed and involved workforce with a stake in the business - and specific goals include:

- improved customer satisfaction;
- reduced costs; and
- improved safety performance.

There are three principal types of IBC programs - profit sharing, gainsharing, and goal sharing - and gainsharing was chosen as the primary means at CPR. Gainsharing provides an opportunity for employees to share savings or increased revenues generated through increased productivity and is generally in addition to regular compensation. The rationale for gainsharing was as follows:

- from the management standpoint, it aligns goals from executive to front-line employee;
- from the union perspective, it offers a direct "line of sight" between affected employees and the improvement they intend to pursue.

The gainsharing provisions were negotiated jointly with the unions, with the collateral benefit of improved union-management relations. Four different gainsharing programs were negotiated in 1998 which resulted in an estimated $15 million in direct benefits to CPR, and by the end of 1999 it is anticipated that 75 percent of the unionized workforce at CPR will be covered by ICB.

As a final encouraging note on labour matters, CPR was fatality-free among its workforce for the first time in its 117-year corporate history in 1998.

Evaluation of the Economic Effects of Train Delays at Canadian National

Sacha Veillette, M.Sc., M.Eng., Atum Software Inc.
Brian Abbott, M. Eng., Canadian National Railway

I. Introduction

A better understanding of the economic implications of service disruptions in the railroad industry can lead to reduced operational costs and improved service. Although much is being done in the important areas of scheduling and dispatching, little effort has been put into understanding the overall network effects of unplanned disruptions. Operations managers occasionally tally delays due to certain major causes but seldom carefully evaluate the downstream effects of local disruptions. Furthermore, attempts at reducing train delays typically focus on on-line events. Related failures that occur in yards are often ignored. Such simplified analyses tend to under-value the actual disruptive effect of unplanned delays.

A new methodology, the "*Train Delay Economic Model*" (TDEM), has been developed at CN to quantify the impact of train delays. It is unique in a number of ways:

- It produces results which are corridor specific;
- It considers the "ripple" effect of a delay upon the balance of the network;
- It considers the economic impacts of revenue loss; and
- It makes use of actual historical train movement data in the formulation of estimates.

Section II of this paper outlines the conceptual framework of the TDEM and discusses the factors considered in the methodology. Section III refines this discussion by walking the reader through some examples of the analysis. The economic aspects of the TDEM, including some novel costing methodologies, are described in Section IV. Finally, Sections V and VI present some typical results and suggest some direction for future application of this methodology.

II. Conceptual Framework

A. Drivers of the Model

Until recently, CN employed a flat "per train-hour" figure to gauge the economic impact of delays to trains en route. While this approach proved somewhat useful in guiding operating and investment decisions, it was limited in four important aspects.

First, it took into account only direct costs attributed to the delayed train. Specifically, the straight time value of crew wages and equipment assets as well as idling fuel consumption were considered. Non-linear effects on costs were ignored in spite of the fact that recoverability may be affected by the duration of the delay.

Second, the network "ripple" effects of localized delay incidents were ignored. In fact, the impact of a delay incident may effectively "snowball" across a larger portion of the network as the duration of the delay increases.

Third, the flat "per train-hour" figure was determined using a global average for the entire network. It thus failed to account for differences in traffic densities and local abilities of the network to recover from the disruptions. In fact, downstream effects are heavily dependent on the local characteristics of the infrastructure as well as traffic patterns. An incident on a branch line will not have the same repercussions as one on the mainline. Similarly, the impact of delays may be greatly diminished on portions of the network with double tracks which provide greater operating flexibility.

Finally, the negative impact on revenues accruing from disruption to customer service was not considered. These shortcomings suggested that any new methodology should seek to establish a "cost function" instead of a single, average cost figure per hour of train delay. Experience with telecommunication network operations, which are in many ways similar to rail networks, also strongly suggested the need for a more refined approach.

B. Delay Categories

In taking a fresh look at the quantification of delay impacts, the TDEM categorized train delays in the following manner:

Primary Operating Delay ("Primary Delay") is a measure of the duration of an initial delay (on-line or in a yard) of a selected train. Primary Delays may result

from a host of primary events: equipment failure, locomotive failure, track failure, etc. The economic impact of Primary Delays stems predominantly from crew costs, idling fuel consumption and the incremental "stop/start" cost associated with braking and re-accelerating the train. Primary Delays also translate into disruptions of work blocks (track maintenance) and yard operations.

Incremental Operating Delay ("Incremental Delay") is a measure of the extra delay (or delays) occurring on the run of a train which is initially affected by a Primary Delay. Incremental delays stem from complications arising from time already lost. For instance, a "meet" (the encounter of two trains traveling in opposite directions) that occurs at a location other than the siding designated in the train's service design, results in incremental lost time. Similarly, long Primary Delays may necessitate downstream re-deployment of crews and / or switching assignments, resulting in a further degradation of the schedule. The economic impact of Incremental Delays includes crew costs, idling fuel consumption and "stop/start" costs associated with any unplanned (or extra) "meets". Incremental Delays also contribute to work block and yard disruption costs.

Delivery Delay is a measure of that portion of the lateness of the selected train at its final destination attributable to the primary event. Delivery Delay is used to estimate the incremental asset ownership costs which accrue from increased locomotive and equipment cycles as well as the revenue impact associated with an erosion of service levels.

Secondary Operating Delay ("Secondary Delay") accounts for the "ripple" impact of a Primary Delay on the balance of the network. It is a cumulative measure of the downstream delays to other trains on the network which occur as a result of a primary event. The impact of Secondary Delays is assumed to be limited to crew costs, idling fuel consumption, incremental "stop/start", work block disruption, and yard disruption. For simplicity, the asset ownership and revenue impacts associated with Secondary Delays are assumed to be negligible.

C. Use of Historical Data

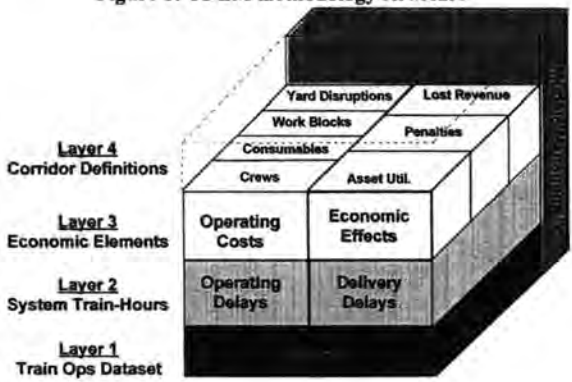
The interrelationship of the various categories of delay and their consequent impacts is obviously very complex. Rather than rely on conventional modeling or simulation techniques, the decision was made to draw upon readily available historical data.

The TDEM has been designed to project how the impact of a train delay of given type and duration may propagate through the network based upon statistical analyses of past incidents of a similar nature. It accomplishes this by sampling a statistically relevant set of events, systematically following the chain of causal events, and collating the data into reliable estimates. The end product is a series of matrices for each specific operating corridor which tabulate the average Secondary, Incremental and Delivery Delays corresponding to Primary Delays of varying duration and causes.

D. Building Block Approach

To allow for increased flexibility in developing the TDEM methodology, a "building block" approach was employed. Figure 1 provides an overall picture of the model in its current form. The advantage of such a structure is that, provided the proper linkages are in place, each 'block' can be developed and managed separately. Also, components may be added at any time to enhance the model's level of sophistication.

Figure 1: TDEM methodology structure



Layer 1 represents CN's actual train movement history. This data is stored in real time in CN's "*Service Reliability Strategy*" system, a state-of-the-art traffic flow management and reporting system, and subsequently uploaded into a "Data Warehouse". The "Data Warehouse" is a large database with extensive report generation capabilities.

Layer 2 comprises the analytical algorithms that utilize data from the "Data Warehouse" to identify and quantify delays of the various categories associated with a given primary event. This information is then coupled to economic data from Layer 3 to generate train delay cost functions. The third layer includes both direct or operating cost components derived from conventional railway costing methodologies and a revenue impact "block".

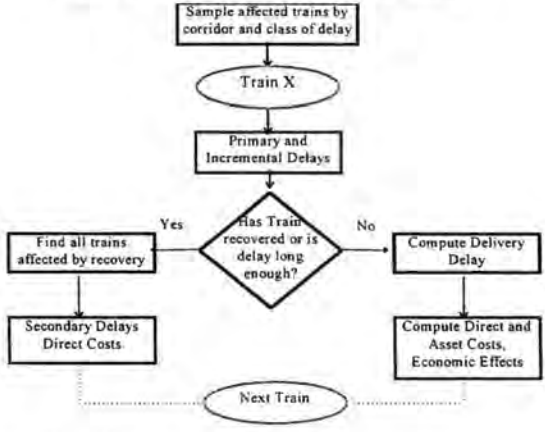
Layer 4 accounts for differences both in the operating characteristics of the network and in traffic mix. It allows the new cost functions to be made locally relevant and accurate.

III. Operational Framework

A. Main Algorithm

Figure 2 presents the TDEM algorithm in its general form, including the types of economic factors that will eventually be assigned to the compiled values.

Figure 2: Simplified main TDEM algorithm



The analysis follows the following sequence:

1. A class of primary events on a specific corridor (e.g., a locomotive failure on the Edmonton-Vancouver corridor), is selected for analysis.

2. A sample of train movement histories is drawn from the "Data Warehouse" and appropriate Primary Delays are flagged.

3. After identifying the Primary Delays incurred by a given train (Train X), we ascribe applicable Incremental Delays and consider whether the train recovered the lost time by its final destination.

4. If Train X has recovered some or all of the lost time, or if the Primary Delay exceeds 60 minutes, then all other trains affected by Train X are identified and their respective delays compiled as Secondary Delays. The number of trains affected by unplanned "meets" is also ascertained.

   It is assumed that recovery occurs at the expense of other trains or operations. As maximum operating speeds are regulated, the only way real time can be made up in a schedule is if "meets" or other conflicting activities are eliminated. If, for example, an opposing train is made to wait in a siding instead of Train X; ten or more minutes may be gained back. Notwithstanding any failure of Train X to recover, experience has shown that the network impact of a Primary Delay exceeding 60 minutes is sufficient to warrant an examination of Secondary Delays. Trains with Primary Delays less than 60 minutes which have not recovered are assumed not to have affected other trains during the balance of their runs.

5. Finally, Train X's Delivery Delay and its relevant economic factors are compiled along with the total Primary Delay and associated costs.

B. From Data to Information

1. Queries

As indicated earlier, the data for the implementation of the TDEM is drawn from CN's "Data Warehouse". The main parameters used to specify delay information comprise "delay codes" and "comments". Although any subset of train delay events could be selected for analysis, the general application of the TDEM uses six classes of delay:

- Power (locomotive problems)
- Equipment (mechanical failures other than locomotives)
- Engineering (fixed plant failures)
- Crews (train crews issues)
- Yards (switching problems, scheduling changes, etc.)
- Accidents

For each singular delay event considered, a complete and detailed description of the train's movement is obtained. This information is used in turn to query the Data Warehouse again looking for any and all references in other train movement histories to the train initially delayed. It then becomes possible to reconstruct the event and its downstream effects.

2. Primary Delays

To better illustrate the functioning of the methodology, we will follow an example through the main steps in the analysis. We begin with a train delay, sampled from the database, with the following basic characteristics (see Table 1):

Table 1: Example of a train delay event's main characteristics

Train ID	Delay Duration	Time of Event	From Station	To Station
X	30 minutes	13:20	E	F

A 30 minute delay occurred to Train X at 13:20, between Stations "E" and "F".

The Primary Delay for this train is thus 30 minutes. Note that the TDEM neglects Primary Delays of less than 10 minutes as it is assumed that scheduling buffers and normal operating practices can easily mitigate the impacts of such minor events.

3. Incremental Delays

To pursue the analysis further, the complete train history for Train X must be extracted. Table 2 provides the data needed to continue our example:

Table 2: Example of a train history for Train X

Station	Scheduled	Actual
A	10:00	10:15
B	10:30	10:45
C	11:00	11:25
D	12:00	12:20
E	13:00	13:15
F	13:30	14:15
G	14:45	15:30
H	16:00	16:40
I	17:15	18:00

Using this information we can compute a series of lateness parameters for this train run.

Table 3: Lateness parameters calculated for Train X

Parameters	Value	Notes
Departure Late	**+15**	Departure from origin (Station "A") 15 minutes behind schedule ("positive lateness").
Incident Late	**+15**	Lateness at the station immediately before the primary incident. In this case, the lateness at Station "E".
Limiting Late	**+45**	Maximum lateness following the primary incident, but prior to either another reported train delay or the start of recovery. In this case, the lateness at Stations "F" and "G", before some recovery occurred (between Stations "G" and "H").
Arrival Late	**+45**	Arrival at destination (Station "I") 45 minutes behind schedule after having lost some more time between Stations "H" and "I".

The Limiting Late parameter serves to define whether there are Incremental Delays to consider. The Incremental Delay can be defined as

Incremental Delay = Limiting Late - Incident Late - Primary Delay

In the case of Train X, we calculate **Incremental Delay = 0** as no additional time was lost before some recovery occurred between Stations "G" and "H".

4. Delivery Delays

Determining the Delivery Delay associated with a given primary incident is a challenge. In simple terms, we are seeking to estimate the portion of the Primary and Incremental Delays which remains at the final destination. However, in practice, this is difficult using historical movement records. In following the sequence of a train's movement, it is impossible to determine with certainty whether a given primary incident is solely responsible for the entire lateness of that train at its final destination. The TDEM deals with this problem by making a few simplifying assumptions.

If the train is late at arrival and has not recovered any of its lost time, then the Delivery Delay is deemed equal to the sum of the Primary and Incremental Delays.

IF **Arrival Late** $\geq$ **Limiting Late**
THEN **Delivery Delay = Primary Delay + Incremental Delay**

If, on the other hand, the train has recovered either partially or completely then the Delivery Delay is deemed to be nil.

IF **Arrival Late** < **Limiting Late**
THEN **Delivery Delay = 0**

In the former case, the impact of the Primary Delay on the Delivery Delay may tend to be over-estimated as some recovery may have occurred but subsequently been off-set by other minor delays on the balance of the train's run. Conversely, in the latter case the impact of the Primary Delay tends to be under-estimated as the recovery of lost time will not have been complete in most cases. Over the entire set of trains sampled it is assumed that these effects balance out.

In our example, Train X is said to have **Delivery Delay = 30 minutes**. Note that the values of the Delivery Delay and Arrival Late parameters will generally differ.

5. Secondary Delays

Secondary Delays attributed to Train X are assessed by searching the Data Warehouse for the delay records of other trains which cite interaction with Train X as a factor in their own problem maintaining the schedule.

Table 4: Example of secondary events for train X

Train ID	Delay Duration	Comment
R	22	Met Trains X and Y
S	5	Met Train X
T	45	Met Trains W, Z and wait connection Train X

We readily note that the data also contains references to trains other than train X. Two aspects must be addressed: the amount of time reported and the number of trains mentioned in the description of the secondary event. For the purposes of determining Secondary Delay, the number of trains is, in fact, a weighted count based on the circumstances indicated in the comment field. Table 5 gives the rules applied to obtain the weighted train count.

Table 5: Some typical situations in comment fields

Comment	Weighted train count
Meet	1
Work Block (track maintenance)	2
Wait	1
Crew, Power	2

Once the weighted train count has been determined, calculating the amount of time that can be attributed as a Secondary Delay is straightforward. We simply take the reported delay duration and divide it by the weighted train count.

Secondary Delay = Delay Duration ÷ Weighted Train Count

Glancing back at Table 4, we can evaluate the Secondary Delays to attribute to Train X (see Table 6):

Table 6: Calculated parameters of Train X's secondary events

Train ID	Weighted Train Count	Attributed Secondary Delay
R	**2**	**11**
S	**1**	**5**
T	**3**	**15**

6. Unplanned Meets

A "meet" occurs when a train must divert into a siding to make way for an opposing movement. As well as creating time delays, "meets" necessitate stopping and starting. Consequently, to complete an assessment of the operating impact associated with a secondary event, it is necessary to quantify the number of unplanned "meets" (i.e., those "meets" which would not have occurred had the train operated in accordance with its designed schedule).

Observation of train histories and estimates based on operating experience have allowed us to develop a simple method for assigning an unplanned "meet" occurrence to a secondary event. If the weighted train count mentioned in the comments field of the Secondary Delay is three or less and the attributed Secondary Delay is at least fifteen minutes, then the "meet" is deemed to be unplanned. If the weighted train count is greater than three, then there must be an attributed Secondary Delay of greater than twenty-five minutes in order for the "meet" to be deemed unplanned. Symbolically:

IF (**# trains** $\leq$ **3** AND **attributed Secondary Delay** $\geq$ **15**)
THEN **unplanned meet = 1**

ELSE IF (**# trains** > **3** AND **attributed Secondary Delay** $\geq$ **25**)
THEN **unplanned meet = 1**

ELSE **unplanned meet = 0**

Referring back to our Train X example (Table 4 and the compiled parameters of Table 6), we would evaluate that there was only one instance of an unplanned "meet". Train T has 3 trains mentioned and an attributed delay of 15 minutes.

IV. Economic Framework

In the preceding section we saw how the TDEM attempts to reconstruct the chain of events beginning at a primary incident and working through its downstream consequences. It remains to assign relevant costs to this operational picture. The TDEM draws upon conventional costing methodology to estimate the direct costs associated with asset utilization and the consumption of fuel due to idling. Its treatment of other related delay costs represents a clear departure from past practice.

A. Idling and Stop & Go Fuel Costs

The cost of idling is applied linearly to Primary, Incremental and Secondary Delays.

Idling Cost = (Primary + Incremental + Secondary) x Fuel Cost

Railroad studies have demonstrated that expenses associated with stopping and re-accelerating a train can be greater than the traditionally considered idling costs. The TDEM incorporates "stop & go" costs in the following way:

Stop & Go Cost = Avg. Fuel Cost of Stop & Go * (1 + Unplanned Meets)

B. Asset Ownership Costs

Asset ownership cost, a weighted average ownership cost of both freight cars and locomotives, is applied linearly to the Delivery Delay. Mathematically, we have:

Asset Cost = Delivery Delay x Avg. Ownership Cost

C. Train Crew Costs

Traditional approaches to quantifying delay impacts calculated crew salaries on a straight time basis. While attractive in its simplicity, this assumption failed to account for very important aspects of train operations: existing regulations and collective agreements which govern running trades employees.

The nature of running trades agreements invalidates the use of straight time values since crews are not paid by the time spent running a train. That notwithstanding, there is an absolute limit to the amount of time that a crew can spend controlling a train before they have to rest. This means that although a delay en route does not have a straight time value due to wages, it may trigger the need for an extra crew to be called in order to complete a train run. The TDEM addresses this on a corridor-specific basis using the following step function designed to account for the trigger as well as the probability, determined from operational experience, that an extra crew will indeed be necessary:

IF **Primary Delay** $\geq$ **Trigger** THEN **Crew Cost = Avg. Crew Cost x P(extra)**
ELSE **Crew Cost = 0**

D. Yard and Work Block Disruption Costs

Train delays have a significant disruptive impact on many aspects of railroading beyond mainline train operation. Yard switching assignments, inspection duties, and infrastructure maintenance activities are all forced to adjust in the face of a broken train schedule. The TDEM considers two of these: work block and yard switching.

Yard switching disruption costs stem from the need for extra crews (or overtime) to inspect and/or marshal traffic off of delayed trains. Also, switching efficiency inevitably suffers when a yard becomes congested as a result of on-line delays. Work block impacts arise when pre-scheduled maintenance "windows" fail to materialize in a disrupted traffic grid. Maintenance productivity plummets and entire shifts may be lost as crews stand idle waiting for an opportunity to occupy the track.

The values of these two types of disruptions are computed by using payroll and work reporting systems and linking them to delay statistics. The experience of

yard operations managers also plays a key role in assessing the amounts attributable to train delays. The cost factors entering the calculations are limited to wages (overtime for yards, lost time for work blocks) and further discounted to account only for those disruptions that must be recovered and not situations where the work may be dropped altogether. In a simplified way,

Yard Cost = (Primary + Incremental + Secondary)
x Avg. Cost of Yard Disruption

Work Block Cost = (Primary + Incremental + Secondary)
x Avg. Value of Time Lost due to Delays

E. Revenue Impact Assessment

Although many of the cost aspects described above constitute a significant departure from past practices, it is in its treatment of revenue impact that the TDEM is truly unique.

The TDEM utilizes a threshold Delivery Delay in attributing revenue loss to a given primary event. Thresholds are established by considering the weighted average of the traffic types on a specific corridor as well as an estimate of the amount of Delivery Delay needed for a connection to be missed. A missed connection is assumed to result in an actual day lost in spotting the shipment at the customer's designated location.

On the revenue side, a summary analysis of the various markets served by CN yields an assessment of the relative sensitivity of each type of customer to a disruption in service. Such assessments are made for each type of commodity / business served on a corridor-specific basis. This information, in turn, is translated into an estimate of the number of one-day delivery disruptions before revenue begins to be adversely affected. The economic effect is evaluated by assuming that a certain percentage of a particular type of business is lost. CN's projected loss, the figure included in the TDEM, is actually based upon average contribution as opposed to full revenue.

V. Results

As initially postulated, results generated by the TDEM show that the impact of train delays is strongly dependent upon the nature and location of the primary incident. Moreover, secondary effects and Delivery Delays vary according to

the actual duration of the Primary Delay as well as the nature and location of the actual delay events. Table 7 illustrates typical results from one corridor.

Table 7: Sample of operational results from the TDEM

Type of Primary Event Analyzed	Interval of Primary Delay Duration	Avg. of Primary + Incremental Delays	Average Secondary Delay as % of Primary	Average Delivery Delay as % of Primary
Equipment	10 to 30 min.	56.5 min.	54%	238%
	31 to 60 min.	46.3 min.	14%	74%
	61 to 120 min.	87.6 min.	24%	84%
	121 to 240 min.	168.3 min.	22%	92%
	> 240 min.	736.9 min.	1%	100%
Power	10 to 30 min.	19.0	9%	70%
	31 to 60 min.	48.5	14%	84%
	61 to 120 min.	99.9	13%	78%
	121 to 240 min.	176.6	5%	93%
	> 240 min.	904.9	3%	97%

Table 8: Sample of economic results per train delayed

Type of Primary Event Analyzed	Interval of Primary Delay Duration	Fuel, Crews and Assets cost figures	Work block and yard disruptions	Revenue effect of service disruption
Equipment	10 to 30 min.	60%	50%	420%
	31 to 60 min.	50%	40%	340%
	61 to 120 min.	100%	80%	650%
	121 to 240 min.	430%	140%	1,250%
	> 241 min.	1,210%	630%	5,460%
Power	10 to 30 min.	30%	20%	140%
	31 to 60 min.	60%	40%	360%
	61 to 120 min.	100%	90%	740%
	121 to 240 min.	440%	150%	1,310%
	> 241 min.	1,180%	780%	6,700%

Note: Results expressed as percentage of CN's previously employed flat per hour rate.

It should be noted that relative results at this level of detail can only be obtained by sampling large populations of delay events. The intervals of duration used in compiling the results have been selected to reflect meaningful operational time

windows. They are also broad enough to help ensure statistically significant sets of samples are present.

The final step of the TDEM ascribes economic values to the operational data. Typical values from one corridor are shown in Table 8. Results are presented here in terms relative to the flat "per train-hour" rate that was previously used at CN. The inclusion of more relevant and accurate cost parameters has led to much larger overall impact values. Even at the lower range of delay duration, the results of operational disruptions are already on par and often greater than the old estimates.

VI. Conclusion

The TDEM demonstrates the feasibility of utilizing historical train movement data to develop estimates of train delay cost which more closely reflect the actual behavior of a network than conventional linear models. Although the TDEM was designed specifically to be used in conjunction with CN's information systems, the principles it embodies are general. The methodology yields valuable information for the management of operations and the planning of investments.

Currently, the TDEM is being used only to generate "rule-of-thumb" delay costs on specific corridors. The obvious next step will be to develop an automated mechanism by which the model can be used frequently to cost delays and observe changes in operational sensitivity over time, or to assess specific proposals on the basis of both the location and the type of disruptions affected.

Other potential enhancements to the methodology being contemplated comprise the inclusion of tool and machinery costs in Work Block disruptions and refinements in the characterization of downstream effects. Also, the overall process of recovery, by which we mean the re-scheduling and exception management that goes into bringing the network back into a smooth traffic flow, has not yet been assessed.

Acknowledgments

The authors are indebted to Ms. Tanaquil Chantrill for her work on the methodology and its detailed documentation over the summer months of 1998. S. Veillette would also like to thank Ms. Saskia Roukema who brought her vast experience of transportation to bear in editing a first draft of this paper.

"GRAIN TRANSPORTATION BY TRUCK: CHANGES AND OUTLOOKS FOR WESTERN CANADA – 1997/98"

by

Rene Kehoe, Transport Canada, Ottawa and
Lloyd Ash, Trimac Consulting Services, Calgary

(The views expressed are those of the author and do not necessarily represent the views of Transport Canada.)

Introduction

Recently, Transport Canada's Motor Carrier Policy Branch commissioned Trimac Consulting Services to conduct two studies on grain trucking in Western Canada. Prior to this work, it was generally believed that grain trucking activity was increasing. The studies sought to develop quantitative empirical evidence to test this notion and also address the need for more specific information on the characteristics and scope of trucking activity to better understand the current situation.

The 1997 study, ***Review of Grain Transportation by Truck in Western Canada,*** [1] demonstrated how recent increases in grain transportation by truck were found to accompany the adjustment of the prairie grain industry to significant change including:

- elimination of rail transportation subsidies for moving grain,
- consolidation of grain elevator and rail branchline services, and
- expansion of secondary processing of grain into other products.

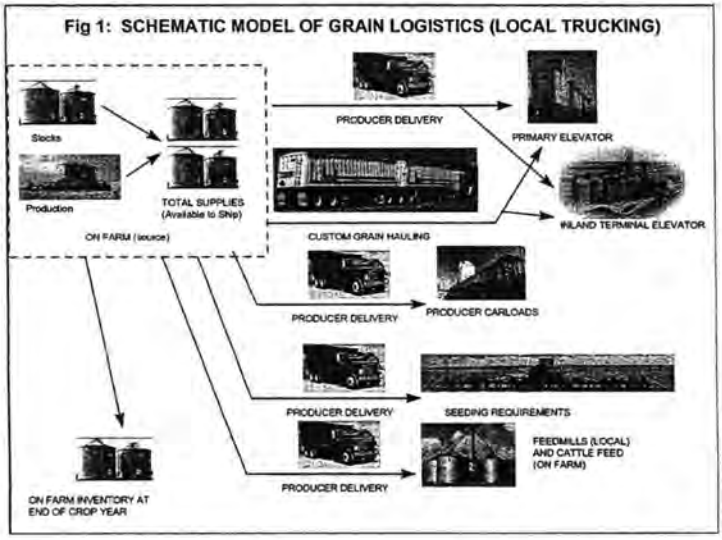
As follow up, the recently completed ***Study of Grain Transportation Changes and Outlooks for Western Canada – 1998*** [2] examines the extent and nature of grain-related agricultural processing in Western Canada and quantifies the expected trucking impacts of specific activities. The report describes trucking-related activities in terms of the underlying business segments being served. In this way, factors which give rise to changes in the trucking sector (elevator consolidation, change of vehicle configuration, length of haul, etc.) can be better understood and related to their constituent sectors. Key sectors investigated include milling and oilseed crushing, alcohol distilling, the malting of barley, animal feeding and meat processing, potatoes and other agro-industrial activities.

Grain Trucking Activity Segments

The following exhibits (Figures 1 and 2) show the principal grain transportation segments in Western Canada in terms of:

- Local Grain Trucking
- Grain Trucking Over Intermediate Distances
- Rail Movements to Export Locations and Markets Outside of Western Canada / the U.S. Midwest

These exhibits do not include the longer distance trucking of grains, which was found to be minimal in comparison to use of rail. They also do not show the significant trucking activity represented by the trucking of products from grain processing locations in Western Canada, discussed later.



As illustrated above, "Local Grain Trucking" encompasses the movement of grain over relatively short distances such as "from field to bins", "to fields for seeding", "from farms to other local farms, feedmills, feedlots", "to rail sidings for loading producer cars" and "from farms to primary and/or inland terminal elevator positions."

Intermediate distance (under 800 kilometers) grain trucking activities arise when

movements are less tied to "individual farms" and are oriented toward longer distance movement to various processing facilities and terminal elevators throughout western Canada and the U.S. Midwest. As distance increases beyond 800 kms, orientation of bulk grain movements toward rail is still very strong and trucking was found to make up an insignificant portion of the movements. These logistics patterns are illustrated in following Figure 2.

Fig 2: SCHEMATIC MODEL OF GRAIN LOGISTICS (INTERMEDIATE TRUCKING AND LONG DISTANCE RAIL)

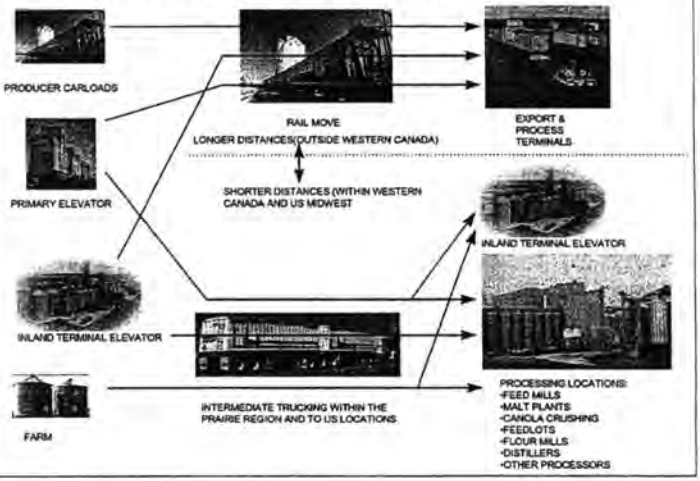


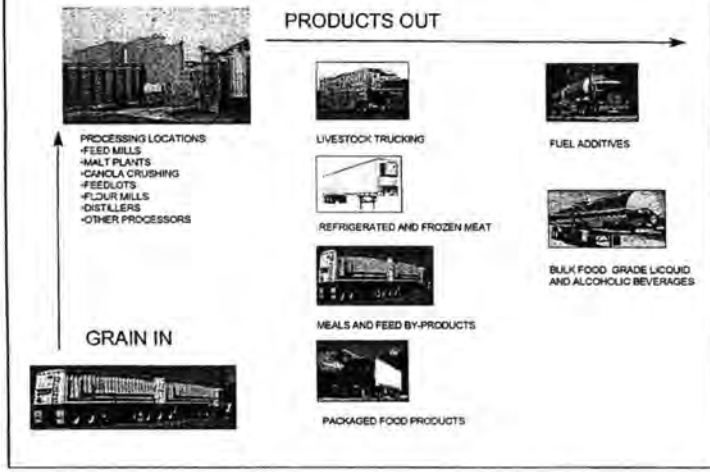
Figure 3 illustrates how secondary grain processing activities give rise to significant "derived" trucking movements that are not strictly "grain trucking". Thus, in addition to the movement of grain feedstocks into the processing facilities – often by truck – we find significant trucking movements of:

- livestock and hogs
- meat products
- meals and feed by-products
- packaged foodstuffs, including oils,
- fuel additives, and
- alcoholic beverages

In this framework, Western Canadian industrial value added processing results in a transportation shift from rail to truck. There is a shift from moving export grain to tidewater (principally a rail movement) to trucking grain inputs to

regional agricultural processing businesses and to trucking the production to markets.

Fig 3: GRAIN DERIVED TRUCKING ACTIVITIES



Following sections further describe our findings about the local and intermediate trucking activity segments.

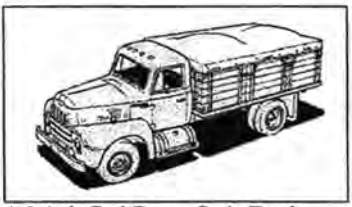
Local Grain Trucking

As noted previously, grain is generally transported as a "local trucking movement" in the vicinity of the farm where it is produced, at least one time and very often, twice. At harvest time, unless it is "directly sold" at that time by the producer, grain will be moved from the combine harvester in the field to the farmer's bins. Subsequently, it may be delivered to a local elevator, a feedlot, a seed cleaning plant, or some other local place of disposition.

About 95% of grain hauling that originates from farms in 1995-96 was done in producer owned trucks. The remaining 5% is trucked commercially from farms, usually to a longer distance destination such as an inland grain terminal or a regional grain processing facility. "On farm commercial pick-ups" are expected by the grain trading and handling companies to grow. To gain a "marketing edge", several of these companies are involved in promoting and

arranging such trucking, as a service option for their clients.

Increasing hauling distances and larger farms have resulted in a decline in the number of two-axle end dump farm trucks from about 75% to roughly 60 % of the producer owned truck fleet. Greater grain volumes per producer and longer distances result in a significant economic advantage to a 3 axle (rear tandem axle) end dump grain truck. As a result, the "tandem" unit has



A 2 Axle End-Dump Grain Truck



A Tandem Axle (3 Axle) Grain Truck

increased to the point where it represents approximately 25 % of the producer owned fleet. Five axle tractor trailer combinations number roughly 10 % of the fleet. This leaves a small market percentage represented by producers with even larger 7 and 8 axle "train" configurations.

In 1995-96, local trucking of grains is estimated to have totaled about 3.4 million loads and represented about 1.1 billion tonne-km. Figures from Agriculture Canada and other sources estimate the average hauling distance for a producer owned truck at 26 kilometers (one way). If one assumes that round trip distance equals 2 times the average one way haul, local trucking of grains amounts to a composite of 176 million kilometers traveled by trucks on primary, secondary and local roads. The average producer hauls grain for a distance of approximately 1500 kilometers per year and has one truck – the utilization levels for the farmer-owned fleet in Western Canada being very low in comparison to commercial trucks.

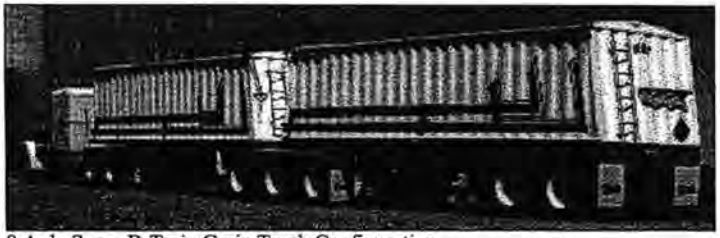
Industry observers are forecasting a sharp increase in the use of commercial truckers to move grain from farms in coming years. This trend will be promoted as the relatively low utilization of farmer trucks can result in a cost for trucking that is higher than hiring a commercial truck to do the same job.

Intermediate Trucking of Grain

Grain shipments trucked less than 800 km within the prairie region are steadily

increasing. Larger combination trucks, on a for-hire basis, are the principal carriers. The shipments originate at farms, primary elevators and inland terminals. Destinations for these trucking movements include inland terminals and a variety of processing locations including large commercial feedlots, feed mills, flour mills, canola crushers, etc.

According to the grain trucking industry, the most popular commercial grain trucking configuration is represented by the 8 Axle Super B-Train Configuration (85% of units operated), followed by the 6 Axle Tridem semi-trailer (5%) and 5 Axle Tandem semi-trailer (3%).



8 Axle Super B-Train Grain Truck Configuration

The total size of the intermediate grain trucking sector was difficult to quantify for a variety of reasons. A highly competitive environment made carriers, shippers and consignees reluctant to share business volume data. Isolation of grain related trucking activity from provincial data sources was often impossible because many carriers haul a combination of grain and other commodities, especially fertilizers. In addition, the sampling size from weigh scale surveys is very small when disaggregated to a commodity such as grain. Despite these obstacles, the size of the intermediate grain trucking sector was estimated reliably in our two studies using independent approaches.

The "Top Down" Approach

The 1997 study [1] subtracted the identified rail exports to terminal position from over-all provincial grain production and on- farm disposition statistics published by the Canadian Grain Commission. The "balance remaining" of the grain volumes was then deemed to represent 166,000 domestic truckloads (Super - B train configuration) of activity as well as 36,000 international truckloads (a mix of tridem and tandem semi trailer loads). The domestic payload averaged 43 tonnes compared to international payloads of 28 tonnes. Annual utilization of tractor units hauling grain commercially was estimated to be 120,000 miles, of which approximately 73% were estimated to be loaded. Of the loaded mileage,

approximately 50% was hauling grain and 50% was hauling other products such as fertilizer. Rate levels for trucking grain tend to dictate that significant backhauling of other products takes place over intermediate distances.

The size of the intermediate grain trucking sector was estimated at 8.1 million metric tonnes, or roughly 17% of total grain supplies. Domestically, this represents approximately 3.5 billion tonne kilometers as well as a further 500 million tonne kilometers hauled to U.S. destinations.

The "Bottom Up" Approach

While the estimate cited in the 1997 study [1] was deemed to be credible when discussed with various senior transportation officials in grain companies, the subsequent study [2] attempted to shed further light on the grain trucking sector by reviewing the truck inflows to the major processing sectors in Western Canada and develop an activity estimate by "summing them up".

Current activity, estimated using this methodology, amounted to approximately 195,000 Super B Train equivalents, a number which agrees reasonably well in magnitude with the previous year's estimate of 166,000 Super B Train loads moving domestically in Western Canada.

In addition to looking at the grain trucking activity (the facility inbounds), the study also reviewed the outbound transportation from these facilities with a view to understanding the extent and nature of trucking for the important "non grain" products produced at grain processing facilities, as previously introduced in Figure 3.

As well as considering grain based agricultural trucking, the study further investigated movements of potatoes (primarily in southern Manitoba and southern Alberta), a sector that has grown based on recent increases in irrigated acreage production. Another new "grain related" trucking activity is the use of straw as fiber for making panel products at newly opened strawboard facilities in Alberta and Manitoba.

Current activity levels, together with known increases in activity, were explored, by means of a "shipper survey" and a literature review of industry and trade publications.

In this way, significant trucking activity that is directly associated with agricultural processing in Western Canada, was identified. The 1998 study report [2] "maps" the trucking activity to specific processing facility locations throughout Western Canada. This locational information could be of

significant value to highway planners and other interested parties for truck traffic estimation and projection purposes. Because of size constraints, the mapped information will not be presented in this paper.

The following processing activity sectors in Western Canada were studied:

- Flour mills, Durum Milling, Oat Processing and Specialty Mills
- Oilseed Crushing Plants
- Gasahol Fractionating Plants
- Distilleries
- Malting Plants
- Potato Processing (Chips, French Fries, and Other Frozen Products)
- Strawboard Plants
- Cattle Feedlots and Hog Barns
- Beef Packing and Pork Processing Plants

On the next page, Figure 4 provides a global overview of the identified current and near term grain related transportation flows that were determined by the study.

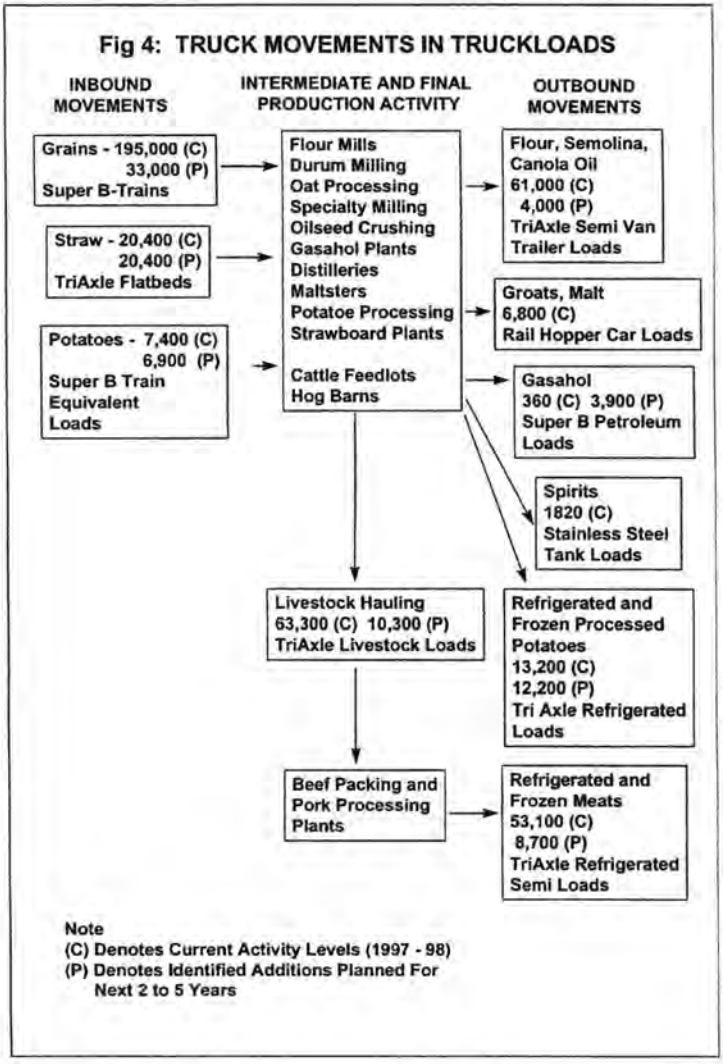
Conclusion

Changes to the export rail costs and consolidation of low volume uneconomic rail branchline and country elevator locations have been extensively discussed in terms of increased truck hauling distances. While significant consolidation of the network has occurred and is occurring, these local trucking effects are perhaps less significant than what has occurred in the intermediate (under 800 km) distance range. There has been a recent significant shift in grain logistics for the agro-processing and related industries in Western Canada. Growth of this sector has, in turn, driven significant growth in all trucking activity related to grain and the "derived products".

REFERENCES:

1 Trimac Consulting Services, "Review of Grain Transportation By Truck in Western Canada", prepared for Transport Canada , 1997

2 Trimac Consulting Services, "Study of Grain Transportation Changes and Outlooks for Western Canada", prepared for Transport Canada , 1998


Fig 4: TRUCK MOVEMENTS IN TRUCKLOADS
INBOUND MOVEMENTS
INTERMEDIATE AND FINAL PRODUCTION ACTIVITY
OUTBOUND MOVEMENTS
Grains - 195,000 (C)
33,000 (P)
Super B-Trains
Straw - 20,400 (C)
20,400 (P)
TriAxle Flatbeds
Potatoes - 7,400 (C)
6,900 (P)
Super B Train
Equivalent
Loads
Flour Mills
Durum Milling
Oat Processing
Specialty Milling
Oilseed Crushing
Gasahol Plants
Distilleries
Maltsters
Potatoe Processing
Strawboard Plants
Cattle Feedlots
Hog Barns
Flour, Semolina,
Canola Oil
61,000 (C)
4,000 (P)
TriAxle Semi Van
Trailer Loads
Groats, Malt
6,800 (C)
Rail Hopper Car Loads
Gasahol
360 (C) 3,900 (P)
Super B Petroleum
Loads
Spirits
1820 (C)
Stainless Steel
Tank Loads
Livestock Hauling
63,300 (C) 10,300 (P)
TriAxle Livestock Loads
Refrigerated and
Frozen Processed
Potatoes
13,200 (C)
12,200 (P)
Tri Axle Refrigerated
Loads
Beef Packing and
Pork Processing
Plants
Refrigerated and
Frozen Meats
53,100 (C)
8,700 (P)
TriAxle Refrigerated
Semi Loads
Note
(C) Denotes Current Activity Levels (1997 - 98)
(P) Denotes Identified Additions Planned For
Next 2 to 5 Years

MANITOBA'S MARINE CONTAINER TRAFFIC: TRENDS AND DEVELOPMENTS IN THE 1990s

Michael Butt and Jill Ogston
University of Manitoba Transport Institute

ABSTRACT *Marine container (MC) usage is growing in the 1990s due to a variety of factors including: multinational trade agreements, expanding overseas markets, and the implementation of new technologies. Understanding how many of these developments are transforming Manitoba's markets thereby increasing marine container commodity flows, is important for strengthening our business in the global marketplace, and creating a new competitive advantage. It also provides considerable insight into the new geographic influences that will likely shape our cultural, and economic life in the decades ahead. By examining Manitoba's marine container traffic flows and volumes in the 1990s this paper identifies several problems in container logistics.*

INTRODUCTION

Although containers have their origins in the 1950s, only since the 1980s has rapid growth in container traffic become a worldwide phenomenon. Growth in container traffic is largely the result of multinational trade agreements like NAFTA, furthermore it is evidence of growing distances to markets, and reflects increased competition in the global economy. As a major exporting nation Canada has benefitted from many of these developments.

Manitoba has also benefitted by increased export trade. Provincial exports to the United States have climbed consecutively during the 1990s; by 1997 they totaled $5.3 billion annually. Since 1990, provincial exports to those states along the Mid-Continent International Trade Corridor has increased three-fold to more than $2.1 billion per annum.[1] Similarly, trade with Mexico, although substantially smaller in terms of total export volumes, has increased five-fold since 1990 (exports to Mexico climbed from $13 million in 1990 to $87 million in 1997). Increasingly, many of the commodities leaving and entering the province arrive and are sent via

container.

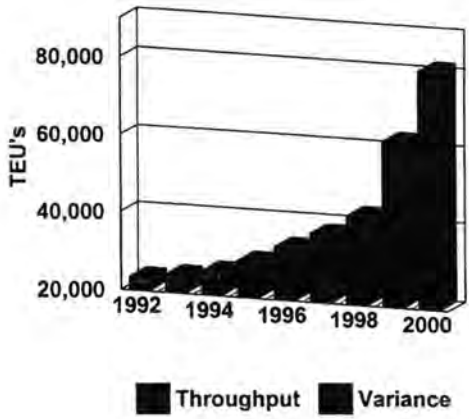
Within the world of container traffic, MC shipments are on the rise. Their networks are also constantly reinventing themselves, as market forces, government policies, geographic and infrastructure rigidities establish channels through which marine containers flow. The result is that certain cities, countries and regions throughout the globe face constant problems of resupply, while other points in the global network have oversupply. For instance, Europe serves as a case in point. In the European Economic Community inland patterns of marine container movements have changed dramatically in the 1990s. They now total about 25 million TEUs per annum shifting between ports and their hinterlands, but increasingly most of their annual 'internal' movements are north bound (in the neighbourhood of 70 to 80 percent).[2] The result of traffic flow imbalances means that resupply costs substantially more on an individual container basis at certain points in the network.

The following study sketches the contours of Manitoba's marine container traffic and their characteristic patterns in the 1990s. It begins with a brief overview of Manitoba's general traffic volumes and then turns to examine commodity import and export flows through Vancouver, Montreal, and Halifax, Canada's principle traffic lanes, as well as through the US. After highlighting some of the principle features of these lanes, this paper identifies some of the main concerns with Manitoba's existing marine container market. The paper concludes that Manitoba's marine container traffic will undoubtably grow in importance over the next decade as Manitobans pursue new opportunities and expand existing overseas markets. However, that being the case, there are several impediments in the supply system, which if ignored, may make us increasingly uncompetitive in the global marketplace of the future.

SECTION 1: GENERAL TRENDS

Manitoba's marine container traffic volume since the 1990s is best characterized by its rapid growth. Over the past seven years international MC traffic throughout in Manitoba has doubled.[3] This is a remarkable change from earlier periods when provincial MC traffic grew at an average annual rate of just 4 to 5 percent. However, since 1995 MC traffic has increased by more than 12 percent per annum and double-digit growth is expected to continue annually over the next decade. **Figure 1** highlights the growth in provincial MC traffic since 1992 and provides a reasonably sound forecast up until 2000.

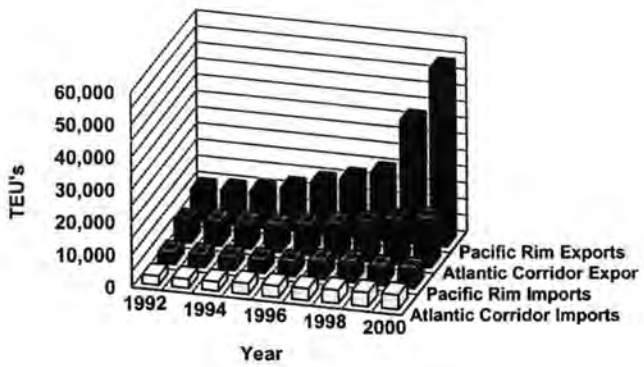
Figure 1 Manitoba's International Marine Container Traffic 1992-2000



The majority of Manitoba's MC traffic flows along two corridors, west to Vancouver, and east to either Montreal or Halifax. In other words, MC traffic flows currently reinforce late 19th century trade networks. Analysis of Manitoba's container traffic by import and export lanes reveals that western-bound trade is growing faster than eastern-bound, both for actual volumes shipped and percentage-based growth. For instance, since 1992 Pacific Rim container exports

have increased by more than 90 percent while imports have risen by 60 percent.[4] Atlantic traffic, to a lesser extent, has also demonstrated considerable growth. During the same period total Atlantic (Montreal and Halifax) MC export volumes have increased by nearly 50 percent, while imports have increased by almost 30 percent. **Figure 2** (below) highlights the MC export and MC import growth in TEU's through Canada's principle traffic lanes.

Figure 2 Manitoba Marine Container Import/Export Volumes by Corridor 1992-2000



The story of Manitoba's marine container flows in the 1990s is best described by analyzing volumes through its principle traffic lanes. Container traffic movement

of commodities from ports can be characterized by two processes: 1) product that is SL and simply 'transferred' and moved, and; 2) product which is 'de-stuffed' (or stuffed into marine containers in the case of exports) before being sent along the supply chain.

Pacific Northwest (PNW) MC imports and exports have increased substantially during the last six years, with an increase from 1,455 to 2,190 TEU's between 1992 and 1997. This should come as no surprise given the heavy emphasis Canadians have put on expanding trade in Asian and Pacific-Rim markets. 'Team Canada' trade missions, APEC conferences, even cultural exchanges have all pushed to expand ties in the region and to help solidify trade alliances. MC export and import commodity movement through the Pacific Northwest channel is dominated by source loaded (SL) twenty and forty foot marine containers that arrive at the Western port and are simply transferred over. In the case of imports, they are then sent direct by motor carrier and rail.[5] De-stuffing of import traffic not sent SL is dominated by Less-Than-Truckload (LTL) shipments, then Trailers On-Flat-Cars (TOFC), then by Truck-Load shipments (TL), and Domestic Container-on-Flat-Cars (DOFC).[6] Export product not SL (and sent by rail or truck) leave, in order of importance, as railcar shipments (either hopper car or boxcar), Less-Than-Truckload, Truckload, Trailer on Flat Car and Domestic Intermodal. **Figures 3 and 4** highlight the principle modes and their respective market share from 1992 to 2000.

Figure 3 1992-2000 Manitoba Pacific Northwest Import Marine Traffic by Inland Mode

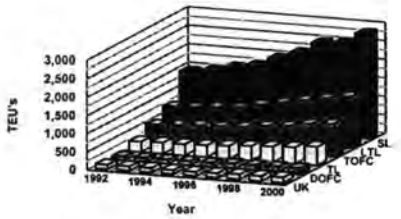
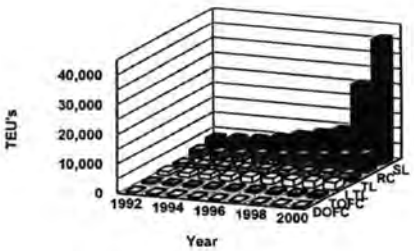


Figure 4 1992-2000 Manitoba Pacific Northwest Export Marine Traffic by Inland Mode



Like Manitoba's Pacific Northwest imports, imported goods sent via the Port of Montreal arrive SL in MC's in a 2:1 ratio when compared with transloaded freight. SL imports are dominated by 40 foot marine containers shipped by truck, then rail, then by 20 foot containers on flatcar. However, that being a positive development, the export picture is more grim from an equipment perspective.

Export traffic patterns via Montreal are similar to import traffic, but the volume of containers shipped is twice as large. As a result, there is a constant scramble to obtain all types of marine containers for source loading in the province for export through Montreal. SL exports are dominated by 20 foot marine containers shipped by rail, followed by truck and rail movements of 40 foot containers. Truck shipments of 20 foot marine containers remains small and have only increased by 1.1 percent during the 1992 to 1997 period (their primary use is grain). **Figures 5 and 6** highlight marine container import and export traffic via Montreal for the 1992-2000 period, by traffic mode.

Figure 5 1992-2000 Manitoba Atlantic Marine Import Traffic by Inland Mode (via Montreal)

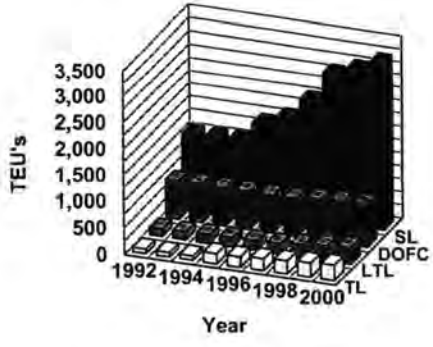
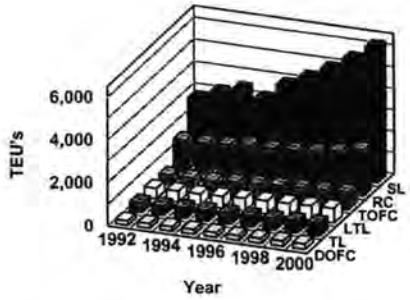


Figure 6 1992-2000 Manitoba Atlantic Marine Export traffic by Inland Mode (via Montreal)



The bleak picture of Montreal's MC imbalance improves little when we turn to examine the case of Halifax. However, Halifax's equipment shipment patterns are unique primarily because of the added distance. To a greater extent, when compared with the other traffic corridors, the majority of Atlantic container imports from Halifax are shipped by rail. Manitoba import traffic via Halifax grew marginally from 232 TEUs in 1992 to 250 TEUs in 1997. Manitoba imports from Halifax were mostly higher valued goods that could justify the cost of extra inland movement from Halifax over Montreal. While Halifax, at present does not account for a significant amount of Manitoba import traffic, it could grow in the future depending upon developments in Atlantic container lanes. Technology and larger container vessels influence port selection and add complexities to the supply chain process which may strengthen Halifax's position for lower valued commodities.

Manitoba's export container traffic sent via Halifax is dominated by SL containers moved by rail. However, increasingly important has been the rise of SL containers sent by truck. Highway transport continues to increase its share of the market.

Goods in forty foot containers are more likely to be high value, low density finished manufactured goods. As with imports this traffic is sent primarily to developing markets in Latin and South America, but also to North and South Africa.

Figures 7 and 8 highlight Manitoba's Atlantic imports and exports via Halifax from 1992 to 2000 by transport mode. For reasons of confidentiality, imports have been lumped together.

Figure 7 Manitoba's Atlantic Marine Import Traffic by Inland Mode (Via Halifax): 1992-2000

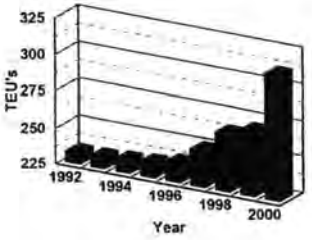
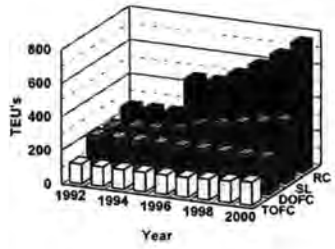


Figure 8 Manitoba's Atlantic Marine Export Traffic by Inland Mode (Via Halifax): 1992-2000



Although previous sections on this study have examined Manitoba's principle Canadian MC traffic lanes, it is also necessary to include a brief comment on US corridors (even though these corridor are less significant in the overall picture of Manitoba's current marine container market). Southern markets in the Pacific Rim, Oceania, Caribbean, Africa and South America for Manitoba-based businesses are increasing. This development will likely fuel growth in Manitoba's container shipments through US gateways. The recent merger of the Illinois Central Railway with CN Rail gives them "seamless rail" service to the Port of New Orleans, which will undoubtedly prove an attractive logistical option for some shippers conducting business in these regions.

Technology too, favours the growth of these routes with volume-based rate incentives to shippers as free trade regions expand and tariffs are reduced between trading blocs. Larger vessels are being introduced continually despite the over capacity in ocean container shipping. For instance, the *Regina* and *Knud Maersk*, 6 000 TEU vessels, were recently christened and more ships of this capacity are being constructed.[7] Vessels of this size require larger hinterlands to fill holds, and container rates will reflect this transformation. Ports such as New York and Los Angeles/Long Beach have the volume of containers to serve these vessels. Canadian deep water ports at Vancouver and Halifax can easily accommodate

these vessels but may be at a disadvantage to attract sufficient freight to make these larger vessels call.

This does not suggest that American gateways will supplant the traditional gateways of Vancouver, Montreal and Halifax, however, it does suggest that the America gateways are viable portals for Manitoba trade. Canadian gateways are also attractive for American shippers. The lower Canadian dollar and higher load factors on Manitoba highways provides an alternative logistics option for Northern US border producers. Future developments in carrier mergers, global trade policies, logistics and technology will determine if this will result in a substantiative shift between corridors.[8]

Up until this point, the paper has outlined the positive aspects of the increasing growth of Manitoba's marine container flow. We must now turn to address some of the problematic issues and concerns associated with this market.

In conducting this study, shippers were asked to forecast their international traffic volumes for 1998-2000.[9] The cumulative results are extremely interesting. The lion's share of Manitoba's import and export container traffic flows to two markets -- Asia and Europe. Between 1992 and 1997 Asian trade (through container traffic) increased by 78 percent, while European trade grew by 49 percent.

Despite the downturn caused by the collapse of Asian markets, shippers remained optimistic, at least in the short term. It can safely be projected from their estimates that provincial throughput by 2000 should come close to, if not surpass, 80,000 TEUs having doubled in little more than three years. This growth will come from both new companies locating in Manitoba and a healthy annual increase of 5 to 15 percent (depending on the trade region) by those firms currently doing business in the province.

Manitoba companies are also in search of alternate markets. With trade driving transport, Manitoba's shippers have noted considerable growth in Latin American, Caribbean, South American and Middle Eastern markets. For the 1992-97 period, container traffic to the three southern markets have grown in *absolute* terms by 49.1 percent.[10] Depending on the country, shippers anticipate that these "southern" markets will grow by 10 to 25 percent annually, bolstered by new trade pacts and potential entrants to NAFTA.[11]

Figures 9 and 10 document these developments, providing reasonable forecasts through 2000.

Figure 9 1992-2000 Manitoba Exports by Region of Commerce

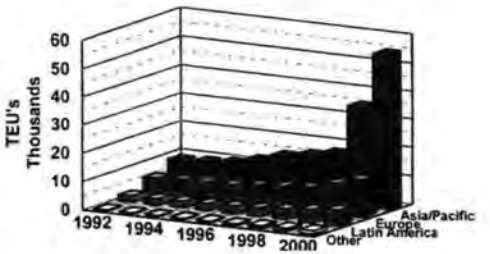
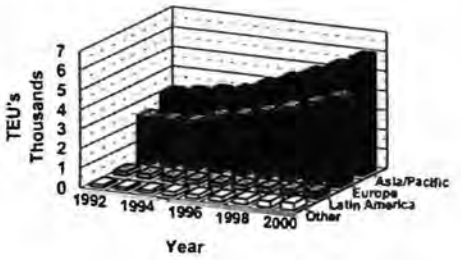


Figure 10 1992-2000 Manitoba Imports by Region Commerce



The differentiated growth pattern in the import and export of containers characterized by Figure 2 also demonstrates an imbalance in the supply of containers, necessitating costly repositioning charges for shippers. Figure 2 suggests this gap between container exports and imports is increasing. The ideal situation would be to have a one-to-one movement of loaded containers between markets. However, this is rarely, if ever, the case. In terms of total traffic, the imbalance in the Pacific Rim export/import ratio has grown steadily from 2.97:1 in 1992 to 3.34:1 in 1997. This means that for approximately every 3 TEU's of Pacific Rim exports from Manitoba, only one import TEU from the same region is realized. Similarly, with Atlantic trade an imbalance in the export/import ratio has risen from 2.47:1 to 2.86:1 during the same period. In sum, current container traffic flows through both Western and Atlantic routes puts a strain on shippers to balance equipment, which also negatively affects freight rate structures.

CONCLUSION

The story of Manitoba's MC 'revolution' is largely revealed through an understanding of its major traffic lanes. The study has found that Manitoba's MC import and export traffic volumes have increased through each of the three principle lanes and to a far lesser extent the US. The Pacific Northwest traffic is by far the most significant, and its growth rates are impressive. Atlantic traffic, too, is also significantly on the rise. Southern gateways, while considerably less significant at present, however, offer a major opportunity for Manitobans in the future and are presently largely unexplored.

If there is one general point that this study makes, it is essentially that container traffic, already an integral feature of business operations in this province, will significantly increase its share of export and import traffic. If Manitobans are to gain a competitive advantage in this global marketplace for many of their export and import industries, success will depend upon their ability to *manage* existing transport services, to take advantage of new technologies and, to push the boundaries in container services.

Above all else, it is crucial to address the problem of marine container imbalances and shortages, and to explore ways to improve this situation. Two possible solutions to help improve this situation might be establishing a multi-user container port facility in Winnipeg that would consolidate the dated existing terminal facilities. And second, trying to encourage increased value added processing of product that could arrive to the province via marine containers prior to consumption or re-export. Only by working to offset the locational

disadvantages of being in the centre of North America, will Winnipeg and Manitoba overcome current MC problems of resupply.

ENDNOTES

1 *'Mid-Continent International Trade Corridor Task Force Report'* Winnipeg, 1998

2 *'World Cargo News'* December, 1998 vol.5, 12 p.30

3 It has risen from 21,800 to 23,400 TEU's in 1992 to a projected total that should exceed
43, 000 in 1998

4 Pacific Rim exports grew from 9,230 to 17,621 TEU's; Pacific Rim imports increased from
3,243 to 5,269 TEU's

5 These two modes are lumped together to provide confidentiality for the carriers involved

6 UK in subsequent figures stands for unknown

7 Maersk Press Release, Aarhus, Denmark, April 13th , 1996.

8 Then major points of comparison between Canadian and US gateways are the following: 1) Vancouver, Montreal and Halifax account for 97.4 percent of Manitoba's container traffic; 2) New York/New Jersey account for 1.1 percent, Seattle/Tacoma account for another 1.1 percent, and other American gateways just 0.25 percent (However, American traffic has climbed steadily at 5 percent per annum); 3) While 811 Manitoba TEUs went through American gateways last year, an equal number of Minnesota and North Dakota TEUs went via Montreal

9 This study was conducted in Summer and Fall of 1998

10 However, in *relative* terms trade to the region has declined by 1.2 percent which should be placed in the context of the extraordinary Asian trade.

11 'Trade Pacts Fuel a Transformation in the Rules of Global Logistics', *Transportation & Distribution*, April 1996, P 60-67.

The authors would like to thank the Manitoba Department of Highways and

transportation for their generous support of this paper which is part of a much larger project. We would also like to thank Dr. Barry E. Prentice and Jake Kosior.

This study is the result of a Manitoba International Overseas Shippers Survey (MIOSS) conducted during the summer of 1998. Through four major business directories a list of 2000 potential Manitoba MC shippers, importers, and exporters was generated. The companies were contacted and it was found that one in four undertook in some MC logistics. This paper is the result of this (MIOSS) study.

US-CANADIAN SYSTEM COMPARISON: A GRAIN SHIPPER'S PERSPECTIVE

I. Introduction

On the North American prairies, the US and Canadian grain rail systems operate parallel to each other on either side of the international border. The regulations and operating practices that characterize each system represents a unique approach to a common challenge; reconciling the demand for transportation services with supply in a seasonal industry. In the US, this reconciliation is done through a combination of price and first-come, first-served or lottery car allocation mechanisms. In Canada, this is done through a combination of statutory freight rates and industry agreed-upon rules.

Pressure for change is building on both sides of the border. In Canada, some stakeholders are suggesting a fully deregulated system, with the implementation of railway-established rules for car allocation along the lines of those in place in the US. Conversely, many US shippers are calling for increased railway regulation on freight rates, performance and access.[1] That there are calls for changes going in opposite directions on both sides of the border creates an interesting paradox.

This paper examines this paradox by comparing the Canadian and US rail systems and their place in the grain supply chain. Specifically, this paper will contrast the approach taken to car allocation in the US against that taken in Canada. Included in this comparison is a discussion about the environment into which current US car allocation mechanisms were introduced in contrast to the environment in which Canadian shippers operate today. Finally the paper will discuss the potential impact on Canadian shippers of implementing US-style car allocation mechanisms in terms of cost and performance.

The conclusion reached is that many of the problems observed in the US when today's car allocation mechanisms were first introduced have been addressed in Canada through a creative, industry-based approach. Canadian shippers should be concerned that a move to US-style deregulation will leave them paying more for reduced service.

II. US Deregulation and the Introduction of Bid Cars

The passage of the Staggers Rail Act in 1980 represented a giant step in the deregulation of the rail industry in the US. One of the most significant changes was the removal of restrictions on demand sensitive pricing for rail service and

the introduction of provisions that would allow railways to price differentiate their service.

Legislators at the time believed that the rules that shippers and railways had developed for car allocation in many instances restricted the railways from attaining higher profit margins and to some extent negatively affected their asset utilization. In order to improve the financial health of the railways, these rules had to be changed. The Staggers Act provided an environment that allowed the railways to develop different methods to allocate cars among shippers.

Initially after the passage of Staggers, railways used confidential contracts to establish rate and service levels. However, the late 1970s saw tremendous government and industry investment in grain storage infrastructure. This coupled with a decrease in production and export demand in the early 1980s provided US shippers with excess capacity which increased their bargaining power against the railways. In the short term, they were able to use confidential contracts to reduce grain freight rates. By the mid-1980s, the US railways realized that confidential contracts were having a negative impact on revenue and began to explore alternate methods of setting rate and service levels.

In 1988, around the same time that the US railways began to decrease the use of confidential contracts to set freight rates, the then Burlington Northern (now Burlington Northern Santa Fe – BNSF) introduced its Certificate of Transportation (COTS) program. This was the first program in the US to sell rail transportation by way of an auction and it is still in place today. Similar programs have been established by all other major US railways.

Through COTS, access to a rail car is sold by way of electronically-conducted sealed-bid auctions. The use of rail cars are offered for sale up to five months in advance, by specific origin-destination groupings and by commodity. Shippers who require a rail car then submit their bids to BNSF. A successful bidder is scheduled to receive cars within a specified two-week window.

If the shipper decides after bidding but before the two-week window has started that they do not want to use the cars they have obtained through the auction, they can resell them in a secondary market. If the original purchaser does not use them and does not resell them in the secondary market, they pay a financial penalty. Similarly, if a shipper wants to change the original bid corridor for the cars they also pay a penalty.

Only a portion of BNSF's fleet can be used for COTS. Therefore, if a shipper does not want to bid on cars they can take their chances at getting tariff cars by way of general allocation. Tariff cars are mostly allocated on a first come, first served basis with some recent rules established to allocate on a historical basis. When demand exceeds supply for tariff cars, BNSF uses a random lottery draw to select the winning shipper.

A. Objectives of the COTS program

US shipper response to the introduction of the COTS program was extremely negative. A coalition of shippers led by the National Grain and Feed Association petitioned the Interstate Commerce Commission to repeal it. This forced BNSF to publicly state the objectives behind the program[iii]. This testimony is particularly interesting because it highlights the difference between where the US system was at the time the COTS program was introduced versus where the Canadian system is now in terms of processes and performance.

1. Risk of Asset Planning

BNSF claimed that the main goal of the COTS program was to redistribute some of the risk of asset planning onto shippers. BNSF, like most US railways, was having a difficult time determining the future demand for grain rail service, given the seasonal variation of demand inherent in the North American grain export business. The US did not have a centralized group like western Canada's Car Allocation Policy Group (CAPG – discussed later) in a position to help the railways determine future demand for grain cars. Through COTS and its penalty system, some of the increased risk the railways must assume in determining fleet size is now transferred to the shipper.

2. Phantom Orders

In the absence of a coordinated industry approach each US railway devised its own rules to allocate cars among shippers. Before implementation of COTS, BNSF simply used a first-come, first-served reservation system. Under this system, shippers had a tendency to over-order to hedge against not getting cars at all. Therefore BNSF had a difficult time determining the validity of rail car orders. BNSF believed that COTS would eliminate the problem of "phantom" orders, because shippers would be held financially responsible for any cars they did not use.

3. Corridor Congestion

COTS were promoted by BNSF as a method to reduce destination and corridor congestion. Again, the US did not have the industry coordinated processes, like

those in place in Canada, to coordinate corridor priorities or monitor and manage actual corridor performance. Through the COTS auction, shippers bid against each other for limited capacity and corridor priority is set by price.

4. Car Spot Performance

COTS came with a guarantee of car spot (within two weeks) and BNSF believed that a higher cost to the shipper was justified because this represented an improved service. The fact that BNSF believed that a two-week window was an acceptable guarantee indicates that the US system was in poor condition before the introduction of COTS.

5. Efficiency

BNSF also claimed that COTS would reduce car cycles and thus create efficiencies for all shippers. They even claimed that non-COTS service would improve because the COTS service would be so efficient that it would make more cars available for other service. BNSF further claimed that efficiencies derived from COTS would allow BNSF to reduce rates to grain shippers because their overall costs would decline. However, BNSF could not prove that car cycles actually were better after the implementation of COTS.[iv]

6. Rate Information

BNSF claimed that COTS would provide them with information about the true value of the commodities being shipped. BNSF could then use this information to develop the proper rate structure and to extract premium prices from the higher valued commodities. If car bids for specific commodities and corridors are consistently high then BNSF will know to increase the base tariff accordingly.

7. Liability

A further benefit to railways of COTS is that it provides BNSF with a mechanism to limit their liability for poor performance. The terms and limitations for shipper compensation are clearly defined in the COTS tariffs, as shippers are restricted to only the defined car spot penalty. That is, if BNSF fails to spot a COT car within the 15-day window, it must pay the shipper a $400 penalty. The shipper cannot seek further damages for poor rail service. The value of this penalty decidedly favors BNSF given that $400 represents less than two per cent of the value of a wheat sale from Pacific Northwest ports.[v]

The ICC voted in favour of allowing BNSF to continue utilizing COTS. BNSF was able to win a favorable ruling from the ICC because the US grain supply

chain with its lack of industry coordination had been performing in less then optimal manner. Under the guise of efficiency improvements the method to allocate car orders was changed by BNSF to suit BNSF.

III. Car Allocation in Canada

The Canadian approach to matching demand for rail transportation service with supply is the result of a high degree of industry collaboration and cooperation.

Interestingly, supply chains in many other industries are beginning to integrate many of the critical functions already in place in the Canadian grain supply chain. For example results of a study concerning the supply chains in the personal computer (PC) industry indicate that "the specific collaborative planning and execution activities that have been most often overlooked and yet, can deliver the greatest value to PC industry participants are:

- collaborative demand planning
- synchronized order fulfillment
- joint capacity planning."[vi]

The US Department of Agriculture and the Surface Transportation Board have also recognized the value of integrating supply chain functions and have recently signed a memorandum of understanding establishing a joint grain logistics task force. "The grain logistics task force will identify the types of information that will help the grain and rail industries better plan for and adjust to shifts in demand and supply for grain and grain transportation. "[vii]

This type of planning and coordination are some of the very functions that CAPG facilitates in the western Canadian grain movement. On August 1, 1996, CAPG assumed the responsibility for high level car allocation and other critical supply chain functions, concurrent with the demise of the Western Grain Transportation Agency. The CAPG Executive Committee is made up of four members, representing the railway, grain handlers, the CWB and farmers. Decisions are made by consensus. CAPG sets corridor priorities for rate regulated movements. An industry technical committee negotiates the high-level split between CWB and non-CWB grain shippers for rate regulated corridors based on policies established by CAPG.

A. Demand Forecasting and Corridor Planning

CAPG administers a four month demand setting mechanism supported by each shipper's projected sales estimate. This reduces shipper and railway uncertainty

particularly in times when demand exceeds supply. The process is intended to provide all participants with accurate demand forecasts that may be used for asset planning purposes. Railways in particular can use this forecasting to plan asset utilization.

CAPG also facilitates corridor priority planning and establishes performance standards. Coupled with the demand setting mechanisms, corridor planning provides marketers with the ability to match sales to supply chain capabilities.

Establishing industry corridor performance standards ensures that railway performance is maintained at a specified level. This is important as a certain performance level will ensure that any premium priced service will have to be at least better than the industry-agreed performance level.

B. Operating Meetings

CAPG holds weekly operating meetings at which all participants review the performance of the past week and set the basis for car allocation among shippers.

The railways provide weekly car supply estimates by shipping corridor to the grain industry. This by design ensures that the railways consider their operational capabilities at the time of offering cars. For example if the Vancouver corridor is congested due to conditions within or beyond the railways' control, the railways simply offer fewer cars to this corridor. This ensures that cars are directed to the best performing corridor. Once cars are offered they are split among shippers based on the sales projections of the commodity being shipped.

Rail cars are then programmed to maximize railway efficiency. Railways establish service plans that detail the minimum number of orders accepted before a train will operate. They also determine the level of service that all train runs will receive.

IV. Impact on Shippers

From a grain shipper's perspective, the Canadian car allocation system functions better than that in the US, from a cost and performance viewpoint. The introduction of price-based allocation systems may mean that captive Canadian grain shippers would be paying much more for much poorer service.

A. Auction Process- Who Benefits?

Auctions have been promoted as an efficient way to allocate a scarce resource. In fact, in the absence of some form of industry input during times when rail car demand exceeds supply an auction may be appealing to those that are not ultimately paying the freight bill. It does provide a quick method to assign priority. However, it does so at the expense of the entire supply chain performance, and it allows for the provider of the auction to capture economic rent from other supply chain participants.

The pertinent issue for shippers, however, is to determine if an auction for transportation services provides them with the best value and if it can actually set fair market value.

Auctions are used to purchase transportation in other modes. For example, auctions are used to sell barge service on the Mississippi River. Purchasers bid for available space on future barge movements. Many have used the Mississippi barge example as an argument to justify the use of auctions in the rail industry.

However, the overriding distinction between the two modes is that there are high barriers of entry into the rail industry that does not exist to the same extent in barge industry. Railways can also effectively control available car supply, not only of the premium service being auctioned, but also of alternative or non-premium service. Therefore rail car auctions in their present format greatly favour the seller at the direct expense of the purchaser.

The fact that bid car systems are an expensive method to marginally increase rail capacity has been recognized by several US transportation practitioners and economists alike. The following quote captures the essence of the relationship between premium priced and non premium priced service levels. "Once the short run quantity of rail capacity available under general tariff rates is exhausted additional capacity must be supplied through negotiated rail contract or premium service agreements, or by alternative transportation modes. All of these alternatives provide only marginal increases in capacity and only at significantly higher costs."[viii]

B. Value of Guaranteed Car Spot

The important question for shippers is to determine, what exactly is the value of a guaranteed car spot? This question becomes increasingly important as railways introduce more products that are promoted based on some form of a

guarantee attached. The value of the premium priced guaranteed car spot is highly dependent upon the quality of non-premium priced service.

A study performed by the Department of Economics of Iowa State University tried to determine the monetary value of guaranteed service.[ix] The study determined that the value of service and thus the price a shipper is willing to pay is dependent upon a number of factors. Two of them are described here.

First of all, value increases as the quality of the guarantee increases. That is to say a 0-day guarantee window is more valuable then a 15 or 30-day window. Accordingly, a shipper should pay less for a wider defined placement window. Secondly, the value increases as conventional non-guaranteed service decreases. The relationship between the two and the degree to which they are different is important to shippers.

Researchers studied data from two major customers of BNSF, the Central Washington Grain Growers Inc. (CWGG), and the West Central Cooperative (WCC) in Iowa. CWGG can be characterized as a captive shipper because they are dependent upon the BNSF for service with no inter-modal or intra-modal competition. The majority of their production must be shipped to export market. WCC, on the other hand, has access to three railways plus economically feasible modal competition and a large domestic market.

Figure 1 shows the average number of days beyond the shippers desired car spot date CWGG and WCC waited for conventional tariff service to be delivered. The level of service on normal tariff cars was found to be extremely different between the two shippers. For example, in January, WCC waited on average six days, while CWGG waited 40. The disparity in performance experienced by the two shippers increases greatly during the winter months when shippers want to move more grain and the Upper Mississippi River freezes. In other words, when demand for transportation services exceeds supply, captive shippers suffer the lion's share of constrained capacity.

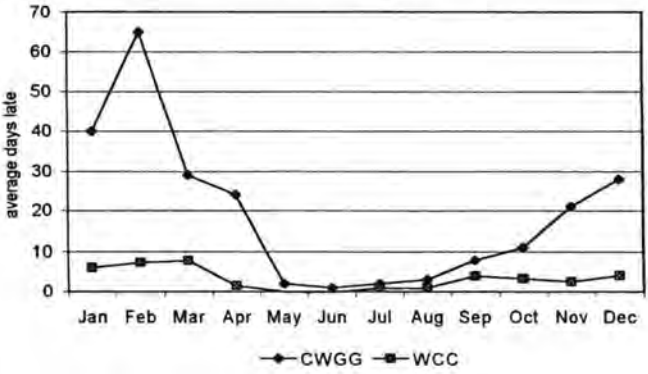
The standard deviation of days waiting to car spot was also found to be considerably higher for the captive shipper. This means that the service was not only on average much later, but also on average more unreliable as actual spot from order dates varied drastically.

The study concluded that the value of guaranteed car spot is much higher for the captive shipper. As Table 1 illustrates, to CWGG, the captive shipper, the value of the 15-day guarantee was nine times that of WCC, the non-captive shipper. This is primarily due to the fact that the captive shipper non-premium

service was much worse then the non-captive shipper non-premium service. The authors suggested that this information would "help railroads in pricing guaranteed service and in setting minimum acceptable bids for guaranteed service auctions."

The implications for the Canadian shipper is fairly significant as a large majority of Canadian producers can be considered as captive shippers. Most producers on the Prairies do not have economical modal choices nor do they have easy access to a large domestic market. Thus, if current recommendations for change are implemented, many Canadian shippers could see normal tariff service greatly decline and priority priced service become very expensive.

Figure 1: Monthly Means of Days Waiting for Rail Cars, Central Washington Grain Growers and West Central Cooperative



Source: Pautsch et al. (CWGG: April 1998 to March 1990, WCC: November 1990 to March 1990 and November 1992 to March 1994.

Table 1: Value of Guaranteed Car Sport, Captive Versus Non-Captive Shipper

	CWGG - Captive	WCC - Non-Captive
	US $ per car	
15-day	141.04	15.53
30-day	133.84	8.33

Source: Pautsch et al.

C. Car Allocation and Railway Performance

The allocation of cars via an auction versus a more collaborative industry approach negatively impacts railway performance because it does not take into account sufficient consideration of actual railway operations. The fact that the auction may take place five months before the actual movement means that by design car allocation is removed from the current operating conditions. In fact, a 15-day car spot window, with the ability of shippers to reassign car spotting locations and destination corridors, after the auction has taken place makes accurate railway operational planning virtually impossible. Contrast that to the Canadian CAPG process which is intertwined with weekly operating conditions factored into the car allocation process.

Further compounding the negative impact on railway operating efficiency is that significant bunching of rail cars at destination position does occur. This is the impact a 15-day spot window has on arrival times at port. Shipments from more than one location that are being consolidated at destination (possibly for vessel loading) can be either two weeks early or two weeks late.

Railway efficiencies in placing rail cars at origin are also compromised by the introduction of premium priced service. If one shipper in a zone or train run purchases premium priced service but another shipper in the same zone or train run does not, the railway must spot the premium priced cars before the non-premium priced cars. To not do so would destroy the integrity and value of the premium priced service. The result is that the railway will have smaller trains with more train starts. Obviously when rail service is in high demand this is not an optimal situation.

D. Loading Performance

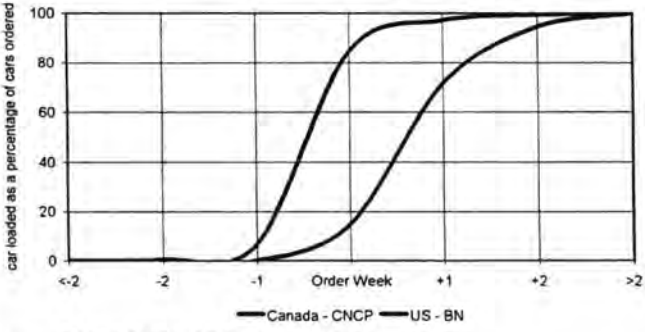
As stated previously, BNSF claimed that COTS would reduce car cycles and thus create efficiencies for all shippers. They even claimed that non-COTS service would improve because the COTS service would be so efficient that it would make more cars available for other service.

Currently the Canadian system strives to spot rail cars within one week of ordering. As Figure 2 illustrates, over the past two year statistics on Canadian rail car loading indicate that 85 per cent of the offered car supply is spotted and loaded within the week of ordering and over 97 per cent is loaded within two weeks of ordering. Contrast this to the performance on BNSF where only 15 per cent is loaded within the order week and 72 per cent is loaded within two weeks. Therefore in comparison to Canadian service standards, BNSF's are lower for its total program of COTS and non-COTS service.

E. Car Cycle Times

One of BNSF's claims was that the introduction of the COTS would create efficiencies for all shippers. A comparison of Canadian and U.S. grain car cycles indicates that overall Canadian cycle times are better than in the US. This is surprising given the amount of system rationalization that has occurred in the US and the fact that BNSF has on average a shorter haul. BNSF grain car cycles indicate an average 29.6 days. CN grain car cycles indicate an average 20.6 days.[x]

Figure 2: Cumulative Loading Performance in Relation to Order Week



Source: BNSF, CWB, All Grains, 1997-98

F. Rail Freight Costs

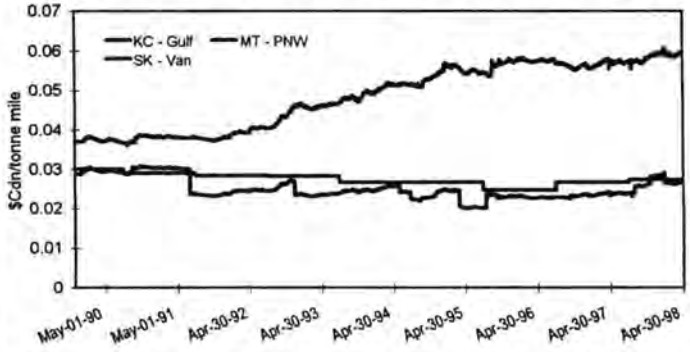
BNSF claimed that efficiencies derived from COTS would allow BNSF to reduce rates to grain shippers because their overall costs would decline. As Figure 3 shows, this has not proven to be true and in fact BNSF grain rates in all but the most competitive locations have increased.

G. Railway Investment

Railways argue that rate caps restrict their ability to reduce operating costs and thus pass on the associated savings to the producers. They also argue that they intentionally restrict investment when rate caps are in place. However, evidence of railway cost reductions and capital investments over the last several years indicates that this is not entirely correct.

Canada's two main railways made capital expenditures into their Canadian operations totaling $694 million in 1996. CN's capital expenditures of $464 million were mainly on new locomotives, additions to rolling stock, and roadway renewal. CP's expenditure level was down in 1996 because they had acquired a significant number of locomotive in 1995. Both railways have increased their capital investments since 1991 when they invested about $200 million each in Canada.[xi]

Figure 3: North American Freight Rates, Point to Port Using 52-car Spot



Source: Saskatchewan Agriculture and Food, US - BNSF Rates, Canada – CP-CN Statutory Rates

All of this investment has been performed within a rate capped environment. It is estimated that the railways have benefited by a two per cent productivity gain every year since the last costing review[xii]. Incidentally, this benefit has not been passed onto producers through lower freight rates. Their freight rates have increased with inflation with a small reduction for branchline abandonment.[xiii]

With a rate cap in place the railway that reduces its costs the best makes the most net revenue. Therefore there exists considerable incentives for railways to reduce operating costs within a capped- rate environment. This is verified by Dr. Alfred Kahn who stated in his address to the Surface Transportation Board, "The imposition of such a ceiling would have the additional virtue, just as the rate caps now widely adopted for the regulation of telephone rates, of giving the railroads every incentive to improve their efficiency."[xiv]

V. Conclusion

The introduction of railway initiated car allocation changes greatly divided shippers and carriers at a time where most other supply chains were evolving to areas of increased cooperation among participants. In particular, the bid car systems provided the railways with a method to segregate the grain market by product and corridor and then quickly attain higher revenue from the segments which would pay a higher freight rate.

US railways sold the concept of bid cars by claiming they would provide transportation efficiencies that would eventually accrue to the shipper. Shippers have now realized that their overall level of service has not improved and in many cases declined.[xv] Shippers have also found that the methods to hold railways accountable are cumbersome and often ineffective. Consequently many are turning to their elected representatives for legislative intervention. There is considerable support for the re-regulation of railways particularly in the grain sector.

Canadian railways are trying to follow the path of their US counterparts. They have introduced car allocation system for the non-rate regulated corridors, which are virtually identical to US bid systems. It is imperative that shippers understand how giving up the industry-based processes currently in place in Canada will impact on all rail movement in the long run.

It is the industry's responsibility to advance changes to the grain supply chain which will foster increased cooperation between all stakeholders and ensure that the overall supply chain is improved. In this way, Canadian producers will have access to an equitable, reasonably priced transportation system.

References

Austin, Terrence, Lee, Hau L., and Kopczak, Laura. "Unlocking Hidden Value in the Personal Computer Supply Chain". Andersen Consulting, Leland Stanford University, Northwestern University, 1997.

Baumel, C. Phillip and Kober, Rodman. "Forward Transportation Contracting and Futures: An Option for Grain Shippers?" Transportation Practitioners Journal. Winter 1991, Volume 58, pp. 150-164.

Bill S. 621. "Railroad Competition and Service Improvement Act of 1999".

Brasher, Philip. "Railroads Running Behind in Moving Grain." The Hastings Tribune. November 7, 1997.

Burlington Northern Santa Fe. 1997 Annual Report.

Canadian National Railway. 1997 Annual Report.

Fitzwater, Alan. Verified statement to the Interstate Commerce Commission, May 2, 1988.

Grainnet. "USDA. STB Sign Pact to Create Grain Logistics Task Force." May 21, 1998.

I.C.C. Docket number, 40169, National Grain and Feed Association vs. Burlington Northern Railroad Company, et al. April 20, 1992.

Kahn, Alfred E. Verified statement. Surface Transportation Board. Review of Rail Access and Competition Issues. Ex Parte No. 575. March 26, 1998.

Kober, Rodman and Baumel, C. Phillip. "Transportation Forward Contracting or Options: A Description and Analysis of an Application to Railroads." Transportation Practitioners Journal. Fall 1990, Volume 58, pp. 51 – 63.

Maki, Ken. Verified statement. Surface Transportation Board. Review of Rail Access and Competition Issues. Ex Parte No. 575. March 26, 1998.

Norton, J.D. "Assessing the Impact of Rail Car Availability on Grain Prices". USDA. September 1995.

Parsons, Graham. "Regulation, Logistics and Efficiency: Introducing Competition and Market Pricing to Western Canada's Grain Handling & Transportation System." CTRF Proceedings, 1998.

Parsons, Graham. "Grain Handling and Transportation Systems: A Canada-United States Comparison." Organization for Western Economic Cooperation. January 1999.

Pautsch, Gregory R., Bacock, Bruce A., and Baumel, C. Phillip. "Estimating the Value of Guaranteed Rail Service." Transportation Research Forum, 1996. Volume 36, Number 1.

Pautsch, Gregory R., McVey, Marty J., and Baumel, C. Phillip. "Railroad Grain Car Pricing and Supply Models." Journal of the Transportation Research Forum, 1991. Volume 32, Number 1.

Priewe, Steven R. and Wilson, William W. "Forward Shipping Options for Grain by Rail: A Strategic Risk Analysis" Agricultural Economics Report 372, March 1997. Department of Agricultural Economics, North Dakota State University.

Transport Canada. "Transportation in Canada 1997. Annual Report." May 1998.

US Department of Transportation. "Assessing the Potential for Improved Functioning of the Grain Merchandising/Transportation System." Federal Railroad Administration. Final Report, March 1994.

Vercammen, James. "Sharing the Railways' Productivity Grains." Eds. J. Vercammen, M. Fulton, R. Gray. The Economics of Western Grain Transportation & Handling, Module B-3. 1996 Van Vliet Publication Services: Department of Agricultural Economics, University of Saskatchewan.

Vercammen, James. "Impact on Western Grain Rail Rates from an Elimination of the Legislated Rate Cap." Currently under review at the Canadian Journal of Agricultural Economics. January 1999.

Whiteside, Terry. Presentation to Keystone Agricultural Producers. Winnipeg, Manitoba, January 13, 1999.

Wilson, William, and Dahl, Bruce C. "Bidding on Rail Cars for Grain: A Strategic Analysis." Agricultural Economics Report 376, May 1997. Department of Agricultural Economics, North Dakota State University.

Zink, Dan. "Forward Pricing in Transportation." Transportation Research Forum. Volume 4, 1989.

---

[1] Congressman Burns, R-Montana, Discussion Draft Presented to the 106th Congress, First Session.

[ii] Congressman Burns, R-Montana, Discussion Draft Presented to the 106th Congress, First Session.
[iii] Alan Fitzwater, Vice-President of Government Affairs, Burlington Northern. Verified statement to the Interstate Commerce Commission, May 2, 1988.
[iv] I.C.C. Docket number, 40169, National Grain and Feed Association vs. Burlington Northern Railroad Company, Et Al. April 20, 1992.
[v] CWB, based on 1997 sales values for US wheat through the PNW.
[vi] Terrence Austin, Et Al, "Unlocking Hidden Value in the Personal Computer Supply Chain", Andersen Consulting, Leland Stanford University, Northwestern University, 1997.
[vii] Grainnet May 21 1998
[viii] Norton, J.D. "Assessing the Impact of Rail Car Availability on Grain Prices". USDA. September 1995.
[ix] Pautsch, G.R., B.A. Babcock, & C.P. Baumel. "Estimating the Value of Guaranteed Rail Service." Transportation Research Forum, 1996, Volume 36, Number 1.
[x] Burlington Northern 1997 Annual Report and BNSF Internet Site. Canadian National 1997 Annual Report and Car Allocation Policy Group Weekly Report.
[xi] Transport Canada. "Transportation in Canada 1997. Annual Report." May 1998.
[xii] Vercammen, J. "Sharing the Railways' Productivity Grains." Eds. J. Vercammen, M. Fulton, R. Gray. The Economics of Western Grain Transportation & Handling, Module B-3. 1996 Van Vliet Publication Services: Department of Agricultural Economics, University of Saskatchewan.
[xiii] Even if the railways abandoned all the lines they have up for abandonment in their three-year plans (approximately 800 miles), farmers would only see a 0.76 per cent drop in their freight rate (according to the formula in the CTA and assuming 0 inflation).
[xiv] Alfred E. Kahn, verified statement before the Surface Transportation Board, ex parte 575, March 26 1998.
[xv] Whiteside, T. Presentation to Keystone Agricultural Producers, Winnipeg, Manitoba, January 13, 1999.

Location and Transportation Impacts of Privatizing the Marketing of Western Canadian Oats

Dr. Barry E. Prentice - Director
Zhaokun Wang - Research Associate
Robert W.R. Morrissey - Former Graduate Student
Transport Institute, University of Manitoba

Introduction

Western Canadian oat production declined over most of the 20th Century, due mainly to the decreased demand for oats as a feed grain and for human consumption. The marginal status of the oat crop contributed to its removal from the Canadian Wheat Board (CWB) jurisdiction in 1989. Subsequently, however the declining trend reversed and acreage has increased 40 percent.

The majority of production increase was driven by expansion of exports to the Unites States, but this demand has not fundamentally changed. Arguments cited by the federal government ten years ago to justify the removal of oats from CWB jurisdiction have been validated by the market. The turnaround of the Western Canadian oat industry can be associated directly with the decentralization of marketing.

The case of oats has implications for the further development and deregulation of Western Canadian grain industry. The objectives of this paper are (1) to present the structural changes in Western Canadian oat industry in the 1990s and (2) to identify the logistical and transportation factors contributing to these changes subsequent to the decentralization of Western Canadian oat marketing.

Policy Changes

Since August 1989, individuals and private companies have had full responsibility for the marketing of oats domestically and internationally. The federal decision contended that oats were not among the same category as

wheat and barley. Wheat and barley were major crops exported in large quantities, and the Board pooling system seemed to work well for this purpose. On the other hand, the market for oats was becoming more specialized, with niche markets for small quantities of high quality products. For these markets, private entrepreneurs were in the best position to capitalize on opportunities.

The repeal of the Western Grain Transportation Act (WGTA) that eliminated the rail freight subsidy (effective August 1, 1995) encouraged farmers to grow crops that had local markets. The changes were brought about for four main reasons: (1) to comply with new global trading rules that established limits on export subsidies and volumes; (2) to create an environment in which a more efficient grain transportation and handling system could evolve; (3) to eliminate freight rate impediments to commodity diversification and processing; and (4) to help reduce government spending and the deficit. While the change in oats marketing set in motion structural changes in production and procurement, the abolition of freight subsidies accelerated the pace of adjustment.

Structural Changes in Production and Procurement

Area seeded to oats in Canada exceeded wheat acreage prior to 1910 when large supplies of oats were required to feed horses. From the 1920s to the 1970s, oat production decreased significantly as horses were replaced by tractors. The declining trend, however, essentially ended in the 1980s although feed consumption of oats continued to decrease. As shown in Figure 1, oat production in Canada stagnated around 3 million tonnes in the 1980s. After a consecutive drop in 1990 and 1991, oat production increased to the current level of about 4.0 million tonnes. The large arrow in Figure 1 shows the point when oats marketing was returned to the private sector.

Figure 1. Western Canadian Oat Production, 1980-1998

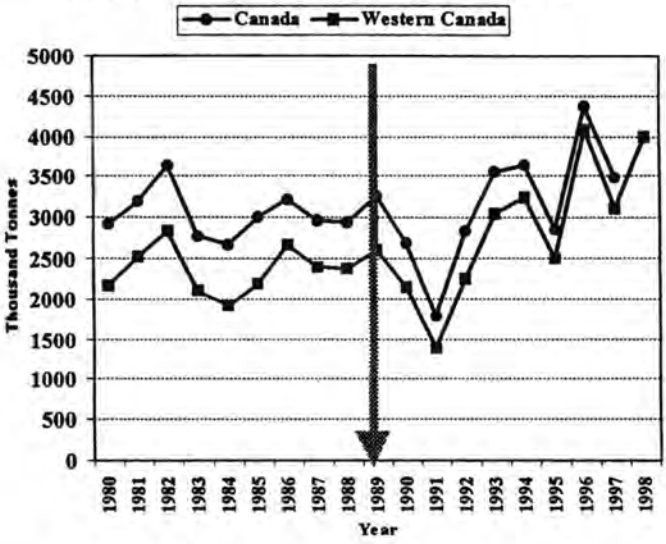
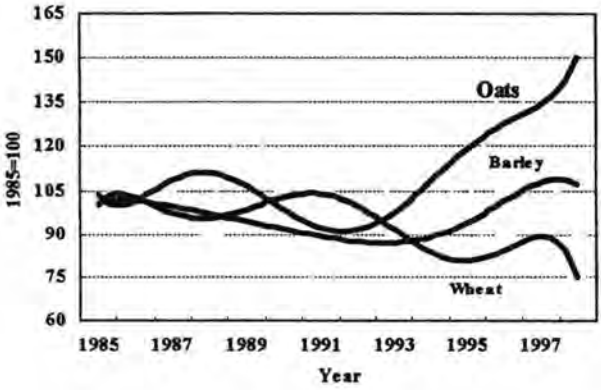


Figure 2 displays the trend in acreage harvested for wheat, barley and oats in Western Canada during the period of 1985 to 1998. The area harvested for oats increased, on average, about 40 percent, compared to a roughly 15 percent increase in barley acreage and more than 20 percent decrease in wheat acreage.

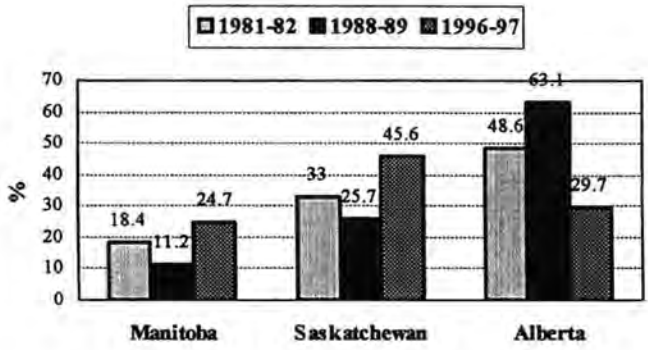
The geography of Western Canadian oat production changed substantially with the growth in production. Following the removal of oat marketing from the CWB jurisdiction, Western Canadian oat production has been shifting from western to eastern Prairies.

Figure 2. Changes in Western Canadian Grain Acreage, 1985 - 1998



Alberta was the largest oat producing province in Western Canada until 1994 when its status was replaced by Saskatchewan. At the beginning of the 1980s, Alberta produced almost half of Western Canadian oat crop, followed by 30 percent for Saskatchewan, and less than 20 percent for Manitoba. Alberta's position in Western Canadian oat production strengthened further throughout the 1980s. Under the auspices of the Canadian Wheat Board, Alberta's production share grew to more than 63 percent, while the share for Saskatchewan and Manitoba dropped to about 26 percent and 11 percent, respectively. Since deregulation, Alberta's share of oat production fluctuated and declined to less than 30 percent in 1996 and 1997, while that for Saskatchewan and Manitoba increased substantially to almost 46 percent and nearly 25 percent, respectively. The geographic changes at the provincial level are illustrated in Figure 3.

Figure 3. Geographic Changes in Western Canadian Oat Production, 1981-1997



Shifts of Oat Procurement Across Prairies Elevators

The geographic changes in oat production resulted in even more substantial spatial changes in oat procurement at primary elevators, which, in turn, influence oat transportation and marketing. In the past 10 or so years, major oat procurement sources on the Prairies shifted eastward and, to a lesser degree, southward from northern and central Alberta to eastern Saskatchewan and southern Manitoba.

Before the deregulation of oat marketing, almost two thirds of the oats entering Western Canadian grain handling and transportation system originated from primary elevators in Alberta. In 1996/97, however, Saskatchewan accounted for almost half the receipts, and Manitoba's share increased to almost one third, while that for Alberta declined to less than one fifth.

Dynamics in Exports and Transportation

The rapid growth in the Prairie hog and cattle industries in the 1990s might be related to growth in oat production for domestic feed consumption. However, trends in feed consumption of oats fail to explain the growth in Western Canadian oat production in the 1990s. In particular, the annual average feed consumption of oats was less than 1.8 million tonnes during this period, which is 0.5 million tonnes less than the average of almost 2.3 million tonnes for the period of 1985/86 to 1990/91. Meanwhile, data on Canadian oats disposition show that annual domestic human consumption of oats increased marginally from about 2.8 percent of the total supply in later 1980s to 3.6 percent in the 1990s.

The major driving forces underlying the growth in Western Canadian oat production during the 1990s has been the substantial expansion in exports of oats and oat products. As illustrated in Figure 4, with an annual average growth of 8.6 percent in the last 10 years, Western Canadian oat exports to the U. S. more than doubled from 0.58 to 1.3 million tonnes. As a result, the proportion of Canadian exports in total oat disposition increased from about 20 percent in later 1980s to 40 percent in later 1990s, while the percentage of domestic feed consumption decreased from 73 percent to 52 percent.

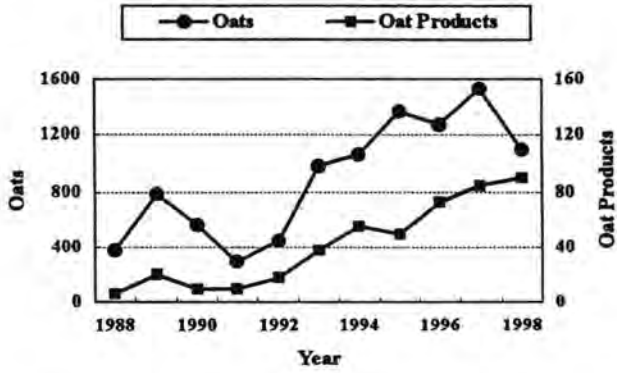
Meanwhile, Canadian exports of oat products increased tremendously in the U.S. markets, from 13 to 87 thousand tonnes. Manitoba and Alberta were the leading exporters and their market shares increased to 60 percent and 27 percent, respectively. The regional growth of processed oat exports can be attributed to the expansion of processing capacity in these two provinces.

During the period of 1988 to 1998, oat exports from Saskatchewan and Manitoba to the U. S. increased 5 times, while Alberta decreased to one third. Minnesota and Wisconsin have been the dominant markets for Canadian oat exports to the U. S.. In later 1980s, the market share for Minnesota was almost 60 percent and that for Wisconsin was about 20 percent, respectively. Other important markets for that period included Ohio, New York, Washington, and North Dakota.

Ten years later, although still the top Canadian oat markets, Minnesota's market share declined sharply to about 30 percent, while Wisconsin's share reduced to 17 percent. Their market shares were picked up by nearby states of

Iowa, Missouri, Nebraska, and Montana. The shares for these fast growing markets were roughly 15 percent, 6 percent, 4 percent and 4 percent, respectively.[1] Consequently, the U.S. markets for Canadian oat exports became more dispersed.

Figure 4. Western Canadian Oat and Oat Product Exports to the United States, 1988-1998 (Unit: '000 Tonnes)



Transport Routes

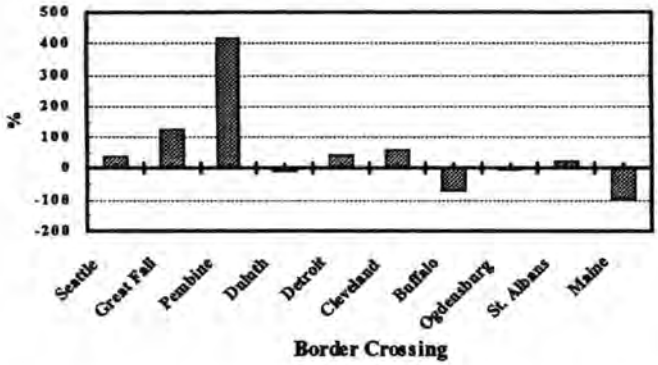
Border crossing data from the U.S. sources are used to analyze changes in transportation routes in Canadian oat exports to the U. S.[2]. Figure 5 demonstrates the changes in volume of Canadian oat exports by U.S. border crossing during 1993 and 1997. In 1993-94, Duluth dominated among the

---

[1] A market share analysis at the province-state pair level would be more appropriate. However, data available from Statistics Canada fail to support this effort.

[2] Census Bureau, U.S. Imports/Exports History: 1993-1997, The U.S. Import and Export History database.

Figure 5. Changes in Canadian Oat Export Volume by U.S. Border Crossing, 1993-94 to 1996-97



routes with an average share of more than 60 percent, which was followed by C Cleveland's 12 percent, Pembina's 12 percent, and Great Fall's and Seattle's 4.2 percent.

The distribution of export volume by route has changed dramatically since the end of the WGTA (1995). For the period of 1996 and 1997, Pembina replaced Duluth as the biggest port for Canadian oat exports. The average annual oat traffic increased more than four times, from less than 0.12 million tonnes for 1993-94 to 0.55 million tonnes for 1996-97. The proportion in total export volume expanded from 12 percent to 40 percent. During the same period, oat volume passing through Duluth decreased more than 7 percent, from 0.61 to 0.49 million tonnes.

Other significant changes included doubling of oat volume through Great Falls a 60 percent volume increase for Cleveland, and a 71 percent volume decline for Buffalo. The average export growth from 1993-94 to 1996-97 was about 50 percent.

Fundamental Logistical and Transport Factors

By the late 1980s, oats commerce had evolved to specification merchandising for which the massive logistics system under the central desk marketing system was unable to adequately meet the specific needs of end-users. A typical specification of oats selling to the U.S. includes protein content, test weight, sound count, foreign matter (such as barley, wheat, and wild oats), and moisture level. The CWB attempted to respond with a designated account for higher quality oats.

Under the CWB Designated Oats Pool Account, exports of designated oats to the U.S. primarily came from Alberta. The new account, for a time, curtailed the shortage of high-grade oats required by the food processing industry. However, U.S. processors remained unsatisfied with the quality of the final product.

Inferior protein content was the most serious allegation against the quality of Canadian oats. This perception harmed the credibility of oat producers in Manitoba and Saskatchewan, who consistently maintain 16 percent protein content. The perception of inferior protein content was rooted in the selection procedures of the Designated Oats Pool Account. Northern Alberta has always been known for their prominence in oat production. Large, plump oat kernels are easily achieved due to cool, moist weather conditions in the region. However, the larger, more plump oat kernel has significantly lower protein content. Ample supply and lower freight rates under the Crow Rate encouraged the CWB to select and export a large quantity of oats from this region (Morrissey, 1996).

High barley content in oats shipments presented another serious problem. Although high sound count was achieved from direct carlot shipments of oats to the U.S., end users complained about the high foreign content from Thunder Bay shipments. On average, direct shipments achieved a sound count of 97 - 99 percent, while shipments via Thunder Bay were only 90 percent. Strict foreign matter tolerances on Canadian oats exported via the Thunder Bay terminals were impossible to achieve. Barley is similar in size to oats and therefore slips through the pre-milling cleaning process. After processing, the flakes of the barley hull were very evident in the final oats products.

Low protein levels and inconsistency of sound count caused the U.S. buyers to bid down prices. Instead of being rewarded for a high quality product, producers in Manitoba and Saskatchewan were paid based on lower grade oats. The solution to the problem lay within the realm of tighter grade specifications. The massive logistics system inherent within the central desk marketing system was unable to solve these problems, holding back the development of oat production, processing and exports. The problems were further intensified by transport subsidies under the WGTA. For a while, it made more sense to direct trains on a round about route through Thunder Bay than to send them directly from origin to destination.

Open Market: New Participants, Efficiency and Integration

The period since 1989 has produced oats traders and dealers in Canada who did not exist when the board was in control. A set of marketing alternatives has been developed for farmers, and there has been significant specialized oat marketing capacity developed within most grain companies.

The removal of oats from CWB jurisdiction also paved the way for the Canadian Grain Commission (CGC), in response to private industry's request, to bring Canada's grading system for oats more in line with the U.S. markets. This has allowed Canadian producers to capture premiums the U.S. market is willing to pay for specific qualities. In recent years, the private trade has gone beyond the CGC grade standard in some cases by responding to end-user needs for specific qualities. These qualities are paying premiums to producers (Morrissey, 1996).

Mills from both Canada and the U.S. actively contract prairie farmers for delivery of high grade human consumption oats. "System charges on CWB grains were higher than they would be in a competitive system. Grain handlers have observed a drop in marketing costs on oats of about one third following the deregulation of that market in 1989." The above quote from the *Western Producer*, attributed to grain industry representatives, depicts how the lack of competition reduces farm prices.

On-farm contracting that pays premiums for high quality oats have caused producers to look again at the market potential of this crop as a viable contribution to their income. New incentives under the open market have also resulted in a greater number of oat varieties growing in regions where traditionally oats were planted only as a utility crop.

"The removal of oats from the control of the CWB in 1989 was an important step that allowed free markets to evolve. Today, the oat markets in the U.S. and Canada are more closely integrated than most other commodities. The favorable exchange rate of the Canadian Dollar has also made imports attractive, while Canada has produced more consistent supplies of high quality oats than the U.S. The increase in oat imports from Canada reflected long-term trends of more integration of the countries' grain economies." (USDA/ERS, 1997)

The open market has provided Western Canadian oat producers with the opportunity to increase revenues by forward contracting directly with end-users. For example, Manitoba's annual farm cash receipts from oats totaled $91.8 million in 1996, rising from $18.5 million in 1992. Manitoba's contribution to Canadian oat receipts rose from 18.9 percent in 1992 to 29.1 percent in 1996. This implies that annual farm cash receipts from oats for Canada increased from $98 million in 1992 to $315 million in 1996.

Geographical Pattern: Quality, spatial Proximity and the WGTA

The combination of higher quality, spatial proximity and the removal of the WGTA explain the shifts of oat production, procurement and exports from northern Alberta to eastern Saskatchewan and southwestern Manitoba.

Transport subsidies under the WGTA had the effects of (1) lowering the overall freight costs for producers, (2) distorting the comparative advantage, and (3) encouraging transshipment through Thunder Bay. With the removal of subsidies, Manitoba and eastern Saskatchewan regained their advantage in terms of spatial proximity and, thus, lower transport costs for direct shipments to U.S. markets, while the disadvantage for Northern Alberta became extremely obvious. The geographic proximity to the leading importing markets in the U.S. gave producers in southern Manitoba and eastern Saskatchewan

substantial cost advantage relative to those in Alberta.[3]

The disadvantage of oat production in Alberta has been intensified by the advantage of wheat and barley production relative to oats in the province. Wheat and barley exports have been dominated by Western Coast ports and Alberta's spatial proximity to these ports implies relatively higher local prices for wheat and barley.

Another important factor contributing to the changes in geographical pattern of oat production and exports is the difference in quality, which becomes crucial in specification buying. As mentioned previously, major oat producing districts in Manitoba and Saskatchewan are in a much better position to supply oats and oat products with the required specification such as high protein content, higher sound count, lower moisture level and desirable groat size.

Oat Processing in Western Canada: Transport Costs Driven

Expansion of oat processing capacity in Western Canada contributed to the fast growth in exports of oat products. Data from Agriculture and Agri-food Canada show that three new plants have been built and one was expanded in Western Canada since 1987. The number of oat processing facilities in Western Canada, thus, increased from 4 to 7 and the capacity expanded from 332 tonnes per day to 1,142 tonnes per day. Meanwhile, the number of oat processing plants in Ontario increased from one to three, and the capacity grew from 145 to 380 tonnes per day.[4]

Increased oat processing capacity, in general, is associated with the recognition of oats as a health food. The economics of transportation however, have driven the expansion of oat processing capacity in Western Canada. Most oat

---

[3]According to Leo Quigley's report in *Feedstuffs*, "the incentive to shift the acreage to oats eastward has been provided by $10-15 (Canadian) differential in the freight bill between Manitoba and Alberta."

[4]Agriculture and Agri-food Canada, Canada: Primary Processing of Grains and Oilseed, Winnipeg, July, 1997. The new and expanded Western Canadian facilities locate in Portage La Prairies, Edmonton, Saskatoon, and Barrhead. A plant owned by Ogilvie Milling in Winnipeg burnt down in 1992.

processing in Western Canada involves the production of groats, which is simply the removal of the oat hulls. This increases the density, as well as the value of the product, and makes "oats" more economic to transport. After processing, much of the goats are shipped from Western Canada to oat millers closer to the end users in the U.S. Freight savings from hauling goats, rather than oats, can reach $20 per tonne.

Customer Service Level: Shipper/Carrier Direct Negotiation

With the removal of oats from the CWB jurisdiction, oat movements to the U.S. are in a more flexible and efficient commercial environment where prices and service levels are negotiated directly between shippers and carriers. A new arrangement of oat transport to the U.S. markets was cited by the Canadian Pacific Railway Company (CPR) as a model to illustrate the efficiency gains from shipper/carrier negotiation in serving customers.[5]

"There is a demand for freshly harvested Canadian oats to be shipped directly to the U.S. mills. This demand occurs at peak season when all other grains are moving, thereby creating a traffic problem. Direct discussion between the shipper and carrier, however, came up with a solution. Starting in 1996, in addition to running its regular trains to serve other regular orders, CPR offered to run a separate train to pick up oats (called Oats Express). Once loaded with oats, the train heads directly to mills in the U.S. This makes room in the elevators and on the farms for other grains. The turn-around time improved from 30 to 7 days. It satisfies the end-use customer, and gets the oats sold for quick cash to the farmers."

Conclusions

Two major logistical factors have contributed to the locational changes of oats production in Western Canada. First, the removal of subsidies made proximity to markets more important and halted the perverse routing over longer, but subsidized, traffic lanes to end markets. Previously, oats were hauled by rail eastward (mainly from Northern Alberta) to Thunder Bay, transferred to lakers and moved to U.S. ports such as Duluth, then by rail to inland terminals such

[5] Canadian Pacific Railway. Moving Canadian Grain, Submission to Justice Estey Review, 1998.

as Minneapolis. U.S. oats markets had been relatively attractive to Alberta producers due to the WGTA subsidies on grain transport from primary elevators to Thunder Bay. With the subsidies gone, the returns to Alberta producers were lowered relatively more than Saskatchewan and Manitoba producers.

Second, processors' requirements for higher, more consistent quality and more sophisticated specifications, demanded a decentralized marketing system to satisfy end-users. Competition for the highest production quality provided incentives to growers with the best agronomic conditions. Under the new institutional arrangements, routes from various Prairies locations, through Pembina, to the major central Midwest U.S. markets became more competitive. Moreover, small merchandisers located on the eastern prairies have the option of using trucks which effectively caps the rail rates for direct shipments.

An open market system with more flexibility stimulates and facilities route shifts to meet processors' requirements for quality and specification. This is achieved through competition among smaller traders and dealers, on-farm contracting, direct shipper/carrier negotiations and higher prices. The success of oats may not be as easily repeated in larger volume crops such as wheat and barley, but it certainly presents a challenge for reform to the current highly centralized marketing system.

References

1. Agricultural and Agri-food Canada. 1995 - 1998. Oats: Situation and Outlook. Winnipeg.

2. Agricultural and Agri-food Canada. 1998. Western Canadian Diversification and Agri-food Processing Since 1995. Winnipeg.

3. Agriculture and Agri-food Canada. 1997. Canada: Primary Processing of Grains and Oilseed. Winnipeg.

4. Canadian Pacific Railway. 1998. Moving Canadian Grain: Growing together in a Business Climate. Submission to the Estey Review.

5. Census Bureau. 1998. U.S. Imports/Exports History: 1993-1997, The U.S. Import and Export History database.

6. Estey, Willard Z. 1998. Grain Handling and Transportation Review: Final Report.

7. McKinsey & Company. 1998. Improving the Western Grain Logistics System.

8. Morrissey, Robert W.R. 1996. Economic Impacts of the Privatizing The Marketing of Canadian Oats. Master of Science Thesis, University of Manitoba.

9. Statistics Canada. 1999. Canadian International Merchandise Trade - Exports.

10. USDA/ERS. 1997. North American Free Trade Agreement: Oats.

11. Wilson, William W. 1998. U.S. Grain Handling and Transportation System: Factors Contributing to the Dynamic Changes in the 1980s and 1990s.

Merging CN and CP

A Proposal for the Improvement in Grain Movement

Rory Hart
Student; Certificate in Logistics Program, University of Manitoba
Student; Canadian Institute of Traffic and Transportation

Introduction

The premise of this research paper is to combine both Canadian National Rail (hereafter referred to as CN Rail), and Canadian Pacific Rail (hereafter referred to as CP Rail), in the movement of grain trains in one-way circular movements. All loaded grain cars to be staged and sent west via one main line and all empties to return via another main line. This research paper will examine the logistics of this endeavor and address the cost/benefit of combining CN Rail and CP Rail in the summary.

Prelude

CN Rail and CP Rail have a past history of combining forces to achieve a single goal. An example of this is CN/CP Telecommunications, which was formed in 1980 and dissolved in 1988, when CN Rail sold its' 50% share to Canadian Pacific Limited. As well CNCP Ottawa Valley established a single railway of over 370 miles between De Beajeau, Quebec and Yellick, Ontario in 1993.

This was made possible by the legislation at the time. The Canadian government was already establishing policy that would enable CN and CP Rail to join together in partnership to further increase efficiencies in rail transportation.

Subsection 158 (1) of the National Transportation Agency, 1987, (N.T.A.) states that "subject to the approval of the N.T.A., a railway company may enter into an agreement with any other company, whether within legislative authority of parliament or not, to sell, lease or otherwise transfer to the other company a line of railway or a segment thereof".[1]

Subsection 158 (2) of the N.T.A., 1987 states, in part, that "on entering into an agreement referred to in subsection 158 (1) in respect of a line of railway or segment, the company shall give notice in writing of the agreement to the Agency and give such notice as the Agency may direct".[2]

The purpose of the agreement was "to effect economies while providing for customer-oriented operations". As well there was an inclination that this might act as a model for future partnerships between CN and CP.[3] Most importantly, many significant changes have taken place in rail transportation in Canada since July 1995.

In August 1995, The Canadian Government repealed the Western Grain Transportation Act of 1897 deflecting the total cost of grain shipments onto the shippers.

CN became a private company on August 24, 1995 and began selling shares November 28, 1995 on the open market.

On July 1, 1996 The Canada Transport Act came into effect. This act is intended to introduce a less restrictive regulatory environment for Canadian Railways and

---

1 National Transportation Agency. November 1993 P. 2.

2 Ibid

3 Ibid

will consolidate railway legislation currently found in several different acts. This will be done to "simplify or eliminate many outdated and unnecessary provisions concerning corporate governance and rail operations, more streamlined process for the conveyance of railway lines, allowing for abandonment of undesirable trackage in less time and regulatory wrangling".[4] Subsequently, and in respect to the deregulation of the railway industry in August 1995, CP Limited announced the plan to allow the railway to become a separate company, rather than an operating division of CP Limited. This would "allow the railway the ability to raise capital on its' own; more flexibility in the commercial markets and allow for merging, joint ventures and sales to take place unhindered".[5]

STUDY ELEMENTS

Primary Elevators

The number of primary elevators in Western Canada is shrinking. 140 fewer primary elevators were in use on the prairies and one less in British Columbia from 1995 to 1996.[6] See Appendix 1.

New high through-put elevators are replacing the smaller regional elevator. These new elevators have the capacity to load and sort up to 52-54, or doubling up, 104-108 cars at any one time. These elevators make it easier for trains to pick up and spot cars, and reduces man-hours considerably. Now two such large through-put elevators can make up one grain train in less time, and if reasonably

---

[4] Ibid
[5] C.P. Limited 1995 Annual Report
[6] Statistics Canada Grain Trade in Canada P 91

close together (60 kilometres apart), reduce the amount of fuel and distance traveled by rail.

Motive Power

Combining the two class I railways motive power, there are close to 3,000 diesel engines split evenly between the two companies. CN has 1,643 diesel locomotives, 1,302 in freight service and 341 in yard service only. CP has 1,216 of which 967 are diesel freight units and 249 are yard units. [7]

In the event of a merger for the movement of grain products, a portion of each fleet could be set aside and designated for grain traffic only. Each carrier would look after their own units, and when necessary the locomotive units of the other partner as part of a common pooling of equipment.

Both CN and CP are modernizing their fleets. CP in 1995 ordered additional 83 new locomotives.[8] CN has additional 125 diesel locomotives ordered through General Motors as well in 1996.[9]

These new units are high output engines capable of 4,000 horsepower each. These locomotives could be assigned to grain traffic to ensure the least amount of motive power is disrupted from the rest of the freight traffic during peak grain handling period (fall and spring). Three new 4,000 horsepower engines could replace four older 3,000 horsepower units.

Hopper Cars

CN has 20,530 hopper cars in its fleet, while CP has 17,883 hopper cars[10]. The Canadian Wheat Board (C.W.B.) has an additional 2,500 government cars

---

[7] Statistics Canada Rail in Canada, 1995 P 56
[8] CP Rail 1995 Annual Report
[9] CN Rail 1996 Annual Report
[10] Statistics Canada Rail in Canada 1995 P 56

according to a C.W.B. spokesperson.[11] Total for the industry excluding class II and III railways is 40,913.[12] See Appendix 2. Hopper cars make up 35.7% of all freight cars in services.[13] See Appendix 3. In the event of a merger between the two class I railways for the purpose of grain movement, these hopper cars could be cycled independent of the owner, with the cars being used on a first come first serve basis.

Thus CP would pick up CN hopper cars and CN would pick up CP hopper cars. This has an added advantage in that train and yard crews would not have to sort out grain cars. A grain car is a grain car . . . etc. This would save time and money for both companies.

Fuel Consumed

For the four western provinces, diesel usage for CN in 1995 was 444,608 ('000 litres). For CP the total was 583,4111 ('000 litres).[14] See Appendix 4. A further breakdown would be required to find out what percentage went to the transportation of grain products.

Rail Lines

CN and CP account for 88.6% of owned track and 75.5% of lines jointly owned or operated under lease, contract or trackage rights.[15]

A closer look reveals that CN has 8,650 KMS. of main line in Manitoba, Saskatchewan, Alberta and British Columbia. CP has 6,404 km's of main line in

---

[11] Canadian Wheat Board 1998
[12] Statistics Canada Rail in Canada 1995
[13] Ibid
[14] Ibid
[15] Statistics Canada Rail in Canada 1995 P44

the same corresponding provinces.[16] See Appendix 5.

As well CN owns 58% of the total trackage and leases another 26.6%. CP on the other hand owns only 30.5% of the total trackage and leases and additional 49%.[17]See Appendix 6.

According to Rail in Canada 1995, CN also owned 10,634 km's of branch lines while CP owned or leased 8,688 kms of track in Canada.

A merger in grain movement would reduce the use of unproductive trackage for both railways. Interchange sites could be used to reduce the back peddling of cars to major yard sites for switching.

The rail link is probably the most important component if a merger were to take place. Access between the two class I carriers is paramount for success. CN and CP interchange traffic in Winnipeg, Regina, Calgary, Edmonton, Kamloops and Vancouver. Other interchange sites are Emerson, Brandon, Portage, in Manitoba and Yorkton, Saskatoon, Moose Jaw and Watson in Saskatchewan. There are also branch line routes for interchanging between Regina and Saskatoon, Calgary and Edmonton.

CP Rail's branch line network has access to the prime southern wheat growing areas of the Prairies, while CN Rail runs a more northerly route, and hence, does not capture as much of the higher quality wheat traffic.

CN Rail does, however, offer a more gradual approach to the coast of British Columbia. Grain trains go thorough Jasper, Alberta, thereafter branching north to Prince George and on to Prince Rupert, or, south through Kamloops to Vancouver. This gradual approach becomes significant when we look at the difficulties of traversing the formidable Rocky and Selkirk Mountains.

---

[16] Ibid
[17] Ibid

Peak Loading

Grain products only account for 14 of CN's and 20% of CP's freight traffic. But this is taken over a calendar year. The peak period for grain movement is from September to May. During this period, the amount of grain traffic plays a larger role in the logistics of freight movement. CN and CP would not comment on precise figures due to the rivalry between the two companies.

At present grain trains are not designated a priority in traffic. Priority traffic are containers, auto carriers and other goods that are time sensitive. Grain traffic must compete for track usage and priority with all other traffic. For a merger to take place and be successful, grain traffic would need to be given a higher priority in routing to the West Coast as loads. An equal consideration for the empties on return to the primary elevators of the prairies is also necessary to keep cars in cycle moving fluidly.

Staging of Trains

It is understandable that by using one-way directional flow that there will be bottlenecks on line and possibly at terminals in Vancouver. Grain traffic would have to complete with other freight traffic of the company whose network is being used. How much grain traffic will get through unhindered would essentially depend on the sincerity of CN and CP to make the merger work to its' most efficient level.

Each railway is modern, using the latest technology available in regards to signals and communication, engineering and maintenance, and on-board computer monitoring of trains. It is possible, especially on CP's dual trackage to move grain trains, one after the other through centralized traffic control (C.T.C.) blocks. Other freight traffic need not be hindered any more than it is presently. The reason for this is that trains will only flow one-way as opposed to the

present two-way traffic on CN and CP tracks. With foresight and advance knowledge of trains departing, rail traffic controllers for both companies can adjust traffic to regulate an even flow for all traffic. When traffic congestion becomes high, grain trains can be left in sidings, crews changed out, and after congestion clears, may proceed west or east as may be the case.
Another method of staging requires grain trains to remain in rail yards until such time that they may proceed without contributing to rail congestion on line.

Employment

1995 employment for class I carriers (CN and CP) amounted to 46,153.[18] Refer to Appendix 7.
The percentage of those in the running trades make up 24.7% or 11,406 combined CN and CP. The average compensation for these employers is 62,241 the second highest overall, next to management.[19]
The transportation employee of the late 1990's is a well re-numerated, motivated person who puts in long hours of service. CN has 8,932 personnel in Transportation, while CP has 7,061.[20]

Benefits and Costs of Proposed Merger

This proposal is to increase our efficiency as an exporting nation in bringing grain products to world markets. By combining resources it is hoped that CN and CP would generate more revenue for themselves than separately. This would be the key motivation for these two class I railways to merge for the transportation of grain products.

---

[18] Statistics Canada Rail in Canada 1995 P 64
[19] Ibid P 60
[20] Ibid

This paper proposes that each company would receive a certain aggregated weight for revenue depending on past performance, market share, personnel, motive power, and infrastructure. In the same regard, each company would share in an aggregated weight cost for operational, financial, and logistical costs. These weights cannot be calculated as there has been no participation in this research paper by the two rail companies. There is not enough information to make a critical decision as to who would gain or lose or in what areas.

Benefits would be:

- Reduced shortages for hopper cars.
- A dedicated rail program for the movement of grain products and cars to ensure timeliness.
- A reduction in duplication of duties by both companies. A joint CNCP grain marketing division could be implemented, reducing personnel costs.
- Joint sharing of market information regarding the timeliness of grain products with the Canadian Wheat Board and importing nations.
- Reduce litigation costs with C.W.B. for "poor performance on un-met target unloads".
- Increase the efficiency of grain movement to port thereby signally to the world that Canada has in place a systemic, reliable, and dedicated mechanism to meet their import needs.
- The possibility of setting forth select product trains; i.e. single quantity/single quality trains to increase efficiency.
- The merger may increase large through-put primary elevators to locate where access by either rail company is advantageous. For example, twenty-five high output primary elevators at strategic locations on the prairies complemented by smaller regional elevators for producers outside of the

60kg ring would reduce rail transportation time in loading/unloading and would increase the number of cars loaded at each elevator.

Costs to the System

Merging the two rail systems would not be easy. There would be many logistical problems to overcome. These are:

- Transference of loaded grain cars from CP to CN for shipments heading west. Where to interchange traffic? How much traffic can these interchanges handle at the present time? What about restructuring to meet expected traffic flow?
- Timeliness of traffic from CP to CN and vice versa. Is it logistically possible to transfer all loaded hopper cars onto one main line from another main line, and two branch line systems? Is it economically feasible?
- Again, only in reverse for empty hopper cars to be dispersed from one main line into two branch line systems and another main line. What will it cost in additional time, infrastructure, and loss of competitiveness to merge in this fashion?
- Motive power and fuel. Would CN rail settle for a shared cost of fuel and use of locomotives to carry all the loads west through the mountains to Vancouver? What would be the cost in terms of returning empties via CP's main line? Would more fuel or less fuel be needed to operate grain transportation in this manner?
- Employee costs - CN has a higher average wage per year than CP. Would these work forces accept the concept of merging grain traffic into one system? Would CP employees cost more to CP as compensation for such an agreement?

- Cost to producers - Would such a merger reduce the competitiveness of the industry such that the producers would pay more to move their products? Another way of looking at this is to suggest that producers may not gain at all in such a merger if the reduction in operating costs are not passed back to the producer.
- Government intervention - With such a merger, the government may step in with regulations to prevent such mergers from happening. Also regulations may be put in place such that it becomes uneconomical to proceed down this course. The strongest reason for increased regulation would be to ensure producers were included in the economic benefits of merging. Lower transportation costs for grain products would have to be in place for the producers if the regulatory agencies are even going to look at such a possibility of a merger.

Conclusion

The movement of grain products from the prairies to terminal ports in Vancouver or Prince Rupert could effectively be changed by such a merger. I would expect to see a reduction in the car cycle time from approximately 21-22 days from elevator to elevator down to a reduction of 18-19 days, based on the operational aspects of interchanging hopper cars, and the increase in high through-put elevators. It is hoped that by using CN as a carrier for loads to the coast, that, because the gradient is less on the rail bed, time and fuel will be saved taking loads to the ports. This increase can come about by the use of new high horsepower engine. By utilizing CN's more advantageous grade, less horse power will be required to pull a loaded grain train through the mountains than by using CP as the main carrier of loaded grain cars. As well, empty grain cars do not require as much horsepower to move. By using CP's main line for

returns, we can nullify the grade factor for the returns east. This saving is significant if you look at the fact that both companies are already duplicating the same service right now. Therefore, the aggregate cost savings in fuel, locomotives and time make the project worthwhile to study more closely.

CN has a larger percentage of rail network, personnel, and newer locomotive power. Also CN uses less fuel and power to move its freight over its tracks. CP has better access to prime growing areas for wheat in each prairie province. CP's double track system does well as traffic can flow relatively unhindered.

The benefits of a merger between CN and CP would be unfettered access for hopper cars, motive power, rail lines and a motivated work force within both transportation departments.

The main emphasis for this undertaking is to increase our world market share, by bringing a competitive grain product to market in a safe, efficient, and economical transportation system. By using this approach, I feel that the benefits out weigh the costs, but that regulatory requirements may prohibit a merger of this magnitude in the rail industry in Canada. As well, the competitive nature of the railways may not allow them to realize that more can be gained together than apart.

Bibliography

Canadian National Railway: 1996 Annual Report, Montreal, Quebec: 1997

Canadian National Railway: 1997 Employee Review, Employee Communications Services, Montreal, Quebec: 1998

Canadian Pacific Railway Limited 1995 Annual Report, Montreal, Quebec: 1996

Patty Parsons, Transportation Analyst, Canadian Wheat Board
Winnipeg, Manitoba 1998

National Transportation Agency of Canada: Decision No. 798-R-1993
Queens Printer for Canada, Ottawa, Ontario 1996

Statistics Canada: Grain Trade in Canada 1995
Queens Printer for Canada, Ottawa, Ontario 1996

Statistics Canada: Grain Trade in Canada 1996
Queens Printer for Canada, Ottawa, Ontario 1996

Statistics Canada: Rail in Canada 1994
Queens Printer for Canada, Ottawa, Ontario 1995

Statistics Canada:
Rail in Canada 1995
Queens Printer for Canada, Ottawa, Ontario 1996

Appendix 1

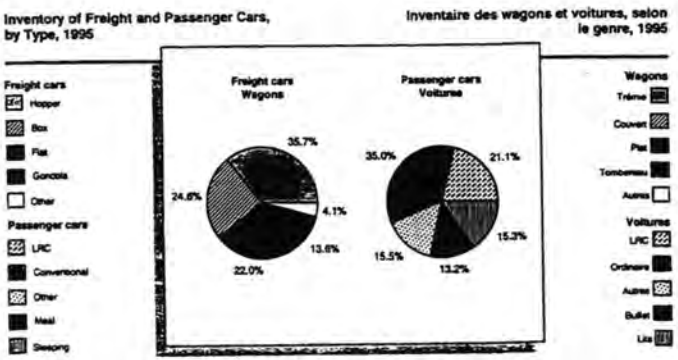
Number of elevators by province	Year	Primary elevators	Terminal	Process	Transfer	Total
Maritimes	1995	-	-	-	1	1
	1996	-	-	-	1	1
Quebec	1995	-	-	-	6	6
	1996	-	-	-	6	6
Ontario	1995	-	9	1	7	17
	1996	-	7	1	7	15
Manitoba	1995	236	1	6	-	243
	1996	220	1	6	-	227
Saskatchewan	1995	709	2	5	-	716
	1996	656	-	7	-	663
Alberta	1995	388	-	10	-	398
	1996	317	-	10	-	327
British Columbia	1995	7	6	-	-	13
	1996	6	6	-	-	12
Total	**1995**	**1,340**	**18**	**22**	**14**	**1,394**
	1996	**1,199**	**14**	**24**	**14**	**1,251**

Appendix 2

Inventory of Freight Cars in Service

Item	Canadian National	Canadian Pacific	Total Class 1
Box	15,694	8,543	24,237
Hopper	20,530	17,883	38,413
Gondola	6,204	4,126	10,330
Refrigerator	14	17	31
Flat	11,955	7,465	19,420
Stock	2	17	19
Caboose	213	251	464
Other	3,167	3	3,170
Total	**57,779**	**38,305**	**96,084**

Appendix 3



Appendix 4

Diesel Fuel Consumption by Province or Territory

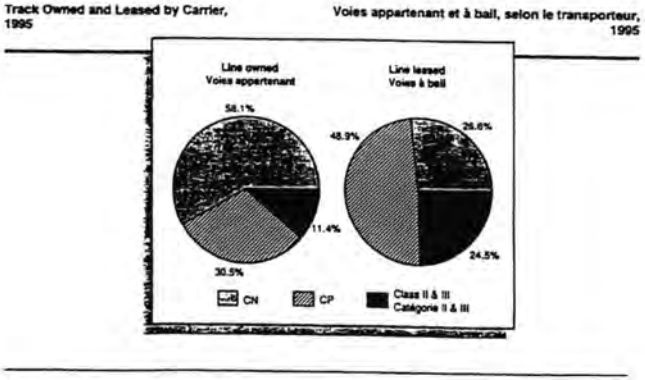
Province	Canadian National Diesel '000 litres	Canadian Pacific	Via Rail	Total Class 1
Newfoundland	-	-	-	-
Prince Edward Island	-	-	-	-
Nova Scotia	9,479	1,646	11,125	
New Brunswick	31,273	-	2,653	33,926
Quebec	99,653	21,378	12,333	133,354
Ontario	281,533	284685	20,167	586,385
Manitoba	92,633	67,070	4,339	164,042
Saskatchewan	78,566	120,265	2,321	201,152
Alberta	110,840	129,053	2,156	242,049
British Columbia	162,569	267,023	3,693	433,285
Yukon	-	-	-	-
Northwest Territories	226	-	-	226
United States	17,316	263	-	17,579
Total	**884,088**	**889,738**	**49,308**	**1,823,133**

Appendix 5

Length of Track Operated by Area at December 31, 1995 in Kilometres

Area	Canadian National	Canadian Pacific	Via Rail	Total Class 1
Newfoundland	-	-	-	-
Prince Edward Island	-	-	-	-
Nova Scotia	305	-	-	305
New Brunswick	949	-	-	949
Quebec	2,685	558	-	3,243
Ontario	6,347	4,470	-	10,816
Manitoba	1,646	1,111	-	2,756
Saskatchewan	1,913	1,804	-	3,717
Alberta	2,701	1,744	-	4,445
British Columbia	2,390	1,745	-	4,135
Yukon	-	-	-	-
Northwest Territories	-	-	-	-
United States	111	-	-	111
Total	19,047	11,432	-	30,479

Appendix 6



Appendix 7

Summary Statistics on Employment by Occupational Classification, Class 1 Carriers, 1995

Occupation classification			Service hours	Compensation		Average hours	Average compensation	
	No.	%	'000	$000	%		hr	year
Managerial supervisory	4,443	9.6	9,608	321,565	13.3	2,163	23.0	72,376
Professional scientific technical	6,073	13.2	13,232	339,990	14.1	2,179	25.7	55,966
Clerical	5,531	12.0	12,458	221,716	9.2	2,252	17.8	40,086
Running Trades	11,406	24.7	32,010	709.920	29.4	2,806	22.2	62,241
Working Foreman	1,631	3.5	3,968	80,195	3.3	2,433	20.2	49,169
Craftsman Tradesman service workers	14,888	32.3	34,847	663,786	27.5	2,341	19	44,585
Labourers including building attendants coach cleaners	2,177	4.7	4.930	78,641	3.3	2,265	16.0	36,123
Floating equipment employees	4	-	10	227	-	2,489	22.8	56,727
Total	**46,153**	**100**	**111,063**	**2,415,930**	**100.0**	**2,404**	**21.8**	**52,346**

Aging, Independence and Vehicle Use in Small Towns and Rural Areas

Irwin Bess
Transportation Division, Statistics Canada

1. Introduction

In recognition of the rapidly aging populations in many industrialized countries, the United Nations General Assembly has declared 1999 the International Year of Older Persons. Governments, community agencies and researchers are using the occasion to foster awareness among all generations of issues pertaining to seniors and the important role that they play in society. In Canada, an important issue for many of the 3.2 million seniors age 65 and older is maintenance of an independent lifestyle, which, in terms of mobility and day-to-day transportation, often means access to a private vehicle and the ability to drive. It is estimated that 8% of Canadians holding valid licenses in 1996 were between the ages of 65 and 74, and 4% were over age 75.[1] Data from the 1996 National Private Vehicle Use Survey (NAPVUS) indicate that two-thirds of non-institutionalized seniors were licensed and about 1.7 million were actually driving the household car, mini-van or light truck. The older driver segment is expected to expand as the proportion of the population aged 65 or older increases from its current level of 12% to about 23% by the year 2030 as men and women born between 1946 and 1965 (the baby boom generation) join the ranks of Canada's elderly (Belanger and Dumas, 1998). In this context, the issue of population aging has substantial implications for transportation planning and road safety.

Despite the financial costs of owning a vehicle and potential health limitations, many seniors rely on their ability to drive to maintain an active lifestyle. Having a

[1] Data source: Provincial motor vehicle license authorities and 1996/1997 National Population Health Survey.

household vehicle makes it possible for older men and women living alone or with others to see their friends and family frequently and to attend personal appointments and recreational activities. This is particularly the case outside of large urbanized areas where there may be very little or no public transit, taxi or special needs transportation. In fact, close to one-third (30%) of seniors who were licensed to operate a motor vehicle in 1996 lived in communities with populations under 30,000 people or in rural areas. Using data from a number of Statistics Canada surveys, this paper examines various facets of car use among seniors living outside large urban areas. A review of the financial costs of car use and the effects of aging on driving performance is followed by a discussion of the relationship between vehicle use and the living arrangements of seniors in small towns and rural areas.

2. Factors affecting car use in rural areas and small towns

2.1 Transportation options and frequency of vehicle use

Unlike residents of large cities who may have access to different forms of transportation, seniors living outside of large urban centres tend to have far fewer transit options and may not live within walking distance of their family, friends, physician or shopping. Researchers have found that having few opportunities to use public transportation forces many small town and rural seniors to be *independently* mobile, but highly *dependent* on the private vehicle for accomplishing day-to-day tasks and activities (Hodge, 1993). One activity for which this may be the case is grocery shopping, which often requires use of a vehicle, particularly in rural areas. According to the 1996 General Social Survey, one in five seniors in rural areas live more than a 30 minute walk or a bus ride away from the nearest grocery or convenience store, yet only 10% of these individuals relied on someone else for help with their shopping and transportation needs.

Most seniors drive only a few times a week, although rural drivers tend to travel the farthest of any group (16.5 km per day on average) (See Table 1). According to the NAPVUS data, seniors in small towns and rural areas use their vehicle most often for shopping, personal appointments such as visiting their family or physician, and social activities. Relatively few older drivers outside large urban centres made long distance trips or used the vehicle for picking up and dropping off other people (see Figure 1). Nevertheless, the most important determinants of whether a senior will be a driver or passenger remain financial resources and health limitations.

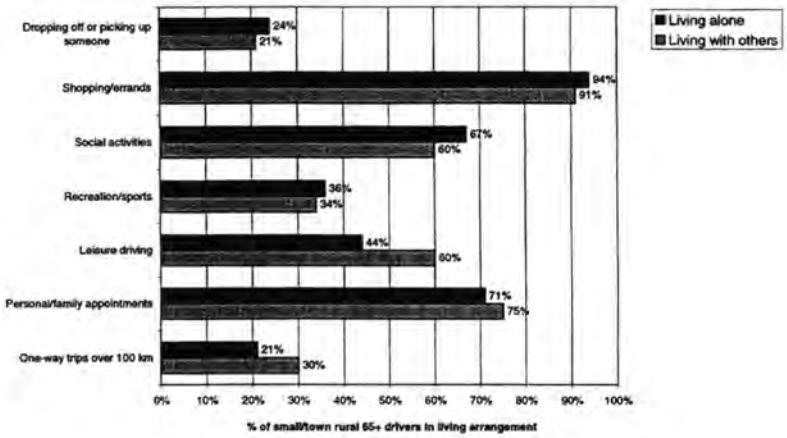
Table 1

Percentage distribution of vehicle use, drivers age 65+ by size of residential area

Frequency - household vehicle use (during 30 days prior to survey)	Urban > 500,000	urban 30,000 - 500,000	Urban under 30,000	rural
Every day	35%	39%	34%	27%
A few times a week	56%	56%	55%	61%
Week days or weekends only	2%	1%	6%	2%
Less than once a week	7%	4%	5%	10%
TOTAL	*100%*	*100%*	*100%*	*100%*
Total drivers aged 65+	*594,100*	*407,246*	*205,895*	*236,415*
Average kilometres driven/day	15.8	13.72	11.1	16.5

Data source: National Private Vehicle Use Survey, 1996

Figure 1 - Reasons for use of household vehicle(s) during 30 day period prior to survey, by living arrangement -senior drivers in areas with less than 30,000 people



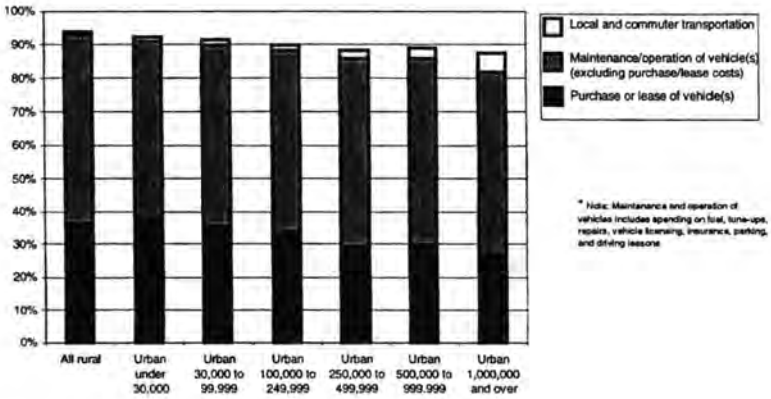
2.2 High cost of automobile ownership and maintenance

Owning and operating a private vehicle can be a costly proposition at any age. Data from the Family Expenditure Survey show that licensing and insuring a car and keeping it fueled and properly maintained account for about two-thirds of the average annual total cost of its ownership and use. In 1996, Canadian households headed by persons between the ages of 65 and 74 spent approximately $4,100 or 12 cents of every dollar of their budget on the purchase and operation of a car or truck.[2] Seniors age 75 or older, who are far less likely to drive, spent less. Households headed by seniors age 75 or older spent an average of $1,800, making payments, maintaining and operating their automobiles. However, despite their lower average household incomes; residents of small towns and rural areas spend (on average) far less of their household transportation budget on public transportation and more on the purchase

[2] In 1996, the average Canadian household (all ages) spent an average of $5,500 a year to operate and maintain household vehicle(s).

and operation of private vehicles compared to residents of larger urban centres (see figure 2).

Figure 2 - Proportion of Average Household Transportation Expenditures on Transit or Vehicles, Canada - 1996 Family Expenditure Survey*



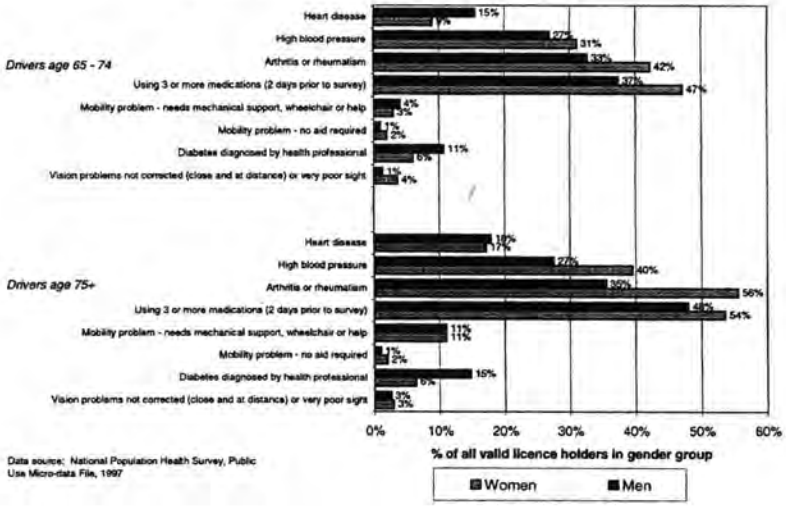
2.3 Aging and Health limitations

In addition to cost, age-related health limitations also become a concern in some instances. The physical and sensory capabilities of an effective driver can be described in terms of four sequential reflexive tasks. Drivers must be able to see or hear a situation developing, recognize it, quickly decide how to respond to the situation and then execute any appropriate driving maneouvres (TRB, 1988). Medical research shows that most sensory and cognitive conditions affecting the ability to effectively perform these tasks such as reduced vision, arthritis or rheumatism, can begin after age 55 and tend to accelerate beyond that age, often without the driver being fully aware of such changes (TRB, 1988). By age 65, men and women are more likely to experience some reduction in visual acuity, hearing ability, and physical strength, potentially restricting their ability to safely operate a vehicle. A number of clinical research studies have also linked the onset of specific stages of

Alzheimer's disease or dementia with increased risk of collisions where older patients under study were driving alone (Fitten et. al. 1995; Shua-Haim and Gross, 1996). Furthermore, multiple medical conditions and use of several prescription medications at any given time has the potential to affect performance, perhaps resulting in the loss of a crucial fraction of a second in reaction time needed to avoid an accident.

Although the 1996/1997 National Population Health Survey (NPHS) does not distinguish between licensed drivers of vehicles and those who do not drive but hold licenses; the survey provides an indication of the health limitations affecting the current pool of potential motorists aged 65 or older. For example, according to the NPHS nearly one-half (48%) of men and more than one-half of women (54%) over age 74 were regularly taking at least three different medications in the two days prior to the survey (See Figure 3). The survey also revealed that 56% of women and 35% of men over age 74 suffered from chronic arthritis or rheumatism which could make sharp turns or merging with heavy traffic particularly challenging.

Figure 3 - Percentage of senior licence holders with selected health limitations, by age group and sex - Canada, 1997



Data source: National Population Health Survey, Public Use Micro-data File, 1997

Older drivers tend to take a number of measures to compensate for age related limitations by driving shorter distances and by avoiding night driving, busy highways and downtown areas. This could be especially important on inter-city and rural routes with posted speed limits in excess of 60 km per hour, where a high-speed collision is likely to result in severe injuries to older drivers (see Appendix-A). In fact, according to Transport Canada data, about three-quarters of fatalities involving drivers age 65 or older in 1996 occurred on roads where the speed limit exceeded 60 km/hr.[3] However, the high rate of fatalities on these roads may not only be a function of their speed limits. Roads with speed limits in excess of 60 km/h tend to be situated outside of highly built-up urban areas where poorer visibility, sparse lighting, and reduced traction during winter months demand a high degree of concentration and performance.

The health and accident profile of seniors has resulted in debates about the relationship between aging, driver performance, and road safety. One view is that seniors should drive as long as they maintain their driving skills and meet certain medical requirements. A number of provinces have instituted mandatory medical examinations or road tests after age 75 while others have relied on discretionary measures on the part of law enforcement agencies, physicians, families or the public.[4] On the other hand, there is concern that such measures may discourage seniors with the appropriate skills and physical ability from driving and increase their dependence on others for their mobility needs, particularly among those living alone in smaller towns and rural areas. For experienced older drivers who may have safely operated a vehicle for many years, giving up driving or going through the license renewal process (which may require taking a road test) can be a very stressful and a potentially traumatic experience. Research has found that seniors who give up driving may be reluctant to ask for help with transportation around the community,

[3] Transport Canada. Custom tabulation fatalities drivers age 65 and older by place of occurrence for 1996.
[4] Seniors may also have the option of taking refresher training such as the "55 Alive Mature Driving Program" which is designed to ensure that older drivers realize their limitations and compensate for age-related changes in physical condition including road safety and collision prevention measures.

resulting in periods of inactivity, feelings of loneliness or loss of control, which can be detrimental to their general health and well-being (Yassuda et. al., 1997).

3. Household vehicle use among marital status groups

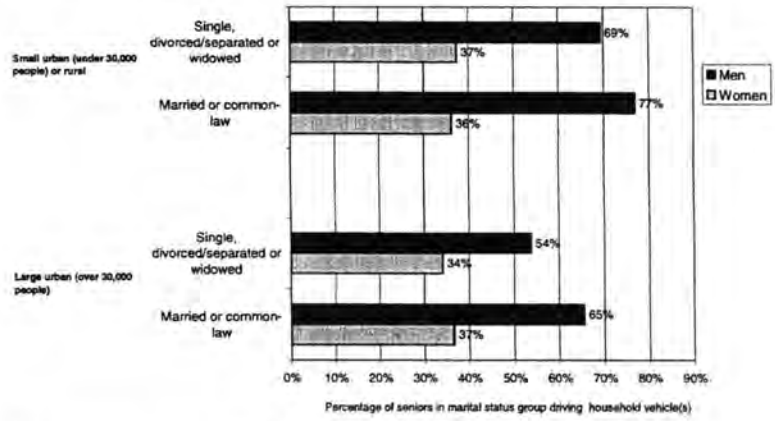
3.1 Husband-wife households

Results of the 1996 NAPVUS survey indicate that among married couples, far more men than women age 65 and older are driving in small towns and rural areas. During the thirty days prior to the 1996 NAPVUS survey, over three-quarters (77%) of older married men had driven the household vehicle, compared to 36% of older married women (See Figure 4). The data also revealed that even when the wife held a valid drivers license, it was the husband who did the bulk of the driving. In fact, two-thirds of married men age 65 or older were driving the household vehicle over three-quarters of the time. Furthermore, in about 59% of households where the elderly husband held a valid license, he was the exclusive driver of the household vehicle. Thus, while women will likely outlive their husbands, few actively drive (or are licensed to drive) the household vehicle. In fact, when an older woman in a husband-wife household does drive, in most cases, it is over very short distances. It is estimated most older married women (90%) who had driven the household vehicle travelled no more than 25 kilometres per day (on average) compared to only three-quarters of older married men. Men were also more likely to use the their vehicles for personal appointments such as visiting the doctor or dentist (79%) and leisure driving (58%) than women: 61% and 38% respectively.

3.2 Non-married living alone

Gender disparities in vehicle access also exist among non-married seniors even though fewer older men (27%) than women (57%) in small urban centres and rural areas are widowed, separated or divorced. According to NAPVUS, only 37% of older separated/divorced, widowed or single women were driving a household vehicle compared to 69% of men. Of the group of non-married women who were driving, over one-half (52%) lived alone and most (71%) were living on pre-tax incomes totalling less than $20,000 per year. About two-thirds of non-married women living alone used their vehicle only a few times a week but travelled an average of 11.3 kilometres per day, and close to one in five (17%) were driving over 25 km per day on average. The car was used most often by non-married women living alone for social activities and personal appointments, although only about one in four had used their vehicle for one-way trips over 100 km.

Figure 4 - Percent of seniors (age 65+) driving household vehicle(s), by area, sex and marital status - Canada, 1996



Source: 1996 National Private Vehicle Use Survey - Public Use Micro-data file

Conclusions and observations

The car is an important part of the lifestyles of small town and rural seniors engaging in a variety of social, cultural and recreational activities. However, the increased dependence of many seniors on the ability to drive or on another older motorist comes at a time in life when they are beginning to find driving more difficult due to age-related health limitations. This is an especially important consideration for older married women who may rely on one household member to do most or all of the driving. Even though women are likely to outlive their male partners, men do most of the driving and hold the only valid license in many husband–wife households. The prospect of widowhood or separation from a partner in old age suggests that women who never have driven or have rarely driven may have to either take up driving or be dependent on others for help, particularly if they live alone. However, it remains to be seen if this situation will persist in the future, given the increasing number of younger women driving and participating in the labour force. This may result in a more diverse group of older drivers with different driving patterns than the current generation of Canadians over age 65.

Appendix A -Older driver fatalities and injuries

Seniors tend to drive outside of rush-hour periods, during daylight hours and under conditions of clear visibility, but they remain susceptible to collisions resulting in fatalities or major injuries. A number of studies have concluded that while older drivers are involved in fewer collisions compared to younger drivers between the ages of 16 and 24, older drivers are involved in a larger number of collisions relative to the number of kilometres they drive (Tasca, 1998). Older drivers who are involved in an accident are also more likely than younger people to die from their injuries and take longer to fully recover. Furthermore, the prevalence of men among the older driver populations increases their exposure to fatal collisions and injuries, particularly on roads with high speeds. According to Transport Canada, about 56% of all older driver fatalities in 1996 were males who were driving on highways or rural roads with speeds in excess of 60 km/hr (See Table 2). Overall, 549 road users age 65+ (drivers, passengers and pedestrians combined) were killed in automobile collisions and 15,606 were injured. Although seniors represent 11% of the population age 15 and older, they accounted for 16% of all fatalities and 7% of injuries occurring on Canadian roadways during 1996.

Table 2: Fatalities and injuries to drivers age 65 and older in 1996

Transport Canada. Custom Tabulation.

	Fatalities		Injured	
Place of occurrence	Men	Women	Men	Women
Roads with speeds exceeding 60 km/hr	136	33	1,847	778
Roads with speeds under 60 km/hr	56	14	3,449	2,326
Total	*192*	*47*	*5,296*	*3,104*

Appendix B - Note on Concepts, Methods and Data

For the purposes of this study, small towns refer to urban areas with populations under 30,000 people and rural refers to areas with populations less than 1,000 people or less than 400 persons per square kilometre. The term "valid provincial driver's license" excludes persons with only a learning permit or suspended license and those who let their license expire. Statistics and estimates presented in this article are based on non-standardized age and sex data.

The National Private Vehicle Use Survey micro-data was compiled by Statistics Canada based on a sub-sample of the monthly Labour Force Survey (LFS) between January 1996 and September 1996 with the cooperation and support of Natural Resources Canada. The exclusion of potential respondents during the months of October, November and December may result in slightly biased estimations of vehicle use due to the nature of winter driving patterns. The LFS is a monthly household survey whose sample of individuals is representative of the civilian, non-institutionalized population 15 years of age or older in Canada's ten provinces.

REFERENCES

Belanger, A. and J. Dumas (1998) *Report on the Demographic Situation in Canada 1997: Current Demographic Analysis.* Minister of Industry: Ottawa. Statistics Canada 91-209-XPE.

Fitten, L., Wilkinson, C., Little, R., Burns, M., Pachana, N., Mervis, J., Malmgren, R., Siembieda, D. and S. Ganzell (1995) "Alzheimer and Vascular Dementias and Driving: A Prospective Road and Laboratory Study", in *The Journal of the American Medical Association.* May 3, 1995, Vol. 273(17), 1360-1365

Hodge, G. (1993) *Canada's Aging Rural Population.* Inter-Governmental Committee on Urban and Regional Research (ICURR). ICURR: Toronto.

Shua-Haim, J. and J. Gross (1996) "The "Co-pilot" Driver Syndrome", in *Journal of the American Geriatrics Society.* July 1996, Vol. 44(7), 815-817

Tasca, L. (1998) *An Overview of Senior Driver Collision Risk.* Ontario Ministry of Transportation. Road Safety Program Office: Safety Policy Branch.

Transport Canada (1997) *Canadian Motor Vehicle Traffic Collision Statistics. (TP3322)* Transport Canada.

TRB (1988) *Transportation in an Aging Society: Improving Mobility and Safety of Older Persons.* Transportation Research Board. Vol. 1 Washington: National Research Council.

Yassuda, M., Wilson, J., and O. Mering (1997). "Driving Cessation: The Perspective of Senior Drivers", in *Educational Gerontology: An International Journal.* Vol.23 (6), 525-538.

THE VALUE OF PREDICTORS ON NONRESPONSE

Cindy Carter
Transportation Division, Statistics Canada

Executive Summary

Nonresponse is an issue of importance to most surveys and can have an impact on data quality. Data acquired from respondents can be used to impute for nonrespondents if there are no underlying differences between the two groups. The use of predictors is effective in establishing the existence of differences and if these differences have any impact on the survey data.

The data collection strategy of the Canadian Vehicle Survey (CVS) incorporates both Computer Assisted Telephone Interviews (CATI) and mail surveys. Predictors of the CVS are incorporated at the CATI stage. The CVS stratifies the sample obtained from vehicle registration files into three categories of vehicles: light (under 4.5 tonnes), heavy (over 4.5 tonnes) and bus (passenger capacity of 12 or more). This paper analyzes the pilot CATI data from the CVS with the focus on light vehicles.

CATI pilot contacts are divided into two streams: vehicles for which a log was returned and vehicles for which a log was not returned. To distinguish potential differences among vehicles, driver characteristics of age and gender are analyzed. Surveyed vehicle drivers under the age of 35 displayed the lowest return rate of a log while respondents over age 35 displayed progressively increasing response rates. A distinction was also apparent between male and female drivers under age 35. However, when a kilometre predictor is applied using simple contrasts in analysis of variance between the age and gender groups, marginal differences are noted between total average kilometres recorded for respondent and nonrespondent vehicles. Overall this CVS pilot predictor shows that most respondent vehicle data can be utilized to impute kilometres for nonrespondent vehicles.

THE VALUE OF PREDICTORS ON NONRESPONSE

1. Introduction

The objective of this paper is to analyze unit nonresponse and also to study the value of predictors. The source of data is the pilot survey for the Canadian Vehicle Survey (CVS) and the focus will be on light vehicles. Light vehicles are defined as on-road vehicles under 4.5 tonnes. This comprehensive pilot survey was conducted in the months of April, May and June of 1998 and included the following jurisdictions: Newfoundland, Nova Scotia, Quebec, Ontario, Saskatchewan, British Columbia and the Northwest Territories. The on-going survey commenced in February 1999.

1.2 What is Nonresponse?

Nonresponse is an issue that affects most surveys and can have an impact on data quality. Essentially nonresponse may be categorized as either unit or item.[1] Unit nonresponse refers to the situation where there is a complete absence of survey data for whatever reason such as unable to locate, a language problem, refusals, extenuating circumstances (e.g. mail strike or bad weather), etc. Item nonresponse occurs when some questions are answered but not all and may be the result of a lack of understanding of what is being asked or simply disinterest by the respondent.

1.3 What are Predictors?

Predictors are variables that can be incorporated into statistical modeling. In some models the respondent's answers are weighted to reduce nonresponse. This is an acceptable method if it is known that the respondents and nonrespondents are homogeneous. Heterogeneity among these two groups can induce nonresponse bias. This is where predictors enter the equation. Predictors include characteristic variables that differentiate respondents. Some well-known predictors are age, gender and marital status. Each survey can adapt its own specialized predictors to assist in the edit and imputation of nonresponse. For example in the Canadian Labour Force Survey (LFS), household size is utilized

[1] R. Platek and G. B. Gray, ***Response Probability Approach to Missing Survey Data***, Methodology Branch Social Survey Methods Division, STC, p. 1-2.

as a predictor.[2] In this analysis recorded kilometres, for a previous week that are collected as part of the first phone contact, will be used as a predictor of vehicle usage.

2. Design of the Canadian Vehicle Survey (CVS) Pilot

The CVS is a voluntary vehicle-based survey sponsored by Transport Canada. The sample is drawn from provincial and territorial motor vehicle registration files on a quarterly basis. Until now there has been no routine measurement of road activity in Canada. As over 90% of all passenger travel and approximately 30% of freight transportation in Canada is by road,[3] this data is extremely important. The CVS will provide estimates of vehicle-kilometres, passenger-kilometres and tonne-kilometres by characteristics of vehicle, users, trips, commodities, road type and time. The target population includes all active on-road motor vehicles with the exception of trailers, motorcycles, snowmobiles and special equipment (e.g. cranes, street cleaners). Vehicles are stratified by age and categorized into three groups – light vehicles (includes cars and trucks under 4.5 tonnes), heavy vehicles (trucks and vehicles over 4.5 tonnes) and buses (12 or greater passenger capacity vehicles).

2.1 The Survey Process of CVS

There are various approaches to conducting surveys. Three standard methods of data collection are in person, by telephone and by mail.[4] Previous studies show that the highest response rates are attained from the 'in person' method followed by telephone and mail. Unfortunately response rate success does not come without a cost as the 'in person' method is by far the most expensive. To efficiently administer the budget and incorporate as large a sample as possible, the CVS utilizes the latter two data collection methods, telephone and mail. These two data collection instruments compliment each other and enhance the effectiveness of the survey. The telephone aspect of the CVS utilizes Computer Assisted Telephone Interviews (CATI), while the mail portion employs vehicle trip logs.

---

[2] A.C. Singh, R. Boyer and S. Wu, ***Consistency of Survey Estimates in the Presence of Nonresponse,*** Social Survey Methods Division, STC, p. 2.
[3] Transport Canada publication, **Transportation in Canada 1997 Annual Report,** catalogue number TP 13198E, p. 3-4.
[4] R. Platek and G. B. Gray, ***Response Probability Approach to Missing Survey Data,*** Methodology Branch Social Survey Methods Division, STC, p. 1.

The first phase of the CVS is the CATI. There is a maximum of three stages to each CATI. The first CATI call is an attempt to contact the vehicle's owner to verify if they still own the vehicle, check the name and address information from the vehicle registration files as well as confirm the vehicle type and determine the correct log to mail (light, heavy or bus). Also obtained in this CATI are predictors such as estimates of vehicle-kilometres plus a profile of vehicle usage. Specific questions are also directed to each vehicle category. For example, if a light vehicle is selected several questions are asked on the nature of vehicle usage such as, is the vehicle mainly used for personal or business purposes, and/or is it normally driven to work or school and if so what is the distance one way. These are questions that can prove to be valuable predictors, for example if it is discovered that driving patterns are correlated to the major purpose of the vehicle (i.e. business usage has higher kilometres than personal usage). Two follow-up CATI's are conducted to help motivate respondents to complete the log and answer any questions the respondents might have. Also in both these subsequent CATI's a current kilometre reading from the vehicle is requested so that where a trip log is not returned, there is a record of vehicle-kilometres and the dates of the readings.

The second phase of the CVS is the survey mail questionnaire. The most detailed source of information is obtained from the vehicle logs that collect trip data over a seven-day period. Each trip recorded on the light vehicle log reveals the duration of a trip in time and kilometres, time of day travelled, the trip purpose, number of passengers, driver characteristics, distance travelled on roadways with posted speed limits of 80 kilometres or more and any fuel purchases. From a methodological viewpoint the two-tier data collection strategy combined with increased mailings and contact efforts is an effective means to reduce nonresponse.

3. Reported Nonresponse in CVS

A successful response is defined as the attainment of vehicle usage information from the CATI answers and/or the trip logs. Information on driver age and gender plus the major purpose and amount of vehicle usage is collected in both the CATI and mail surveys of the CVS. The most important information to obtain is recorded vehicle kilometres and/or vehicle kilometre predictors. In accordance with this definition the response rate of all vehicles surveyed in the CVS pilot survey was 69.1% (excluding the Northwest Territories it was 73.2%). It is anticipated that the response rate for the on-going survey will be

the main driver from the pilot CVS data. The low number of records obtained for the under 25 year-old age group may be related to the fact that the data source is derived from vehicle registration files, and in contemporary society most individuals who own or lease vehicles are older than twenty-five. To control for the variability among age categories, the approach this paper takes is to study averages.

An interesting pattern is seen when comparing the successfully contacted CATI contacts that returned a log with the CATI respondents that did not return a log. Examination of the log response rate over all the age categories indicates that response is correlated to age. Graph 2 indicates the average (or midpoint) of nonresponse to a log occurs in the age group 35-44. For age groups below this average age bracket nonresponse rates are greater. On the other hand, all age groups beyond the average show a positive increase in response rate.

Graph 3 further stratifies the sample according to another CATI predictor, gender. The trend below the median age group (35-44) shows that males surveyed in the pilot CATI have about a 10% lower rate of return to a log than females.

Ages 45-54 show the women's rate of return for a log at its lowest in the pilot, even lower than the lowest male non-return rate. Results of Statistics Canada's 1992 General Social Survey were published in an article "Tempus Fugit: Are you time crunched?"[7] The findings of this article point out that women aged 45-54 are considerably "time crunched" balancing family responsibility, work and social activities. Many women in this age group find that they not only have to care for their children but their parents as well. From the pilot data it appears that whatever impacts the low response rate to the log from women in the age group 45-54 does not impact the men in this age bracket, who show the second highest rate of logs returned. The aforementioned paper supports the theory that males overall are less time stressed than females and also points out that at age 55 the "time crunched stress" drops dramatically. This theory is reaffirmed in the graph above where women at age 55-64 rebound from the previous age group to show the highest rate of return for a log among all age and gender categories. The response rate between males and females in the remaining age categories show fluctuations in the rates of responses (of 15% or more) with trends shifting in opposite directions.

[7] Judith Frederick, ***Tempus Fugit: Are you time crunched?***, Canadian Social Trends, Winter 1993, Statistics Canada catalogue 11-008E, p. 155, 156.

4.1 Impact of the Kilometre Predictor

A main question of interest is, do these different trends among age groups and between male and female impact the recording of kilometres by vehicle? To answer this question, kilometre readings were obtained from the CATI question "What was the total distance driven with this vehicle in the last seven days (best estimate)?" This question is what will be analyzed in this paper, although other predictors exist from the CVS CATI pilot that may be used to provide data for cases where no log is returned. These questions will be researched in the upcoming months.

To determine if the predicted kilometres can be used to impute for nonrespondents to the log, it is necessary first to compare the average kilometres recorded from the CATI question stated above between the respondents and nonrespondents to the log. For the total CATI sample the average recorded kilometres are 233 per vehicle. When distinguishing between nonrespondent and respondent vehicles the difference in total average kilometres is 7.7%. From graph 2 it is evident that nonresponse is greatest for those vehicles that have drivers under 35 years of age. When predicted vehicle kilometres are averaged for drivers in the under 35 age group, a marginal difference (less than 3%) is found between respondents and nonrespondents. When the predicted kilometres for vehicles whose drivers are over age 35 is compared a 13.8% difference is recorded. This is 6% above the difference in total average kilometres between all respondents and nonrespondents vehicle drivers. As the above 35 age group of vehicle drivers had successively higher responses, when this fact is weighted into the equation, the impact of the difference in total average kilometres is also minimal in this age category. Therefore this indicates that in the CATI pilot respondent predicted vehicle kilometres can be used to impute predicted vehicle kilometres for nonrespondents in the same driver age groupings.

Graph 4 depicts the difference in average predicted kilometres among male and female vehicle drivers from the total CATI sample of vehicles. It is interesting to note that in the two extreme age groups, the female drivers in this papers' sample of vehicles drove more kilometres on average during the week in question than the surveyed vehicles who designated the main driver as male. Applying the predicted average kilometres to the two different gender groups, one discovers that the difference in average kilometres is 7.3% among vehicles with female drivers who responded (i.e. returned a log) and female drivers who did not respond. This falls within the range of the difference in predicted kilometres among all respondents and nonrespondents. Therefore when imputing for nonresponse, female driver predicted vehicle kilometres may be used for nonrespondent female driver predicted vehicle kilometres. A

higher due to changes in the survey process as a result of lessons learned in the pilot.[5]

In terms of the percentage of on road vehicles, light vehicles are the most dominant. Road motor vehicle records in 1997 show that passenger automobiles make up 79% of total road motor vehicle registrations.[6] (Note: As the CVS does not survey motorcycles and registered mopeds, removing these from the total number of road motor vehicle registrations increases the passenger automobiles to 79%.) It should also be noted that in addition to passenger vehicles, light trucks are also included in the light vehicle stratum of the CVS, hence this would increase the number over 80%. As a result of this the CVS samples more light vehicles than heavy vehicles and buses. For the pilot the national sample proportion selected was 86:9:5 (light:heavy:bus).

3.1 Light Vehicle Unit Nonresponse in the CVS

The unit nonreponse recorded by the light vehicles in the CATI and survey mail instruments (e.g. logs) of the pilot is approximately 32%. There are various levels of unit nonresponse. This paper will analyze if there exists a difference in the predictor values (such as gender, age and vehicle-kilometres) among contacts in the first CATI. Initial CATI contacts will be stratified into two streams of respondents, those who returned a log for a light vehicle and those who did not. Essentially if there is a difference in the values of the predictors between these two streams, this is an indication of response bias and caution must be taken in making inferences. If there are no distinct differences in predictor data in this stratification, edit and imputation methods can be employed to increase the effective response rate.

4. Analyzing Predictors

Graph 1 shows how the CVS pilot CATI sample is dispersed according to seven age groups. It should be noted that the CVS survey unit is the vehicle, not the driver. Vehicle data is chosen from the survey frame that is made up of selected provincial and territorial vehicle registration files. It is realized that the main driver of a vehicle is not always the same as the individual who registered the vehicle. This paper addresses this issue by selecting the CATI records where information on the main driver is obtained. Thus graph 1 does not serve as any indicator of the average population, but merely to show the age breakdown of

---

[5] **The Canadian Vehicle Survey Proposal**. (Internal paper)

[6] Statistics Canada publication, **Road Motor Vehicle Registrations, 1997**, catalogue number 53-219-XIB, p. 10-11.

comparison of average vehicle kilometres of both streams of male drivers finds a difference of 15%. At initial glance this would imply response bias. A further breakdown among age groups of male drivers weighted with the rate of responses shows those vehicle with male drivers over age 35 fall within acceptable limits, however those vehicles with male drivers under age 35 do not. A more detailed analysis on male drivers under age 35 is required in the next stage when other CATI predictor questions are analyzed.

5. Conclusion

The purpose of this paper was to analyze unit nonresponse and study the value of CATI predictors from the pilot CVS. The CATI environment was selected, as this is where the predictors are derived for the CVS. The pilot CATI responses were split into two streams: vehicles for which a log was returned and vehicles for which a log was not returned. Two characteristic predictors, gender and age were studied and differences were noted among drivers in the two streams. Surveyed drivers under the age of 35 showed the lowest response rate (rate of return of a log) while respondents above age 35 displayed progressively higher response rates. The leading distinction between male and female drivers occurred in the under 35 age group where female drivers' rate of return of a log exceeded that of male drivers.

Differences in characteristic predictors indicate heterogeneity and a potential nonresponse bias. However, when the kilometre predictor is applied to the heterogeneous groups analyzed, there are marginal differences noted between total average kilometres recorded for respondent and nonrespondent vehicles which have main drivers that are female (for all age groups) and male (over the age of 35). This effectively states that most of the differences noted among characteristic predictors do not induce response bias because they have no impact on the kilometres driven by the vehicle. The only exception noted was that for vehicles having male drivers under the age of 35, where the kilometre predictor weighted with the response rates found potential bias. A contributing factor to this ambiguity may be the smaller number of vehicle records having the main driver in this age and gender group, in relation to the entire CATI pilot sample. Overall from the pilot, most CATI respondent and nonrespondent vehicles are homogeneous, allowing respondent vehicle kilometre values to be used to impute for kilometres of vehicles whose drivers did not respond.

This analysis only looked at a subsection of nonresponse of the pilot CVS. To encompass the full spectrum of nonresponse one has to analyze all the

respondent/nonrespondent components at the data collection phase.[8] It is essential to record and monitor reasons for nonresponse to determine if nonresponse is due mainly to refusal of the survey or non-contact. In addition to analyzing other CATI predictors, especially for vehicles with main drivers under age 35 and male, further study on nonrespondents that the pilot coded as 'unable to locate' or 'refused' will be the next step. This will be initiated by attempting to contact these nonrespondents by phone to try and find out why they did not respond. If nonrespondents can be successfully contacted, brief questions on characteristics of the main driver and kilometres of the vehicle will aid in further determining the extent of nonresponse bias within the CVS.

[8] M. A. Hidiroglou, J.D. Drew and G.B. Gray, ***A Framework for Measuring and Reducing Nonresponse in Surveys***. Survey Methodology. STC. p. 81-83.

Modelling the Travel Needs of the Elderly in the 21st Century

Eric D. Hildebrand, PhD, PEng
University of New Brunswick, Transportation Group

1.0 Introduction

Over the coming decades, a significant increase in the numbers of elderly people requiring travel will occur as the demographic profile of North Americans shifts thereby affecting all aspects of transportation demand. Furthermore, cohort effects are anticipated which may see tomorrow's elderly leading more dynamic lives and travelling to more activities than today's aged. These trends, when considered in concert with current fiscal pressures to reduce subsidies to public transportation systems/services and growing pressures to mitigate elderly driver safety issues, create a pending crisis in elderly mobility.

The current lack of a detailed description of elderly travel characteristics and behaviours, particularly one that examines the issue at a level involving activity engagement, was a deficiency addressed by this research. A further product of this study was the development and testing of a simplified activity-based modelling framework. The framework was designed to describe elderly travel characteristics and demand with the added benefit of providing a tool that can evaluate transportation related impacts of proposed policies.

2.0 Research Approach and Methodology

The data set used for this study was the 1994/95 Portland, Oregon, Household Activity and Stated Preference Survey (Cambridge Systematics, 1996). Among the respondents, there were 1,150 who were 65 years of age and over. Since each respondent described activity participation for a two-day period, there were 2,300 person-days of information for the elderly including nearly 6,600 activities requiring travel.

An activity-based model was developed using microsimulation as the platform which incorporated the Portland activity data set. Much of the research that is currently underway in the area of activity-based modelling is trying to synthesize

the complex behavioural and decision-making processes of individuals and households. Although the framework developed through this research might be considered more descriptive in nature, it does inherently replicate behavioural characteristics and has the advantage of being easily implemented.

Although many different frameworks have been proposed, the essence of all activity-based frameworks is that individuals participate in activities that might lead to trip-making satisfied by transport resources. Ettema and Timmermans (1997) note that:

> "... activity-based approaches typically describe which activities people pursue, at what locations, at what times and how these activities are scheduled, given the locations and attributes of destinations, the state of the transportation network, aspects of the institutional context, and their personal and household characteristics."

The model framework developed through this study is depicted in Figure 1. Much was learned concerning elderly travel behaviour and characteristics through the development of Module 1, *Categorization of Individuals*.

Figure 1 shows that the model framework processes individuals discretely until a set of daily trip tours (or chains) is developed based on the assigned activity itinerary. For the purposes of this study, a trip tour was considered a string of activities that begins and ends at home. This is a definition that is consistent with several existing activity-based models. Each of the modules are described in more detail in ensuing sections.

Some of the deficiencies of current modelling systems addressed by the subject framework include:

(1) Practical demonstration of a simplified activity-based model.
(2) Categorization of individuals to reduce the amount and detail of data required for the model (i.e., lifestyle segmentation will homogenate activity and subsequent travel behaviour patterns).
(3) Application to a specific user group rather than the typical commuter focus.
(4) Inclusion of microsimulation as a platform for model development.
(5) Construction and operationalization of a framework that can be expanded to include more complex behavioural processes.
(6) Ability to analyse the travel implications associated with adaptation responses.

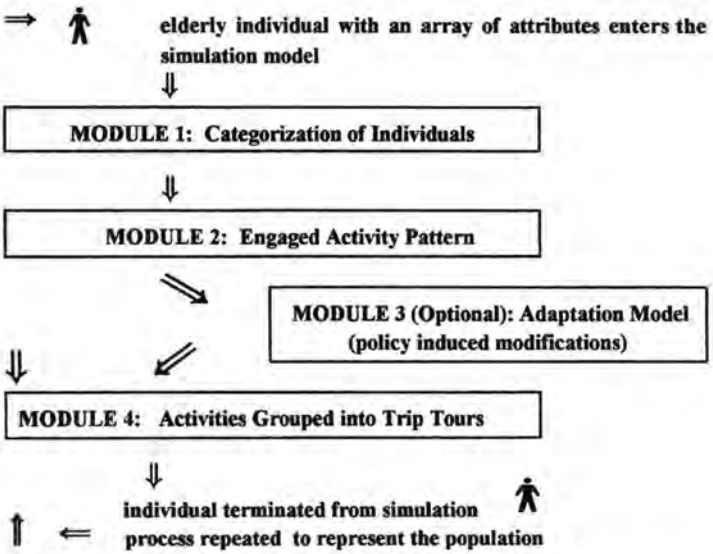


Figure 1: Activity-Based Model Flowchart

One of the major disadvantages of the proposed framework is the omission of any scheduling constraints or optimization routines which could be used to more realistically assemble activity patterns and trip tours.

3.0 Delineation of Elderly Lifestyle Groups

The efforts undertaken to delineate sub-populations of the elderly that have distinctive lifestyle attributes are presented in this section. A fundamental premise proven by this effort was that members of common lifestyle groups can have distinct patterns of activity engagement and therefore characteristic travel behaviour. Partitioning the elderly therefore allows the development of an activity-based travel model that processes individuals by applying utilities and algorithms unique to specific clusters.

Since the dimensions which define lifestyle are somewhat ambiguous, the basis for stratification was not definitive. However, it must be stressed that any preferred classification basis is highly dependent on the final use of the cluster information and the ability to identify individuals with a predefined cluster based on commonly available observational data.

Clusters developed based solely on socio-demographic characteristics of the elderly were found to provide the most appropriate cluster solution for inclusion in the simulation model. Analysis of variance techniques, agglomeration schedules, cluster size limits, and interpretive descriptions (based on cluster centres) were used to identify an optimal solution. Subsequent sections in this paper concentrate on findings from this approach. Detailed descriptions of cluster analyses are described by Hildebrand (1998). Analysis of Variance and Bonferroni Multiple Comparisons were undertaken to compare how many cluster means were significantly different from one another across key activity, socio-demographic, and travel behaviour variables.

Variables used as dimensions to define the cluster groups included: age, the total number of vehicles owned by a household, total household income, household size, gender, possession of a driver's license, presence of a disability significant enough to affect travel outside the home, relationship to the household head, and employment. Other variables contained in the data set were excluded either because of correlation or because they did not contribute to the formation of clusters.

The R^2 developed by the final solution of six clusters was determined to be 0.62. This value indicates that by segregating the elderly into subgroups, the respective cluster means explain 62 percent of the variance in the socio-demographic variables used for cluster dimensions. The clusters ranged in size from 50 to 436, representing approximately 4 to 38 percent of the entire sample.

Table 1 presents the cluster means of the socio-demographic variables developed through the analyses. The cluster means provide the ability to interpret the dominant characteristics of each group. All variables used to delineate cluster membership are shown to have statistically significant differences between the six groupings.

Table 1: Lifestyle Cluster Means

Socio-demographic Variable	Lifestyle Cluster					
	Workers	Mobile Widows	Granny Flats	Mobility Impaired	Affluent Males	Disabled Drivers
Age	*69.7*	72.8	**78.0**	77.8	72.3	74.7
Hshld. Vehicles	1.90	1.41	**2.18**	*0.63*	1.93	1.54
Hshld. Income (x $1,000)	37.6	27.6	**42.3**	24.7	38.1	*24.4*
Hshld. Size	1.86	*1.58*	**3.26**	1.63	2.02	1.74
Gender	60.8	*0.6*	20.0	22.7	**81.4**	37.7
Licensed (%)	96.9	**100.0**	48.0	*0.0*	**100.0**	**100.0**
Handicapped (%)	1.6	*0.0*	36.0	27.7	*0.0*	**100.0**
Hshld. Head (%)	62.4	**92.6**	*0.0*	66.0	45.6	63.9
Parent of Hshld. Head (%)	1.6	*0.0*	**100.0**	*0.0*	*0.0*	*0.0*
Employed (%)	**100.0**	*0.0*	2.0	4.3	*0.0*	*0.0*

Note: Bold typeface indicates the **highest** mean for a particular socio-demographic variable.
Italics typeface indicates the *lowest* mean for a particular socio-demographic variable.

The *Workers* cluster is subjectively named because all of its members continue to be employed either full or part-time. The group has the youngest average age. Perhaps surprisingly, more than 39 percent of the group are female and only 62 percent are listed as the head of their respective households. Nearly 97 percent of the cluster members are licensed to drive an automobile. Cluster size is 125 of the sample of 1,150 elderly.

Mobile Widows is a cluster whose membership is almost exclusively female (99.4 percent), most of whom live alone or are the household heads. The members have the second lowest average income, however, all maintain a driver's license. Cluster size is 337 of a sample of 1,150 elderly.

All of those who belong to the *Granny Flats* cluster live with their children, resulting in the group with the largest average household size and income. Most are female (80 percent), oldest on average, more than one-third disabled, very few are employed, and only 48 percent are licensed to drive. Such characteristics would imply that members of this cluster rely on others for at least some of their transportation needs. Cluster size is 50 of a sample of 1,150 elderly.

The *Mobility Impaired* cluster is characterized by members who collectively have the second oldest average age, only 0.63 vehicles per household, more than 77 percent are female, more than one-quarter are disabled, and none hold a driver's license. These attributes suggest that this group is also highly dependent on spouses, relatives, friends, or public services for their travel needs. Cluster size is 141 of a sample of 1,150 elderly.

More than 81 percent of the members of the *Affluent Males* cluster are male. Cluster members are on average the second youngest, have the second highest income, no incidence of disability, and all hold a valid driver's license. Furthermore, none reside with their offspring, and they have the second highest vehicle ownership. These indicators suggest that this cluster represents an independent and mobile membership. Cluster size is 436 of a sample of 1,150 elderly.

Those belonging to the *Disabled Drivers* cluster all maintain a driver's license yet everyone reports a disability significant enough to affect outside travel. The group is nearly two-thirds female, slightly older than average, with no members who are employed. Cluster size is 61 of a sample of 1,150 elderly.

3.1 Activity Engagement of the Lifestyle Clusters

The mean hours that members of the lifestyle clusters participate in each of the eight activity classes are presented in Table 2. All but one of the eight activity

classes (Personal Maintenance) were found to have statistically significant variations between the six clusters.

Table 2: Activity Engagement for Lifestyle Clusters

Activity Type	Lifestyle Cluster (mean participation over 2-day period; hours)					
	Workers	Mobile Widows	Granny Flats	Mobility Impaired	Affluent Males	Disabled Drivers
Meals	*3.4*	**4.3**	3.5	4.0	3.8	3.8
Work/school	**7.9**	0.3	0.5	0.5	0.2	*0.0*
House Maint.	*4.0*	**6.2**	4.4	4.1	5.8	5.1
Personal Maint.	*0.1*	0.4	**0.7**	0.2	0.4	0.5
Social	1.3	**2.2**	*0.8*	2.1	**2.2**	1.5
Amusement	*7.1*	9.8	11.2	**11.6**	10.3	10.6
Recreation	*1.8*	2.3	**4.7**	3.5	2.5	3.8
Other	**0.2**	*0.1*	*0.1*	*0.1*	**0.2**	*0.1*

Note: **Bold** typeface indicates the **highest** mean for a particular activity type.
Italics typeface indicates the *lowest* mean for a particular activity type.

Not surprisingly, the clusters that have mobility restrictions (*Granny Flats, Mobility Impaired* and *Disabled Drivers)* engage in amusement activities more often. Note that this class of activities tends to be dominated by the specific activity of 'in-home amusement'.

The *Mobile Widows* spend the most time engaged in house maintenance activities which are dominated by the 'general shopping' activity. It is interesting that the *Workers* participate the least in five of seven activities other than subsistence.

3.2 Travel Behaviour of the Lifestyle Clusters

All travel behaviour variables presented in Table 3 were found to have statistically significant variations between the lifestyle clusters delineated based on socio-demographic variables. Most important, both the total number of trip tours and the number of activities reached by travel are strongly discriminated between the groups.

Interestingly, trip duration was found to vary from a low average of about 14 minutes for those belonging to the *Granny Flats* to a high that is nearly double for the *Affluent Males* cluster. If trip duration is used as a proxy for distance, the findings suggest that some groups tend to stay much closer to home than others.

The average auto occupancy for those in the *Mobility Impaired* and *Granny Flats* clusters is higher than any of the other groups. This corresponds with the fact that few in these clusters are licensed to drive. Those in the *Mobility Impaired* group make the fewest auto trips, yet when they do they almost never drive. Furthermore, they rely on either walking or the transit system much more than any of the other clusters.

A significant finding shows that those belonging to the *Disabled Drivers* cluster rely on the auto for more than 92 percent of their trips yet all report a disability significant enough to affect their transportation needs. Furthermore, they use the transit system and walk the least of any other cluster. This identifies a segment among the elderly who seem to have some very specific travel needs.

Since travel behaviour is considered the result of servicing travel needs (or activity engagement) the next step was to understand if, in fact, these needs varied between the clusters. Figure 2 illustrates the underlying reasons for travel among the six clusters identified. The patterns of daily activities that require travel are presented for each cluster. The levels of daily engagement for all but one activity class (personal maintenance) were found to have statistically significant variations. Most notable is the importance of 'house maintenance' activities among all clusters. Although the frequency of engagement changes from group to group, it is the dominant reason for travel. Recall that 'general shopping' is the primary activity within this category.

Table 3: Travel Behaviour Variable Means for Lifestyle Clusters

Travel Variable	Lifestyle Cluster					
	Workers	Mobile Widows	Granny Flats	Mobility Impaired	Affluent Males	Disabled Drivers
Total Activities Requiring Travel	**7.74**	6.21	*2.94*	3.45	6.03	4.51
Total Trip Tours	**2.89**	2.36	*1.18*	1.37	2.44	1.64
Avg. Trip Duration (min.)	20.18	18.96	*14.11*	21.34	**26.16**	17.94
People in Auto	*1.34*	1.53	2.14	**2.34**	1.63	1.68
Auto Role (% trips)						
Driver	**83.9**	62.0	22.7	*2.6*	75.0	54.6
Passenger	*9.3*	25.6	**54.0**	53.2	15.7	37.8
Mode (% of trips):						
Auto	**93.2**	87.6	76.8	*55.8*	90.6	92.4
Walk	*5.5*	9.2	16.0	**24.4**	6.7	6.4
Transit	1.3	2.2	1.7	**16.5**	1.7	*0.6*
Other Mode	*0.1*	1.0	**5.6**	3.4	1.0	0.7

Note: **Bold** typeface indicates the **highest** mean for a particular travel variable.
Italics typeface indicates the *lowest* mean for a particular travel variable.

The overall patterns for the *Mobile Widows, Mobility Impaired, Affluent Males,* and *Disabled Drivers* are somewhat similar in that meals and amusement are either the second or third most common reason for travel. Nevertheless, the frequency rate of engagement varies significantly from group to group.

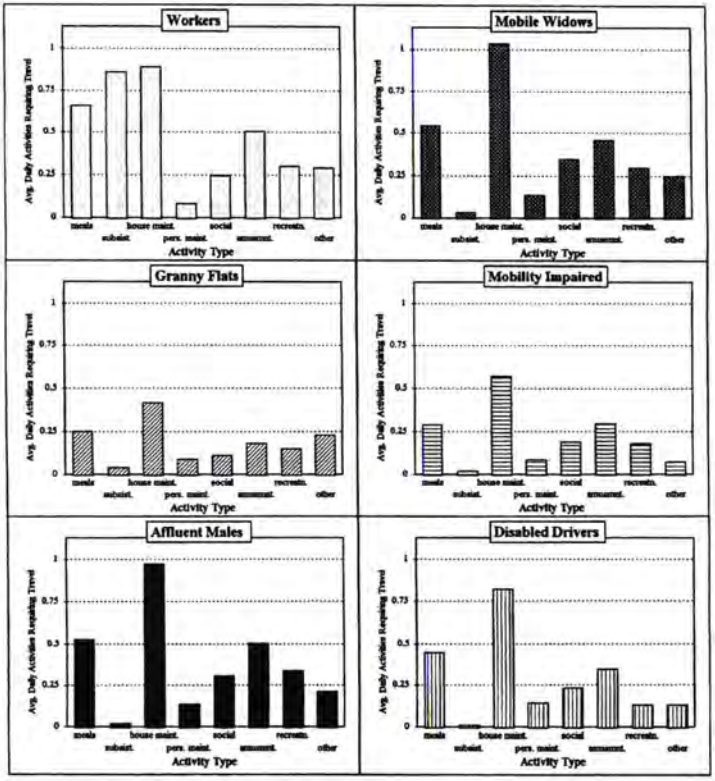


Figure 2: Daily Engagement Rates for Activities Requiring Travel (Lifestyle Clusters)

Although ANOVA tests the null hypothesis that the means are equivalent from cluster to cluster, it does not lend any insight into which pairs of means, or how many pairs, are significantly different. To explore these relationships further, the Bonferroni Multiple Comparisons technique was applied to cluster means (Norusis, 1993). There was a total of 150 matched pairs compared to examine the

differences across the travel behaviour variables (i.e., comparing the means of six clusters results in 15 matched pairs which were applied to all 10 travel behaviour variables). The analyses found that 79 of these 150 pairs (or 53%) were statistically different. Similarly, 29% of matched pairs of travel activities and 67% of socio-demographic variables were found to be significantly different between clusters.

4.0 Development of Activity-Based Model: An Overview

The microsimulation activity-based model that was developed provided a synthesis of the four modules depicted in Figure 1. The model structure can be considered a 'bottom-up' approach where individuals are processed in series until an entire population or study area is replicated. Each individual is stochastically assigned a daily itinerary of activities (both at and away from home) which are converted into trip tours. Many of the simulation steps relied on stochastic assignment which was based on cumulative distribution functions derived from the Portland data set. Each of the modules is briefly discussed in subsequent sections.

4.1 Module 1: Categorization of Individuals

The first step in the modelling framework requires that each individual be classified into one of the six socio-demographic clusters delineated (in the previous section). This requires that each individual being included in the modelling effort has an array of socio-demographic attributes consistent with the cluster dimensions previously developed including age, gender, income, number of household vehicles, household size, driver's license, disability, household role, and employment status. Euclidean distances are calculated between the point defined by each individual's attributes and the centres of each cluster. Individuals are classified, or assigned, to the clusters to which they are closest (in Euclidean space).

4.2 Module 2: Engaged Activity Patterns

Once a transaction is created by the simulation model and assigned to one of the six lifestyle clusters it was then subjected to a series of processes encompassed by Module 2 which ultimately assigned a daily itinerary of specific activities. The

activities were differentiated according to whether travel outside the home was required or not. The basic steps that the module followed are:

(1) Daily total number of activities were assigned to each individual using Monte Carlo simulation based on cumulative distribution functions derived for each cluster.

(2) The number of activities that will require travel outside the home was defined as a function of the daily total number of activities.

(3) The specific activities were assigned to each of eight predefined activity classes. Probability of assignment was conditioned upon the individual's cluster membership and their daily total number of activities. Requirement for travel was conditioned upon the activity class, total daily activities assigned to the individual, and cluster membership.

(4) Constraining rules tempered the minimum and maximum number of times a specific activity class could be assigned to an individual for a given day.

4.3 Module 3: Adaptation Module

The Adaptation Module takes on different forms depending on the particular policy being studied. It therefore does not have a generic format that can be designed into the base simulation programming. The module is optional (see Figure 1) in the sense that it is only employed if the impacts of a proposed policy are being studied. The application of the Adaptation Module could modify frequency distributions developed for Module 2 (using, for example, stated adaptations) or the assembly of the activities into trip tours in Module 4. Hildebrand (1998) discusses the implementation of the Adaptation Module in detail where exemplary test applications of the simulation model are undertaken.

4.4 Module 4: Assembly of Trip Tours

The next step required the assembly of activities into a set of trip tours so that a link could be made between travel needs and behaviour. A linear relationship was developed for each lifestyle cluster to predict the number of trip tours based on the

characteristics of the activities that required travel. Note that for this study, a trip tour is defined as the collection and sequencing of different activities, which require travel, into a linked journey that starts and ends at home. The incorporation of a series of activities into trip tours can be an extremely complicated process requiring a profusion of constraining conditions and optimization routines. It was not the intent of this project to explore these relationships in depth; simple estimates of the number of trip tours were sufficient to permit a broader understanding of travel behaviour and policy effects.

Linear regression analyses were performed to develop relationships between the total number of daily trip tours for an individual and independent variables which were the number of activities requiring travel by class (i.e., meals, subsistence, etc.). The R^2 values of the six models ranged from 0.65 to 0.93. Model coefficients were found to vary widely between different cluster models. For example, the coefficient for the number of subsistence activities engaged in by *Workers* was 0.11 while it ranged from 0.26 for the *Affluent Males* to as high as 0.60 for those belonging to the *Granny Flats* cluster. Comparative values of the coefficients provided insight into the different travel behaviour, particularly linking of activities into tours, among the six lifestyle clusters.

Cumulative probability functions were developed to assign stochastically the mode of travel for each of the trip tours generated by the regression functions discussed above. Given the significant differences in mode split proportions between the six clusters, separate distributions were developed for each cluster. For example, although the elderly as a whole walk for 9.4 percent of all trip tours, the corresponding value for the *Mobility Impaired* was found to be 24.4 percent.

4.5 Model Validation

Once the previous modules were developed and coded into the simulation program, it was partially validated by simulating the trip-making of 1,150 individuals and comparing the output with the entire base data set. The analysis was undertaken on a cluster-by-cluster basis. Overall, the model overestimated the total number of trip tours by only 3.7 percent. By way of comparison, the PCATS model system found that it underestimated the number of trips for a sample of 374 individuals by 14.5 percent (Kitamura, 1997).

With the acquisition of the preliminary results of an external survey, it was possible to extend the validation analyses. The data sets associated with a complementary activity-based survey carried out in Vancouver, Washington were used as a test case. In total, 404 elderly respondents were interviewed through this survey. Using only the socio-demographic information associated with these respondents, the simulation model was applied. The model outputs were then compared, on a cluster by cluster basis, to the corresponding activity and travel behaviour information recorded in the survey database.

The model-generated distributions of the number of daily activities, activities requiring travel, trip tours, and mode split were found not to be statistically different than observed data. The resulting overall total number of trip tours were overestimated by the model by 10.5 percent. However, the hypotheses that the distributions of assigned daily activities by class were no different from the observed data had to be rejected for three of the six lifestyle clusters. Similar results were found for the distributions of activities requiring travel. The number of activities requiring travel was overestimated by 9.2 percent for all of the elderly combined. It is unclear whether the differences in these distributions are a result of model mis-specification, intrinsic differences in the characteristics of the Vancouver elderly, or the small number of observations provided for each of the clusters by the Vancouver data set.

5.0 Discussion

The most significant contributions of the research include the delineation of the elderly into different lifestyle groups with correspondingly varied travel behaviours, the development of a simplified activity-based travel model, and its application to test cases. An important first step has been taken toward the development of a comprehensive modelling framework that can be used to estimate the impacts of policies on specific groups of individuals. The activity-based framework not only measures the net effect of trip-making, but the impacts on individual activity participation can be gauged as well.

It is essential that planners recognize and respond to the fact that some groups can be more adversely affected by policies than the population overall. Most of the current activity-based models being developed are designed to represent the travel

demands and responses for an entire MPO. These large scale models often focus on congestion and travel management for transportation networks. The framework developed through this research meets a far less ambitious need of providing a tool that allows researchers to study the travel behaviours and needs of specific subgroups of the population. The model helps to identify any adverse impacts so that some form of mitigation might be employed.

Although this study has made several significant contributions, much work is still needed concerning elderly travel needs and activity-based modelling to learn if similar subgroups as those found in this study can be delineated for different geographic areas. Furthermore, the model developed as part of this research did not incorporate temporal and spatial attributes of individual activities. This would inherently provide more sophisticated constraining rules for the model structure.

6.0 Acknowledgements

The bulk of this paper is based on work undertaken toward the author's Ph.D. dissertation. The author gratefully acknowledges the contributions made by his supervisor, Dr. Bruce G. Hutchinson of the University of Waterloo.

7.0 References

Cambridge Systematics Inc. (1996). *Data collection in the Portland, Oregon metropolitan area: case study.* Technology Sharing Program, United States Department of Transportation, Washington, D.C.

Ettema, D.F. and H.J.P. Timmermans. (1997). *Activity-based approaches to travel analysis.* Pergamon, Elsevier Science, New York.

Hildebrand, E.D. (1998). *An Activity-Based Travel Needs Model for the Elderly.* Ph.D. Dissertation. University of Waterloo, ON, Canada.

Kitamura, R. (1997). Applications of models of activity behaviour for activity based demand forecasting. *Proceedings of the activity-based travel forecasting conference,* Travel Model Improvement Program, F HW A, Washington, D.C.

Norušis, M.J. (1993). *SPSS® for Windows™: base system user's guide release 6.0.* SPSS Inc., Chicago, IL.

Cross-Price Elasticities of Freight Demand:A Dynamic Approach

Yuri V. Yevdokimov

Research Associate, Transport Institute, University of Manitoba,

Phone: (204) 474-9766, Fax: (204) 474-7530, E-mail: yevdokim@cc.umanitoba.ca

Abstract

Traffic growth, its effects on congestion and pollution, and the adoption of new policies to cope with these problems, have prompted a reconsideration of some long-standing established ideas in demand analysis and policy appraisal in transport studies. For example, an assessment of the potential for mode shift of freight transport as means for reductions in greenhouse gas emissions has to be done in a dynamic framework. The paper is dedicated to the analysis of different dynamic tools to estimate the short-run and long-run cross-price elasticities of freight demand as well as to describe the adjustment mechanism between the two. In particular, Vector Autoregression modeling with Impulse Response Function approach is applied to freight transport in a two-mode case. Some advantages of the approach are identified. The paper also discusses several other advanced tools of a dynamic analysis with respect to tracing consequences of structural changes in transport sector.

Introduction

Yuri Yevdokimov

As extensive literature analysis has shown, the majority of estimates of cross-price elasticities of freight demand are derived from static demand models. Moreover, all these models are equilibrium models which produce long-run elasticities. However, no evolving system, and transport markets are no exclusion, can be in the long-run equilibrium at any given point in time. Therefore, at any given point in time we observe short-run elasticities with long-run elasticities as a target level. From economic theory we know that demand is more elastic in the long-run than in the short-run, and thus, what we observe is not the same what we estimate with the help from static equilibrium models.

This problem was identified by several researchers. For example, Oum, Waters and Yong (1992) admit that it is a well known fact that demand for freight transport becomes more elastic in the long-run because users are better able to adjust to price changes.

In this paper we claim that static equilibrium models have reached their limits. The present need is to have dynamic models able to take into account temporal variations of the demand for different freight modes as well as variations in cross-elasticities associated with them.

In particular, such a need arises with respect to tracing consequences of different public policies in transport sector. For instance, at present Transport Canada is undertaking a project associated with reductions in greenhouse gas emissions from freight activities. As a possible solution, shifts to more efficient modes are suggested.

Of course, shift from one mode to another causes redistribution of transport services between those modes, and such a process does take time. Therefore, it has to be analyzed in terms of dynamic approach.

In general, public policies in transport markets affect freight rates first and demand for transport services second. From an econometric standpoint, change in a freight rate of one mode, because of introduction of a new policy, is a kind of one-time shock to a system under question. Even if the system is in the long-run equilibrium, shock to the system results in a disequilibrium with further adjustment to the equilibrium.

If we are to understand the consequences of such a shock, we have to have a dynamic framework. In this regard, change in the freight rate of one mode results in immediate impact on the demand for another one which can be analyzed through cross-price elasticities. Of course, users of both modes do not immediately respond to such a change. There is some inertia in this process. First of all, this inertia is associated with expectations based upon past history or the so-called backward-looking expectations. As a matter of fact, current demand for freight transport and elasticities associated with this demand, reflect the entire history of past freight rates changes as well as changes in transport services performed. On the other hand, there exist forward-looking expectations which depend on the nature of current changes because users try to understand whether these changes are temporary or permanent.

In order to analyze such a process we have to specify the adjustment mechanism. This is possible only with the help from dynamic modeling. From a theoretical

standpoint, we actually observe pivot of freight demand function over time from its inelastic short-run position to its elastic long-run position. In addition to the pivot, economic and population growth will shift the demand outwards. Therefore, we have to have tools to derive the short-run cross-elasticities in addition to existing static equilibrium methods designed to derive the long-run cross-elasticities as well as tools to describe the adjustment mechanism between the two.

Actually cross-price elasticities of freight demand are not single numbers but rather time dependent functions. If we use point estimates of the cross-price elasticities, then we end up with what Dargay and Goodwin (1995) call *bias of pivot elasticity*.

Dargay and Goodwin (1995) identified two more advantages of a dynamic modeling:

1. It might show how much of the shock (impact) happens in the first years or how long it takes before 90% of the impact is realized.
2. It might tell us when the real impact will occur.

Econometric tools available for dynamic analysis of freight demand

The need for comprehensive dynamic economic analysis caused the appearance of several new econometric techniques. Previously in order to analyze dynamics of transport markets, distributed lag models with pure time-series data were employed to capture the adjustment mechanism of freight rates changes (see, for example, Oum,

1979). New techniques include Seemingly Unrelated Regression (SUR), Vector Autoregression (VAR), Error-Correction Model (ECM) and Structural Vector Autoregression (SVAR).

For instance, Oum, Waters and Yong (1992) argue that ideally transport demand has to be estimated along with firm's location choice and asset ownership which eventually produces system of simultaneous equations. In this system some parameters will appear in more than one of the regression functions. In such a case the system is said to be a subject to cross-equation restrictions. In the presence of such restrictions it is necessary to estimate all equations as a system which means that error terms are correlated with each other throughout the system. In this situation it is possible to apply SUR, firstly defined by Zellner (1962). SUR uses pooled data, produces unbiased estimates of parameters and is free from a simultaneity bias.

Many economic systems, including transport markets, exhibit feedback. Sometimes it is not known if the path of a series designed to be *an independent* variable has been unaffected by the time path of the *dependent* variable. VAR, introduced by Sims (1980), treats all variables symmetrically without making reference to the issue of dependence versus independence. Moreover, VAR has Vector Moving Average (VMA) representation which produces the so-called Impulse Response Function (IRF). The IRF can directly provide estimates of the short-run and long-run cross-price elasticities of freight demand. In this paper we present such a procedure for a two-mode case.

If we are to understand the adjustment process of the short-run cross-elasticities to their long-run values, then ECM is the best tool available. If a system is to return to the long-run equilibrium, the movements of at least some variables in the system must respond to the magnitude of the disequilibrium. Therefore, in ECM the short-run dynamics of variables in the system is influenced by the deviations from the long-run equilibrium. Enders (1995) presents a very good description of this technique.

Finally, SVAR is a very attractive technique in order to estimate transport demand system. SVAR arose because of critique of VAR as being an "atheoretical" approach. In turn, SVAR relies on economic theory to provide structural interpretations for the system's dynamics. Pioneering work by Sims (1986) and Bernanke (1986) resulted in methodology for SVAR.

Therefore, it appears that recent econometric work has given us a lot of powerful tools to consistently estimate cross-price elasticities of freight demand in a dynamic setting. Surprisingly enough, these tools have not been used by researchers in the field. Of course, in order to apply these techniques one has to have a long time series. Fortunately, it is possible to do so in Canada.

In 1972 Peterson developed the "Canadian Freight Transportation Model (CFTM) Data Base". The CFTM Base uses 78 commodity groups and 69 geographical regions. The data base is maintained and upgraded by the Canadian Institute of Guided Ground Transport (CIGGT) of Queen's University. It contains information on freight rates, commodity flows, distances of links, shares of revenue by mode, tonnage/ton-miles,

etc.

Therefore, in fact we have a series of at least 26 observations which allows us to apply the above described econometric tools. Below we present an application of VAR modeling to a two-mode case.

Application of VAR modeling to a two-mode case

Here we follow method designed in Yevdokimov (1998). Let Q_t^1 be quantity of transport services of the first mode demanded in ton-miles, Q_t^2 be quantity of transport services of the second mode demanded in ton-miles. In turn, P_t^1 and P_t^2 are freight rates of the first and second modes respectively in dollars per ton-mile. In such a case we can construct the following 4×1 vector

$$x_t = \begin{bmatrix} q_t^1 \\ q_t^2 \\ p_t^1 \\ p_t^2 \end{bmatrix}$$

where $q_t^1 = \ln Q_t^1$, $q_t^2 = \ln Q_t^2$, $p_t^1 = \ln P_t^1$ and $p_t^2 = \ln P_t^2$. First-order Vector Autoregression (VAR) can be presented as

$$x_t = A_0 + A_1 x_{t-1} + E_t$$

where A_0 is 4×1 vector of constant terms, A_1 is 4×4 matrix of coefficients with typical element a_{ij}; and E_t is 4×1 vector of error terms. Error terms in vector E_t are inter-related or they are composites of some elementary error terms associated with each of the variables in vector x_t. Therefore, vector E_t can be decomposed as follows

$$E_t = \mathrm{P} \times \mathrm{H}_t$$

where

$$\mathrm{P} = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 \end{bmatrix}$$

is 4×4 symmetric correlation matrix of error terms and

$$\mathrm{H}_t = \begin{bmatrix} \eta_{1t} \\ \eta_{2t} \\ \eta_{3t} \\ \eta_{4t} \end{bmatrix}$$

is 4×1 vector of independent and identically distributed error terms. We treat these

independent error terms as elementary shocks to each of the four variables in vector x_t. For example, if we set $\eta_{1t} = \eta_{2t} = \eta_{3t} = 0$ and $\eta_{4t} = p_t^2$, then

$$E_t = \begin{bmatrix} 1 & \rho_{12} & \rho_{13} & \rho_{14} \\ \rho_{21} & 1 & \rho_{23} & \rho_{24} \\ \rho_{31} & \rho_{32} & 1 & \rho_{34} \\ \rho_{41} & \rho_{42} & \rho_{43} & 1 \end{bmatrix} \times \begin{bmatrix} 0 \\ 0 \\ 0 \\ p_t^2 \end{bmatrix} = \begin{bmatrix} \rho_{14} p_t^2 \\ \rho_{24} p_t^2 \\ \rho_{34} p_t^2 \\ p_t^2 \end{bmatrix}$$

In such a case ρ_{14} is the short-run cross-price elasticity ε_{12} because percentage change in Q_t^1 with respect to percentage change in P_t^2 is $\partial q_t^1 / \partial p_t^2 = \rho_{14}$ which is definition of the cross-price elasticity of demand in period t (short-run) when $q_t^1 = \ln Q_t^1$ and $p_t^2 = \ln P_t^2$.

Therefore, if we run VAR in its original form, we can derive matrix P and directly obtain estimate of the short-run cross-price elasticity $\rho_{14} = \varepsilon_{12}$. Consequently, correlation coefficient ρ_{24} is the short run own-price elasticity ε_2 of the second mode's demand. Moreover, in VAR setting, $(1 - a_{11})$ is portion of total effect in quantity adjustment of the first mode within first period. Thus $\varepsilon^* = \rho_{14} / (1 - a_{11})$ is long-run cross-price elasticity which is greater than the short-run cross-price elasticity ε_{12} because $(1 - a_{11}) < 1$. If we arrange VAR in Vector Moving Average form as follows

$$x_t = x + \sum_{i=0}^{\infty} A_1^i E_{t-i}$$

where x is the vector of mean values of the variables of interest, then 4×4 matrix A_1^i will contain the so-called short-run impact multipliers. For example, a_{14} is the short-run impact multiplier associated with effect of change in P_t^2 on Q_t^1 one period after the change. Now we can specify the dynamic adjustment mechanism for the short-run cross-price elasticity ε_{12} to its long-run value ε^* as follows

$$\varepsilon_t - \varepsilon^* = (1 - a_{14})^t (\varepsilon_{12} - \varepsilon^*)$$

For instance, if $t = 0$, then $\varepsilon_0 = \varepsilon_{12} = \rho_{14}$ is the short-run cross-price elasticity or it is what we observe in present. With increase in t, ε_t increases and adjusts to ε^*.

In order to illustrate the above described methodology, below we present numerical example.

Numerical Example: Let us assume the following values for the short-run cross-price elasticity of demand ε_{12}, long-run cross-price elasticity ε^* and speed of adjustment a_{14}:

$\varepsilon_{12} = 0.2 \quad \varepsilon^* = 1.2 \quad a_{14} = 0.5$ (50% of the gap between ε_{12} and ε^* is eliminated in the first period)

$\varepsilon_0 = \varepsilon_{12} = 0.2$

$\varepsilon_1 = \varepsilon^* + (1 - a_{14})(\varepsilon_{12} - \varepsilon^*) = 1.2 + 0.5(0.2 - 1.2) = 0.7$

$\varepsilon_2 = \varepsilon^* + (1 - a_{14})^2 (\varepsilon_{12} - \varepsilon^*) = 1.2 + 0.5^2 (0.2 - 1.2) = 0.95$

...

$\varepsilon_6 = \varepsilon^* + (1 - a_{14})^6 (\varepsilon_{12} - \varepsilon^*) = 1.2 + 0.5^6 (0.2 - 1.2) = 1.184375$

or [1 - (1.2 - 1.184375)/1.2] ×100% = 98.7% of the gap is eliminated in first 6 years. Thus, after six years we have to use the long-run value of cross-price elasticity for our calculations.

Another important conclusion is:

If freight rate of the second mode increases by 1%, then immediate impact on quantity demanded of the first mode is increase by 0.2%. In year 3, for example, we would expect 1.075% increase in demand for the first mode due to today's 1%-increase in freight rate of the second mode.

Conclusion

The described methodology provides estimates of cross-price elasticities of freight demand as functions of time. It allows us to trace consequences of the change in freight rate of one mode with respect to the quantity of transport services demanded of the other mode over time and vice versa. It gives us a clear picture for analysis of different scenarios of implementation of different public policies. For example, if the first mode is more efficient in terms of reduction in greenhouse gas emissions, then we might increase the freight rate of the second mode and trace consequences of such an increase for transport demand of the first mode over time as well as the second mode. Such a framework is useful for short-term policies as well as for long-term policies.

Ideally, we have to specify the freight demand system as a structural model and then apply structural vector Autoregression. SVAR is consistent with economic theory and econometric modeling at the same time.

References

Bernanke, B. Alternative explanation of money-income correlation. *Carnegie-Rochester Conference Series on Public Policy*, 25, 1986, 49-100

Dargay, J.M. and Goodwin, P.B. Evaluation of consumer surplus with dynamic demand. *Journal of Transport Economics and Policy*, 29 (1), 1995, 179-196

Enders, Walter. *Applied econometric time series*. New York: John Wiley and Sons, Inc., 1995

Oum, T.H. A cross-sectional study of freight transport demand and rail-truck competition in Canada. *Bell Journal of Economics*, 10, 1979, 463-482

Oum, T.H., W.G.Waters II and J.S.Yong. Concepts of price elasticities of transport demand and recent empirical estimates. *Journal of Transport Economics and Policy*, 26 (2), 1992, 139-154

Sims, C. Macroeconomics and reality. *Econometrica*, 48, January 1980, 1-49

Sims, C. Are forecasting models usable for policy analysis. *Federal Reserve Bank of Minneapolis Quarterly Review*, Winter 1986, 3-16

Yevdokimov, Y. *Macroeconomic consequences of large environmental impacts: the case of the Chernobyl accident in the Soviet economy*. Ph.D Thesis. University of Manitoba, Winnipeg, 1998

Zellner, A. An efficient method of estimating seemingly unrelated regressions, and tests for aggregation bias. *Journal of the American Statistical Association*, 57, 1962, 348-368

The Effects of Highway Infrastructure Capital on the Cost Structure and Productivity Performance of Canadian Goods-Producing Industry

by Bilkis R. Khanam*

Abstract:
This paper examines the impact of highway infrastructure capital on the cost structure and productivity performance of Canadian goods-producing firms. The size of this impact has important implications for policymaker's decisions on whether to invest in highway infrastructure. The results suggest that highway infrastructure capital does provide significant benefits to goods-producing firms and thus augments productivity growth. Not only is the cost function shifted downward in goods-producing firms, generating productivity improvements, but the factor demand in goods production is also affected by this type of public capital, suggesting bias effects. The "net benefits" of highway infrastructure capital is positive for the goods-producing industry in our sample.

Introduction

In most industrialized countries, private sector productivity growth has declined during the 70's and 80's. As a result, many nations standards of living are not keeping pace with expectations. Economists, regional scientists, transport planners and public policy-makers have not reached agreement on the exact cause of this decline. Among the major factors considered in the literature as potential causes of the decline in productivity growth are the following: rising energy prices; social regulation; changes in the composition of the work force; reduced spending on research and development; different rates of obsolescence of the private capital stock; and any number of other matters.

More recently, a growing body of literature argues that another potential cause of the decline in private sector productivity growth is the inadequate growth in public infrastructure. Many studies [Aschauer (1989 a, b), Munnell (1990), Garcia-Mila and McGuire (1992), Holtz-Eakin (1994), Khanam (1996)] have been conducted to measure and compare the impact of public infrastructure capital on private sector productivity growth over time and across firm. For a recent review see Gramlich (1994) and Gillen (1996). These studies generally agree on one point: that public infrastructure is a determinant of private sector economic growth and productivity performance. The question on which they have disagreed is the magnitude and significance of this contribution.

---

* Economist, Policy-Economic Analysis, Transport Canada. The views expressed are those of the author and do not necessarily those of Transport Canada.

Aschauer (1989), using production function approach and aggregate time series data, estimated output elasticities with respect to public capital ranging from 0.39 to 0.56. The primary criticism of Aschauer's finding was that the sizeable elasticity merely reflected a **spurious correlation** between output and the stock of public capital, and that once one controlled for the **nonstationarity** of the national time series, the relationship disappeared (Tatom 1991). Moreover, the production methodology employed by Aschaur (1989) and others raises the critical question of the **"direction of causality"**. Does public infrastructure investment increase productivity or is it high productivity and income levels that increase public investment? However, the question of causality does not arise in the cost function methodology, as the price of inputs rather than the quantities are exogenous.

Most of the above studies have been done for the United States and other countries. Investigations of the effect of publicly provided capital on private sector productivity have been limited in Canada by a lack of data. Using recently constructed estimates of highway capital stocks for Canada, this study investigates the impact of highway capital on the Canadian goods-producing sector's cost and productivity performance over time. The size of this impact has important implications for policymaker's decisions on whether to invest in highway infrastructure. Over time the interest in cost analysis has been motivated primarily by the implications for making decisions, either by firms or for public policy decisions.

The interest in empirical analysis of highway infrastructure capital's impact on private sector productivity growth has been motivated primarily by the implications for making public (in this case highway) investment policy decisions. Highway investments are frequently seen as an important means for improving community economic development prospects. Federal and provincial governments are faced with difficult choices when selecting highway improvement projects, as communities aggressively vie for the limited funds available. In order to address the issue of spending on highways, policymakers at all levels of government need to know more about the significance of highway infrastructure investment in facilitating Canadian economic activity.

The purposes of this research are:(1) to contribute to the existing literature by investigating the impact of highway infrastructure capital on the costs and productivity of the Canadian goods-producing industry; (2) to formulate a modified analytical model that incorporates most of the criticisms aimed at previous studies based on production function approach; (3) to improve the body of knowledge in Canada about the role of highway infrastructure capital in facilitating Canadian economic growth and productivity; and,(4) to better inform the provincial and federal decision makers who are facing more complex policy choices in the 1990s.

Most of the previous studies in this area are based on the production function approach and have been criticized on the methodological approach used[1]. Although analyses based on the production function approach provide a useful tool to investigate the relationship between infrastructure investment and productivity growth, they generally disregard the potentially large impact of public infrastructure investment on firms' costs and therefore economic performance. The cost function adds additional information, in the form of prices that allow efficiency conditions to be examined[2].

In order to avoid the inherent problems in the production function approach, this paper employs a cost function approach. It incorporates explicitly time specific effects in the equation to control for the time specific component that varies over time through the use of time dummy variables. In addition model is estimated in first difference form, a specification commonly used to examine the possibility of spurious correlation between output and the public capital stock.

The analysis in this paper is based on shadow value and cost elasticity measures of highway capital. The shadow value of highway capital is the cost equivalent of the marginal product of highway capital, reflecting the reduction in variable costs due to an incremental addition to highway infrastructure capital and thus the contribution of highway capital to the firm's efficiency and economic performance.

This paper estimates the shadow value and cost elasticity in order to measure the potential cost savings from a decline in variable inputs to produce a given amount of output when highway infrastructure investment occurs. The shadow value and cost elasticity are then used to estimate the "rates of return" from highway infrastructure investment. Finally it measures the effect of highway capital services on the demand for labour, private capital and material inputs.

A cost function is estimated using time series data for the period 1962-1994 on the quantity and prices of output, labour, material inputs, private capital and highway capital. The model is tested using translog specifications.

The organization of this paper is as follows: section 1 describes methodology, section 2 presents the empirical model and discusses the results; and, section 3 concludes the paper. Appendix A describes the data used for the model.

1. Methodology

To examine the effects of highway infrastructure capital on the cost structure and productivity performance of the Canadian goods-producing sector, the traditional cost functions must be modified to include the quantities of highway

[1] Few studies have used cost function approach.

[2] For a recent review see, Oum and Water, (1996)

infrastructure capital along with relative factor prices and the output quantity. The firm's cost minimization problem then becomes one of choosing the cost minimizing combination of inputs, given the exogeneously set input prices, the level of output and the level of highway capital. The cost function, C_t, for the goods-producing industry can be written as:

$$C_t = C(w_t, y_t, T, H_t) \qquad (1)$$

where C_t, w_t, y_t and H_t represent total cost, relative variable input prices, output and highway capital services[3] for goods production at time t, respectively. T represents disembodied technical change.

Public capital services (highway capital) affect the cost structure of an industry in two ways. First, a larger quantity or better quality of public capital services will shift the cost per unit of output downward in an industry if the industry receives any benefit from improved or larger public capital services. This can be called the " productivity effect". Second, firms will adjust their demand for labour, intermediate inputs, and physical capital stock if public sector capital either substitutes for or complements the factors of production in the private sector[4]. That is, the effects of public sector services may not be neutral with respect to private sector input decisions.

The Shadow values or marginal benefits of highway capital services can be obtained by taking the negative of the partial derivative of the cost function (1) with respect to highway capital services H_t. These values yield the magnitude of the cost reductions experienced by the private sector. The marginal cost reduction resulting from the highway infrastructure capital is given by:

$$B_{ht} = -\frac{\partial C_t}{\partial H_t} = B_{ht}(w_t, T, H_t, Y_t) \qquad (2)$$

B_{ht} in equation (2) is referred to as the 'willingness-to-pay' or the shadow value of highway capital services. Because the firm does not pay for it, one should expect nonnegative values for B_{ht}.

2.1. Empirical Model

To estimate the effects of highway capital services on the cost structure and the productivity of the goods- producing industry the following cost function is specified:

---

[3] Assume one unit of highway capital stock provides one unit of highway capital services. In the production and cost function, public capital services are often treated as unpaid factors of production.

[4] See Nadiri and Mamuneas (1994) for details

$$\ln(C_t / P_{mt}) - \ln y_t = \beta_{0t} + \sum_i \beta_{it} \ln w_{it} + \beta_t T + \sum_{i \neq j} \sum_j \beta_{ijt} \ln w_{it} \ln w_{jt}$$

$$+ \sum_i \beta_{iT} \ln w_i T + \phi_{ht} \ln H_t + \sum_i \phi_{iht} \ln w_{it} \ln H_t + V_t$$

$$i, j = L, K$$

$$t = 1,2.....n$$

(3)

The cost variable C_t is defined as $C_t = \sum_i p_{it} x_{it}$ where p_i and x_i are the prices and quantities of private inputs (labour and capital); w_i is the relative input prices defined as: $w_i = \frac{p_i}{p_m}$, where p_m is the price of material inputs. The subscripts i and j denote the private inputs. V_t is the random error and H_t is the highway capital services. The parameter ϕ_{ht} captures the effects generated by the highway capital services, H_t on cost. Input cost share equations are obtained applying Shepherd's lemma:

$$S_{it} = \sum_i \beta_{it} + \sum_{j \neq i} \beta_{ij} \ln w_{jt} + \beta_{iT} T + \phi_{iht} \ln H_t + U_t \quad \text{i,j =L,K,} \qquad (4)$$

where $S_{it} = p_i x_i / C_t$. U_t is the random error. The share equation of material input is obtained residually because of the constraint that variable cost shares must sum to one as: $S_{mt} = 1 - \sum_i S_{it}$. The parameter ϕ_{iht} measures the effect of highway capital services on the demand for labour, private capital and material inputs. That is, it measures the factor bias effects associated with highway capital. Equations 3 and 4 are estimated simultaneously using the Seemingly Unrelated Regression (SUR) technique.

2.2 Estimation Results

Table 1 presents the estimated parameters and the standard error of the estimates from the system of equations 3 and 4. The numbers in parentheses below the estimated coefficients are the standard errors of the estimates. These equations are estimated in three different specifications: (1) GLS estimates with no time effect[5]; (2) GLS estimates with fixed time effect[6]; and, (3) GLS estimates in first difference forms, as an adjustment for the nonstationarity of variables[7]. Column (5.1) presents GLS estimates with no time effects. It shows that the estimated

[5]This equation originally estimated had very low Durbin –Watson (DW) statistics, signaling the presence of significance positive serial correlation in the residuals of the equation. To deal with the problem the equation is re-estimated with a correction for first order correlation and the corrected results are presented in column (5.1).

[6]To control for time specific effects which varies over time.

[7] Without going into technical details, stationarity means that data fluctuates around a constant mean or variance with no trend over time

coefficient of highway capital ϕ_h is -0.13, which is statistically significant and negative, suggesting negative cost elasticity. With respect to technical progress, we identify the cost reducing effects, $\beta_t < 0$, that is decreasing over time. The negative parameters of ϕ_{Lh} and ϕ_{Kh} indicate that highway infrastructure capital is both labour and capital saving. With fixed time effects, the estimated coefficient of highway capital, ϕ_h is -0.26, which is negative and significant (column 5.2). Coefficients of the time dummy variables, not shown in column (5.2), are not statistically significant. In the same column, the coefficients ϕ_{Lh} and ϕ_{Kh} are negative, suggesting that highway infrastructure capital is both labour and capital saving. Table 1 also presents regression results, where the variables are in first difference forms as an adjustment for the nonstationarity of variables, in column (5.3). It shows that even with the correction for the nonstationarity of variables, the estimated coefficient of highway capital ϕ_h is -0.21, which is negative and insignificant[8]. In column (5.3) the negative parameter of ϕ_{Lh} indicates that highway infrastructure capital is labour saving and the positive parameter of ϕ_{Kh} indicates that highway infrastructure is capital using. The estimated parameters in Table 1 are used to calculate the contribution of highway capital to:

1. cost reduction;
2. marginal benefits or shadow values of highway capital;
3. demand for labour, private capital stock, and intermediate inputs in Canadian goods production, which are the primary focus of this analysis and are discussed below.

Cost Elasticity

An assessment of the cost reduction and, ultimately, the productivity impacts of highway capital services H, can be accomplished by calculating the elasticity of cost with respect to highway capital services. Cost elasticity measures the percentage change in costs due to a one percent change in highway capital services H, given everything else remaining constant. The cost elasticity is computed as:

$$\xi_{ch} = \frac{\partial \ln C_t}{\partial \ln H_t} = \theta_{ht} + \sum \theta_{ihi} \ln w_{it} \qquad \text{I, j = L,K} \qquad (5)$$

where ξ_{ch} is the elasticity of cost with respect to highway capital. The elasticity estimates ξ_{ch} are presented in Table 2 for two different estimation forms: (1) GLS estimates with no time effect; and (2) GLS estimates in first differences form[9].

---

[8] It is significant at the 80% level.

[9] Elasticity estimates with time dummies which has insignificant coefficients are omitted from Table 2. Estimates with time dummies are available upon request.

TABLE 1
Estimated Parameters (standard errors in parentheses)
Cost Function, (1961-1994)

Parameter	Estimates (5.1) No time effect	Estimates (5.2) Fixed time effect	Estimates (5.3) First difference
β_{0t}	2.4802	3.9053	0.8374
	(0.8548)	(0.8213)	(0.0420)
β_L	0.9718	7.2234	0.2728
	(0.3909)	(1.3284)	(0.0112)
β_K	0.4273	0.5536	0.1493
	(0.3325)	(0.4849)	(0.0071)
β_t	-0.0025	-0.0006	0.0011
	(0.0011)	(0.0020)	(0.0018)
β_{LK}	0.0424	0.0433	0.0175
	(0.0063)	(0.0194)	(0.0082)
β_{Lt}	-0.0007	-0.0384	-0.0011
	(0.0006)	(0.0087)	(0.0005)
β_{Kt}	1.49E-05	-0.0015	0.0019
	(0.0006)	(0.0008)	(0.0003)
ϕ_h	-0.1359	-0.2639	-0.2132
	(0.0839)	(0.0814)	(0.4001)
ϕ_{Lh}	-0.0624	-0.6759	-0.0358
	(0.0384)	(0.1350)	(0.0108)
ϕ_{Kh}	-0.0222	-0.0305	0.0047
	(0.0329)	(0.0466)	(0.0066)
Equation	R^2	R^2	R^2
Cost	0.85	0.97	0.54
Standard Error	0.0305	0.0518	0.0390

The results in Table 2 indicate that the highway capital services reduce costs in the goods-producing industries. The cost elasticities range from 0.07 to 0.22. This implies a large cost-saving benefit of additional units of highway infrastructure capital, which is statistically significant (since the shadow value is significantly different from zero).

Marginal Benefits or Shadow Values

Shadow values measure the cost-saving benefits of highway capital and thus productive performance. The shadow values or marginal benefits of highway capital are computed using the following relation:

$$B_{ht} = -\frac{\partial C_t}{\partial H_t} = \xi_{ch}\frac{C}{H}, \qquad (6)$$

TABLE 2

COST ELASTICITIES (ξ_{CH})

Year	Cost elasticity No time effect	Cost elasticity First Difference
1962	-0.070	-0.192
1963	-0.073	-0.194
1964	-0.076	-0.196
1965	-0.080	-0.198
1966	-0.086	-0.201
1967	-0.092	-0.202
1968	-0.097	-0.204
1969	-0.101	-0.206
1970	-0.108	-0.208
1971	-0.113	-0.210
1972	-0.116	-0.212
1973	-0.112	-0.212
1974	-0.103	-0.210
1975	-0.107	-0.210
1976	-0.114	-0.213
1977	-0.115	-0.214
1978	-0.112	-0.212
1979	-0.108	-0.210
1980	-0.108	-0.210
1981	-0.110	-0.210
1982	-0.114	-0.211
1983	-0.115	-0.211
1984	-0.112	-0.211
1985	-0.114	-0.212
1986	-0.121	-0.216
1987	-0.123	-0.217
1988	-0.125	-0.218
1989	-0.127	-0.219
1990	-0.126	-0.221
1991	-0.132	-0.223
1992	-0.132	-0.224
1993	-0.133	-0.225
1994	-0.127	-0.221

where B_{hi} is the marginal benefit or shadow value of highway capital, ξ_{ch} is the elasticity of cost with respect to highway capital. The shadow values or marginal benefits of highway capital are estimated in two different estimation

forms: (1) GLS estimates with no time effect; and, (2) GLS estimates in first difference forms. The shadow values B_{ht} exceed zero for all estimation forms and all time periods, indicating a positive marginal product of highway infrastructure capital for firms, i.e., an increase in highway capital services decreases private sector production costs. Table 3 presents the shadow value or marginal benefit of highway capital.[10] The cost saving benefits of highway capital must be weighted against the cost of using highway capital for that year, that is, the social user cost of highway capital.

Social Rates of Return

One issue that has been raised in the literature and has important public policy implications is whether public capital is over or under supplied. The optimal provision of public capital service (highway capital) can be derived by the well-known Samuelson condition, as modified by Kaizuka (1965). This condition requires that public capital be provided at the point where the sum of marginal benefits of producers and consumers is equal to the marginal cost of providing an additional unit of public capital. Ignoring the consumption sector, an alternative means of determining whether public capital is provided optimally is to compute the rate of return to highway capital and compare it with the rate of return to private capital for the whole economy. If the rate of return of highway capital is higher than that of private capital, highway capital is under supplied and an increase in public investment is necessary. Morrison and Schwartz (1996) take another approach. They compare the shadow price of public capital with the social user cost of public capital, and find that Tobin's q ratio of public investment exceeds one, suggesting that infrastructure investment has been too low for social optimization for the manufacturing sector of all regions in their sample. In this paper rates of return of highway infrastructure capital are computed by comparing shadow values of highway capital with the social user cost of highway capital. Table 3 presents the estimates of the social user costs of highway capital. Construction of this measure is elaborated in appendix A. The user costs of highway capital are estimated in three different forms: user cost (P_{ht}^1) is computed without a tax adjustment; user costs P_{ht}^2 and P_{ht}^3 are computed based on an adjustment for the marginal cost of public funds.The second column of Table 3 reports the estimates based on our calculation of social user cost when P_{ht}^1 is computed without a tax adjustment, the third column is based on Jorgenson and Yun (1973) estimates of marginal cost (P_{ht}^2), and the last column is based on Ballard et al. (1985) estimates of marginal cost (P_{ht}^3). A comparison of shadow values with the social user costs of highway capital indicates that the shadow values exceed the social user costs of highway capital across all estimates of user costs --- suggesting that the "social rates of

[10] Table 3 presents estimates based on the GLS method with no time dummy. Estimates based on other estimation methods are available upon request

Table 3
Shadow Values* and Alternative measures of User Costs of Highway Capital

Year	Shadow Values	User Cost	User Cost	User Cost
		p_{ht}^1	p_{ht}^2	p_{ht}^3
1962	0.054	0.031	0.046	0.036
1963	0.056	0.032	0.048	0.038
1964	0.059	0.034	0.050	0.040
1965	0.065	0.036	0.053	0.042
1966	0.076	0.040	0.059	0.047
1967	0.087	0.045	0.067	0.053
1968	0.095	0.045	0.066	0.053
1969	0.103	0.046	0.068	0.054
1970	0.119	0.050	0.074	0.059
1971	0.128	0.054	0.079	0.063
1972	0.136	0.056	0.082	0.065
1973	0.138	0.059	0.086	0.069
1974	0.146	0.067	0.098	0.078
1975	0.183	0.098	0.144	0.115
1976	0.220	0.113	0.165	0.132
1977	0.252	0.116	0.171	0.136
1978	0.274	0.120	0.177	0.141
1979	0.292	0.132	0.193	0.154
1980	0.349	0.148	0.217	0.173
1981	0.421	0.185	0.271	0.216
1982	0.523	0.252	0.370	0.295
1983	0.519	0.259	0.381	0.303
1984	0.501	0.240	0.353	0.281
1985	0.574	0.257	0.378	0.301
1986	0.635	0.249	0.365	0.291
1987	0.664	0.228	0.335	0.267
1988	0.728	0.224	0.329	0.262
1989	0.787	0.232	0.340	0.271
1990	0.764	0.237	0.348	0.277
1991	0.800	0.255	0.375	0.298
1992	0.753	0.234	0.345	0.274
1993	0.731	0.229	0.337	0.268
1994	0.658	0.217	0.319	0.254

* shadow values are based on no fixed time effects. Shadow vales based on (fixed time effect and first difference estimation forms) are available upon request.

return" to highway capital are positive for the goods-producing sector in that sample.

Effect of Highway Capital on Demand for Labour, Capital and Material Input

The effect of highway capital on the private sector's demand for labour and capital is computed using the following relation:

$$\eta_{iht} = \frac{\partial \ln x_i}{\partial \ln H_t} = \xi_{sch} + \frac{\phi_{iht}}{S_{it}}, \quad \text{I=L,K,M} \tag{7}$$

where ξ_{sch} is the cost elasticity with respect to highway capital stock, which measures the productivity effect. $\frac{\phi_{iiht}}{S_{it}}$ is the factor bias effect over share. η_{iht} is the elasticity of input demand with respect to highway capital, which is the sum of the "productivity effect" and the "factor bias effect". If η_{iht} in (7) is positive, negative or zero, it implies that the highway capital and the i^{th} private input are substitutes complementary or neutral, respectively. The elasticity of the material input is computed as:

$$\eta_{mht} = \xi_{sch} - \frac{\sum_i \phi_{iht}}{1 - \sum_i S_{it}}, \quad \text{I, j= L,K} \tag{8}$$

η_{mht} is the elasticity of material input with respect to highway capital services. The elasticities of input demand η_{iht} (labour, capital and material) is presented in Table 4. The sign of the coefficients in Table 4 suggests that the highway capital is a substitute for the private sector factors of production. That is, an increase in highway capital is always cost saving. Empirical evidence supports the hypothesis that labour and public capital are substitutes while the relationship between public capital and private capital is not clear cut. The empirical evidence of cost function estimates supports the hypothesis that cost savings are associated with an increase in public capital.

Summary and Conclusions:

The objective of this paper is to estimate the contributions of highway infrastructure capital to the Canadian goods-producing sector's cost savings and thus to productivity performance. To identify the cost saving impacts of highway capital, we have used shadow values and cost elasticity measures. The results suggest that the cost saving impact of highway capital is significant. Its effects on the cost structure vary over time. Not only is the cost function shifted downward in goods production, generating productivity improvement, but the factor demand in goods production is also affected by the highway capital. Using shadow values and user costs measures, we evaluate the 'social rates of return' to highway infrastructure investment for the Canadian goods-producing industries in our sample.

TABLE 4
Elasticities of Input Demand*

Year	Labour η_{LH}	Capital η_{KH}	Material inputs η_{MH}
1962	-0.382	-0.218	-0.021
1963	-0.387	-0.226	-0.023
1964	-0.395	-0.234	-0.026
1965	-0.389	-0.234	-0.031
1966	-0.379	-0.235	-0.037
1967	-0.319	-0.227	-0.044
1968	-0.325	-0.230	-0.050
1969	-0.333	-0.232	-0.054
1970	-0.334	-0.228	-0.062
1971	-0.343	-0.233	-0.067
1972	-0.345	-0.240	-0.069
1973	-0.348	-0.250	-0.063
1974	-0.348	-0.254	-0.052
1975	-0.343	-0.241	-0.058
1976	-0.348	-0.245	-0.066
1977	-0.348	-0.243	-0.067
1978	-0.369	-0.232	-0.064
1979	-0.379	-0.232	-0.058
1980	-0.377	-0.224	-0.059
1981	-0.383	-0.220	-0.062
1982	-0.380	-0.204	-0.070
1983	-0.401	-0.208	-0.069
1984	-0.402	-0.218	-0.063
1985	-0.408	-0.216	-0.066
1986	-0.391	-0.223	-0.074
1987	-0.394	-0.229	-0.075
1988	-0.393	-0.235	-0.077
1989	-0.387	-0.238	-0.079
1990	-0.370	-0.247	-0.079
1991	-0.365	-0.247	-0.086
1992	-0.371	-0.254	-0.085
1993	-0.376	-0.255	-0.085
1994	-0.385	-0.246	-0.078

*Elasticities of input Demand on no fixed time effects. Shadow vales based on (fixed time effect and first difference estimation forms) are available upon request.

The user cost of highway capital is computed with and without a tax adjustment for the marginal cost of public funds. The 'social rates of return' are positive and vary over time, across all measures of user cost, reflecting the underlying rates of public investment in highway infrastructure. In addition, our analysis finds that spending on highway capital has a significant effect on employment, private capital formation and demand for material inputs in the goods-producing sector. At a given level of output, an increase in highway capital leads to a reduction in demand for all inputs in goods production. The magnitude of this effect varies among the three inputs.

The main point that can be drawn from this study is that highway infrastructure capital does affect the cost and productivity of the goods-producing industry and have a positive social rate of return.

One might argue that the cost function approach does not exhaust all possible methods for examining the relationship between highway capital and productivity. For example, this approach does not include other public infrastructure capital which contributes to cost reduction and thus productivity improvement in goods production. Also, it will be desirable to examine the impact of highway capital on the costs and productivity of various industries. Despite these shortcomings, it is believed that the approach taken in the present paper provides evidence of a link between highway investment and cost reduction in goods production, and that it provides a fruitful area for further research.

Bibliography

Aschauer, D.A., (1989a), "Is Public Expenditure Productive ?", Journal of Monetary Economics, 23, pp. 177-200.

Aschauer, D.A., (1989b), "Public Investment and Productivity Growth in the group of Seven", Economic Perspectives, 13 (5) (1989b), pp.17-25.

Ballard, Charles L. and Fullerton, Donald. " Distortionary taxes and the provision of public good." Journal of Economic Perspectives, Summer 1992, 6(3), pp.21-50.

Garcia-Mila, T. and McGuire T.J., (1992), "The Contribution of Publicly Provided Inputs to State Economies", Regional Science and Urban Economics, 22, 229-241.

Gillen, D.W. (1996), " Transportation Infrastructure and Economic Development" Logistics and Transportation Review, 32:1, 39-69.

Gramlich, E. M. (1994), "Infrastructure Investment: A Review Essay" Journal of Economic Literature, Vol. XXXII (September), pp. 1176-1196

Jorganson , Dale W.and Yun, K.Y. "The excess burden of U.S. Taxation." Journal of accounting , Auditing and Finance, Fall 1991, 6(4), pp.37-44

Holtz-Eakin, D., (1994), "Public sector capital and productivity puzzle", Review of Economics and Statistics, Vol. LXXVI, February, 12-21

Khanam, B. R., (1996), "Highway Infrastructure Capital and Productivity Growth: Evidence from the Canadian Goods-Producing Sector", The Logistics and Transportation Review, Vol 32, No. 3, September 1996, 251-268.

Morrison, C.J. and Schwartz A.E., (1996), "State Infrastructure and Productive Performance", The American Economic Review, Vol. 86 No. 5, December 1996, pp. 1095-1109.
Munnell, A. H., (1990a), "Why Has Productivity Growth Declined? Productivity and Public Investment", New England Economic Review, Jan./Feb., 3-22.
Nadiri, M. Ishaq and Mamuneas, Theofanis P. " The effects of Public Infrastructure and R&D Capital on the Cost Structure and Performance of U.S. Manufacturing Industries," Review of Economics and Statistics, February 1994, 74(1), pp. 22-33.
Oum, T.H. and W.G. Waters II (1996), "A Survey of Recent Developments in Transportation Cost Function Research" Logistics and Transportation Review", 32:4, 423-463.
Tatom, J. A., (1991), "Public Capital and Private Sector Performance," St. Louis Federal Reserve Bank Review, May/June, 3-15.

Appendix A:

Data description and sources used for this study are listed below:

Private Capital Stocks:

The quantity of private capital stock, Kp are obtained from Statistics Canada's fixed capital stocks and flows series (end year net stocks, based on geometric depreciation, in constant 1986 dollars), 1961-1994, Cat. # 13-568.

Price of Private Capital:

For private capital, the price is generally measured as user cost. The user cost of the capital stock, is constructed according to: $P_{Kt} = \frac{1}{TXt} PI(r_t + \delta_t)$, where PI is the asset price or investment deflator, r_t is the rate of return representing the cost of funds or opportunity cost of the last dollar of investment, δ_t is the depreciation rate and TXt is the corporate income tax rate, is obtained from Gilmores Tax Handbook, CCH (Canadian) Ltd., Canadian Master Tax Guide. For this paper, r is approximated as the long-term bond rate. Depreciation, δ_t is measured as the ratio of total annual depreciation of equipment and structures in the goods-producing sector to the stocks of equipment and structures, both in constant 1986 dollars (from Statistics Canada's fixed capital stocks and flows series (end year net stocks, based on geometric depreciation, in constant 1986 dollars, 1961-1994, Cat. # 13-568.) The investment deflator for the goods producing capital stock, PI, is calculated as the ratio of Statistics Canada's current and constant dollar estimates of the goods producing sector's net equipment and structure capital.

Highway Capital:

TTThe quantity of highway capital stock, H_t, is measured as the end of year public capital stocks of highways and bridges, in 1986 dollars, with a one year lag to reflect beginning of year stocks. Highway capital stocks are obtained from Statistics Canada on

special request, (end year, net stocks, based on geometric depreciation, in constant 1986 dollars)[11].

Price of Highway Capital:

The user cost of highway capital stock, p_h is constructed according to:

$P_{ht} = PI(r_h + \delta_h)$ where PI is the investment deflator, r_h is the government cost of obtaining funds and is approximated by the rate on long term government bonds. δ_{ht} is the depreciation rate and is measured as the ratio of total annual depreciation of highway capital stock to the total stock of highway capital, both in constant 1986 dollars. These are obtained from Statistics Canada on special request (end year, net stocks, based on geometric depreciation, in constant 1986 dollars). To incorporate the excess burden of taxation, we choose among widely ranging estimates. Most estimates of the marginal cost of public funds (or the marginal excess burden from raising a dollar of public funds through taxation) fall between $1 and $1.50 for each dollar raised. Although two of the more commonly cited estimates are Dale W. Jorgenson and K.Y. Yun's (1991) " marginal cost of tax dollars" of $1.46 and Charles Ballard et al's (1985) " cost elasticity of $1.33, there is no consensus that this measure even exceeds 1. For purposes of comparison with the shadow value estimates, we computed user cost in three different forms: (1) like Morrison and Schurtz (1996) the social user cost of highway capital is measured using the following relation $P^1_{ht} = PI(r_h + \delta_h)$, the variables are defined above; (2) the social user cost of highway capital is also measured using this formula $p^2_{ht} = PI(r_{ht} + \delta_{ht})(1+\varpi)$ where ϖ is the price distortion effect of taxes levied to finance highway capital, [ϖ is set to 0.46; see Jorgenson and Yun (1990)]; and (3) $p^3_{ht} = PI(r_{ht} + \delta_{ht})(1+\varpi)$ where ϖ is the price distortion effect of taxes levied to finance highway capital, (w is set to 0.33; see Ballard et al (1985)).

Output:

The quantity of output is measured as the Gross Domestic Product at factor cost in 1986 dollars, in the goods-producing sector, 1961-1994. Data were obtained from Statistics Canada's Aggregate Productivity measures series, CANSIM, matrix 7938, series I34033 cat. # 15-204.

Labour:

The labour input quantity is measured as the number of hours worked in the goods-producing sector, in millions. It is obtained from Statistics Canada, CANSIM, matrix 7918, series I190201.

Labour Price:

Wage bill per worker is obtained as the ratio of wages and salaries and supplementary labour income to the number of hours worked.

Wages, salaries and supplementary labour income is obtained from Statistics Canada, CANSIM, matrix 6655, 1962-1994, series D11801-06, agriculture, forestry, fisheries, mines, manufacturing and construction.

---

[11] The perpetual inventory method has been used to estimate the highway capital stock. The method is discussed in Special Infrastructure Projects, "evaluation of Canadian Road and Highway System". Transport Canada, policy, March 1996.

GUIDELINES TO CONSOLIDATE LOW VOLUME ROADS: A CASE STUDY APPROACH

Kiel Ova
Upper Great Plains Transp. Inst.
North Dakota State University
P.O. Box 5074
Fargo, North Dakota 58105
Phone: 701-231-1086
Fax: 701-231-1945
e-mail: ova@plains.nodak.edu

Jill Hough
Upper Great Plains Transp. Inst.
North Dakota State University
P.O. Box 5074
Fargo, North Dakota 58105
Phone: 701-231-8082
Fax: 701-231-1945
e-mail: hough@plains.nodak.edu

EXECUTIVE SUMMARY

Local governments, including counties and townships, in rural America have a difficult challenge to maintain their road systems to current standards. Limited road funding, the migration of population from rural to urban areas, and the deteriorating road infrastructure are impeding local governments. It is becoming more important for local governments to prioritize their road network and to search for maintenance alternatives. The purpose of this paper is to take a more in-depth look at reducing the road network by eliminating low volume, nonessential roads. The methodology used in this study is based on a Geographical Information System (GIS) of a case study township in North Dakota. Several types of data were collected for this study, including origin-destination data, budget information, and road centerline data. Three possible scenarios for closing road segments were evaluated using benefit/cost analysis. As a result of closing specific road segments of the township network, annual net benefits were $6,038, $3,693, and $7,565, respectively.

INTRODUCTION

Transportation planning is becoming a higher priority for local governments and road officials. It is apparent that maintenance and planning decisions cannot continue on immediate demand basis; short and long term planning must exist for a reliable future infrastructure. Local governments establish and maintain local roads while faced with declining tax bases, increasing traffic

surrounding immediate urban areas and decreased traffic in extreme rural areas, increased vehicle loading, funding targeted at higher priority roads such as interstate or arterial roads, and lack of resources to provide future improvements and adequate maintenance. Investigating alternative maintenance strategies will help townships and local governments maintain their infrastructure. One solution may be the elimination of unnecessary roads that provide duplicate service yet provide reasonable service to its users, while at the same time increasing funds to help improve the remaining infrastructure.

Most townships already face the increasing pressure from lower tax-bases due to a decreasing population and have problems maintaining the existing road infrastructure. For example, the township used in the case study analysis for this paper has experienced nearly a 60 percent decline in population since 1960. In comparison, the network has reduced a maximum of 8 percent in the same period of time.

In addition, changes in the agricultural industry and increased commuter traffic are redistributing traffic in several counties, thus contributing to the problem of road maintenance for township governments. Townships surrounding cities such as Fargo, North Dakota are experiencing increasing traffic from commuters in surrounding small developments or communities, whereas townships removed from urban areas continually experience a decline in traffic with the removal of farms from the area due to bankruptcies and retired families moving to urban areas. This trend indirectly contributes to another difficulty for townships, the advent of the corporate farm.

The inception of the large or corporate farm has resulted in the increase of equipment size. The corporate farm includes larger fields within a section of land or the same owner for an entire section therefore reducing the need for multiple field accesses. The local road infrastructure was built over 60 years ago when the equipment and vehicles were one half to one third the size and weight of the vehicles today. The infrastructure needs to be wider and stronger to handle the larger and heavier equipment. The prioritization and elimination of unnecessary township roads will allow more money to be spent on improving the road conditions for increased travel and heavier loads.

Funding is also a problem for townships. In addition to a decreasing tax base, townships receive little monetary help from state or federal agencies. County governments are reluctant to help townships by taking jurisdictional control of roads because they are pressured with decreased funding from the state and often look to give control of some roads to township control. Increased costs of infrastructure repair are also impairing townships. For example, one township in Cass County spent fifteen percent of it's total budget on one culvert replacement. In addition, increased gravel costs have decreased

the townships ability to budget for improvements.

Objective of the Study

The objective of this paper is to provide guidelines for the consolidation of township roads. A methodology was developed to show a level of township roads that provides adequate service to it's users while increasing township resources. More specifically, a case study township was selected, cost and travel pattern data were collected, proposed alternative networks based on traffic levels were evaluated, and a benefit/cost analysis was used to demonstrate the best case scenario.

LITERATURE REVIEW

Several studies have been conducted on the reduction or addition of roads to county and state networks, however few have been conducted on the local township level. In addition, these studies concerning the reduction or addition of roads to a network provide a methodology for the means but lack a simplified guide for local or township officials to follow to implement possible closures. Further, none have included the application of GIS (Geographical Information System) for the analysis of the networks.

Lamberton (1992) conducted a study to evaluate road reductions for a township in South Dakota. Four alternative networks were considered for reducing their network. The analysis applied to removing roads from the network were based on minimizing travel distance to identified origins and destinations. The alternative networks considered were: 1.) removing township roads with no farm access but maintaining school and postal routes, 2.) removing township and county roads with no farm access while changing school and postal routes, 3.) removing only those roads that did not provide access to farmsteads, and 4.) removing only those roads with the annual cost of rerouting the traffic less than $500. The results for the four alternatives showed net changes of -$1,700, $2,600, $2,600, and -$5,100 respectively. The report did not include details on the calculation of vehicle operating costs, opportunity costs, or determination of origin and destination data.

Baumel (1986) conducted a case study analysis of three counties in Iowa to evaluate reducing the road network. The results in this report included comprehensive analysis of the alternative networks and the impact to travel costs. Baumel included various tables calculating the costs associated with travel on gravel and pavement, which was referenced by Lamberton. Some major conclusions from the study are that 1) major sources of vehicle miles on county roads are automobiles used for household purposes and pickup truck travel for farm purposes; 2) farm related travel represents small percent of total

travel but high percent of total travel costs; 3) areas with small rural population and large percent of gravel roads, small number of roads with no property access can be abandoned; 4) areas with small rural population and high percent of paved roads, a large number of miles of county roads with no property access can be abandoned, 5) dead-end roads with property access can be converted to private drives.

Case Study Selection

Clifton township posed the best representation of townships in North Dakota. It also represents an ideal case study for examining the potential benefits of closing or reducing maintenance of low volume township roads for several reasons. The township has 1) a very limited tax base; 2) a continually decreasing tax base as residents continue to migrate to more urban areas; 3) a large number of fully maintained roads with the inclusion of some county paved roads, suggesting that significant maintenance savings could be realized through selective road closing or designation as minimum maintenance.

Data Collection

Several types of data were collected for this study, including origin-destination data, budget information, and road centerline data. Origin-destination data was collected through a telephone survey of the Clifton Township residents. Residents were asked about the nature of their trips during a normal week; the frequency and destination of the trips were then determined for all residents of the household. The occupations of the residents, number of school children, and seasonal trips were also investigated. Of the thirty resident locations in the township, thirteen responses were obtained. The locations with no responses were estimated by taking a weighted average of the nearest neighbors origin-destination data. Budget information was obtained from the case study township representatives.

The application of a Geographical Information System (GIS) was used for case study analysis. Attributes attached to each road segment for this study included speed, length, vehicle operating costs per mile by surface type, opportunity costs per minute, and total travel time. The GIS transportation software, TransCAD3.1, was used to calculate the shortest path for the origin/ destination routes based on minimizing travel time.

Preparation of the network consisted of obtaining the road centerline from TIGER/LINE® 1995 files[1], selecting the specific road types, and designating them with the above attributes. Visual inspection and Cass County maps were then used to locate the locations of all residences and businesses within the township and outside Alice city limits. Actual road conditions were obtained from county maps and on-site inspections.

Description of Township

Clifton township is on the western border of Cass County North Dakota approximately 7 miles south of I-94. According to the 1990 Census data, Clifton township had a population of 78. The 1960, 1970, and 1980 Census data showed Clifton township with a population of 188, 146, and 113 respectively. This represents approximately a 59% decline in population over a thirty-year period. This trend of population decline is predicted to continue due to the out-migration of people in this area to urban areas (Rathge, 1993). With a decreasing population, a smaller tax base will be available for the upkeep of the road network. This poses a common problem in most, if not all, townships in North Dakota except those townships immediately adjacent to urban areas.

Clifton has a road network that consists of approximately 75 miles, with eight bridges crossing the Maple River. These bridges were built between 1950 and 1960 except one in 1979. The road network consists of 12 miles of paved county roads, 50 miles of graveled roads (including 6 miles of county gravel roads), 8 ½ miles of un-graveled roads, and approximately 6 miles of designated minimum maintenance roads. The paved roads consist of Cass County 38 on the eastern boundary of Clifton township, and Cass County 6 dividing the township into equal north and south regions. Cass County 1 is a gravel road on the western boundary of Clifton Township. Figure 1 illustrates the road types, resident locations, and destination locations.

---

[1]TIGER/Line® stands for Topographically Integrated Geographic Encoding and Referencing System developed by the Bureau of the Census. At the initial start of this report, TIGER/Line® files were the only centerline data available. Concerns have been raised about the accuracy of TIGER/Line® centerline. After comparison with Cass County centerline data obtained from the North Dakota Department of Transportation, it was determined the TIGER/Line® centerline contains the correct length, however is shifted approximately a tenth of a mile south. This does not affect the accuracy of the results presented in this report.

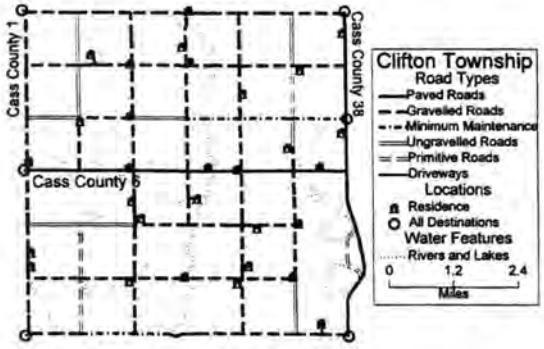


Figure 1. Clifton Township Roads by Type

General Methodology

The methodology presented in this section provides an evaluation process used to examine the feasibility of closing or reducing maintenance of low volume road segments of a township network. Road segments are defined as sections of the township network that represent a direct path from one point to another without an intersection, usually from section corner to section corner or driveway access to driveway access, etc.

The methodology compares the reduction in road maintenance costs (the benefit) to the increase in user costs[2] (the cost) from closing low volume road segments. The methodology is really a three-step process. The first step is to determine the number of vehicle trips occurring on the various road segments within a given amount of time under the present road configuration. This is done by: 1) making an assessment of the origin, destination, and frequency of trips originating or terminating in the township, 2) evaluating the time necessary to make each trip for all possible routes, 3) choosing the least time route for each trip, and 4) tabulating the number of trips traveled on each segment when least time routes are chosen. The second step is to decide which segments to eliminate from the township network for a benefit cost comparison. This determination is primarily based on the number of trips realized on each road

---

[2]User costs, or vehicle operating costs and opportunity costs are discussed in detail in the benefit/cost analysis section.

segment by evaluating the network collectively and determining a level that differentiates low and high volumes. The last step is to compare the change in road maintenance cost to opportunity and vehicle operating cost changes given the proposed segment closings.

Specifically, the general steps for the methodology are:

1. Collect data for all road segments - attributes such as speed, length, surface type, width, route number or name, designation, annual maintenance costs (blading, graveling, snow removal).
1. Collect destination/origin data for all residences in the candidate township - frequency of trips, destination of trips, number of people in vehicle, age of driver, purpose of trip.
2. Analyze and develop the original network, minimize travel time from each origin to the respective destination, and compute costs for each route.
3. Analyze the routes - estimate the total number of trips occurring on each road segment and determine low volume segments.
4. Develop alternative networks based on removing low volume roads, minimize travel time from each origin to the respective destination, and compute costs for each route.
5. Compare the benefits and costs associated with the original network and the alternative networks.

It is imperative to understand that the results found in this study are specific to Clifton township, but representative of many townships in North Dakota and the Midwest, where township roads are built on the section grid system. While the methodology used to determine segments of a network to be eliminated from the network is specifically defined, it could be modified for any township in question. Each township poses a unique topography or layout of the network, has different users, may include bridges or county roads, or has more critical user routes.

Scenarios

The origin/destination data based on the telephone survey were used to determine the shortest-path of travel time routes from the location of residences to their typical destination points for Clifton township. These routes revealed the road segments not used for any trips and segments with less than ten trips. These natural breaks provided the basis for determinating alternative networks.

Three alternative networks were chosen to compare the benefit and cost of removing roads from a network. The first alternative is based on removing the segments that have no regular local travel. The second alternative network is based on removing all of the segments that have less than ten weekly trips.

Finally, the third alternative uses the same criteria as the second but takes into consideration the connectivity of the township network, the conditions of the roadways, and most importantly, the general shift of traffic due to other road segment closures.

After reviewing the second alternative, one segment was determined to cause a significant increase in user costs by limiting east - west travel for the northern end of the township. These trips were forced to travel up to three miles south to Cass County 6 to get to the east end of the township and then travel Cass County 38 to go north. This resulted in a substantial increase to user miles traveled. Figure 2 illustrates the three scenarios corresponding with the proposed changes to the road network.

For this case study, school bus routes and mail carrier routes were included in the determination of user costs but were not included in the determination of removing routes from the network. This was determined to be more effective in the analysis of the case study because some of the school and mail routes were on roads providing duplicate service to a residence. These systems are adjustable from year to year due to students graduating and residents moving to urban areas, therefore limiting the criteria for removing a road from the network based on school bus or mail carriers did not seem advantageous to the analysis of the network. When comparing the alternative networks, there were minimal increases in the amount of miles traveled by either service.

Tangible factors may be taken into consideration for removal of segments such as bridge conditions, existing surface conditions, and connectivity to corresponding township networks. By visual inspection and familiarity of the township, routes that have less gravel, experience seasonal travel, or are unsafe could be considered for closure or minimum maintenance designation. In the next section, benefit/cost analysis will be applied to the three scenarios to illustrate the net savings to the users.

Benefit/Cost Analysis

The feasibility of the alternative networks is determined by comparing the increase in user cost verses the decrease in maintenance cost. Closing a road segment increases vehicle miles traveled and therefore increases vehicle operating costs and opportunity costs, but decreases total maintenance costs. By decreasing maintenance costs, there will be more money available for other improvements, such as gravel stabilization and road widening, thus decreasing the vehicle operating cost; in return increasing benefits by reducing the vehicle operating costs on gravel. However, this paper only focuses on the initial benefits for the three scenarios and does not take into consideration the added long term benefits from possible future improvements. This section examines

the benefits of the three networks compared to the original network.

Vehicle Operating Costs

Vehicle operating costs (VOC) include cost of fuel, fuel taxes, maintenance, financing, registration/taxes, insurance and repairs, and use-related depreciation (FHA, 1995). Including vehicle operating costs to reflect the additional costs of operating on deteriorating pavements is often useful in pavement management; this analysis uses the same principle but compares the vehicle operating costs of operating on different road segments and surfaces.

Road user costs will typically be higher on gravel roads than paved roads for several reasons. First, paved roads will permit greater vehicle speeds to be achieved with higher levels of safety and comfort than gravel roads. Second, the increased smoothness of paved roads produces less damage on vehicles and requires less fuel consumption. This results in decreased vehicle operating costs incurred on paved roads compared to those incurred on gravel roads. Thus, the vehicle operating costs and opportunity cost incurred on gravel roads will be greater than those incurred on paved roads (Bitzan et. al., 1992).

The vehicle operating costs for the township residents and the postal route were estimated to be $.45 per mile for gravel surfaces and $.395 per mile for pavement surfaces. The value for gravel was based on adjusting the national pavement vehicle operating cost by a factor of 1.14[3].

The value for pavement was obtained from the Federal Highway Administration estimates based on the 1994 editions of *The Complete Small Truck Guide and The Complete Car Cost Guide*, from Intellichoice, Inc., and sales figures from Automotive News. The vehicle operating cost per mile for the school bus route was calculated to be $1.30, based on an interview with Dietrich and Son's Inc., a distributor of school buses in North Dakota. This value is based on private contractors' prices for operating a bus per mile, therefore it includes profit for the company and reflects an opportunity cost for

---

[3]This factor was obtained by taking a comparison of the 1992 VOC for gravel and VOC for pavement, as reported in Bitzan et. al. These values reported by Bitzan were based on the Highway Performance Monitoring System, Version 2.0, January 1986, issued by the Federal Highway Administration, where a formula is used to determine the effect of the pavement condition on the VOC. The formula relates the cost at a PSR of 4.5 (good pavement condition) to a PSR of 2.0(condition equivalent to gravel). The formula is:

$$VOC = 0.9818182 + (5.0 - PSR)/(20.0 + (5.0 \times (PSR - 3.0)))$$

It is assumed the adjustment factor is the same for 1997.

the driver. The VOC for the school bus route on gravel is adjusted by the 1.14 factor mentioned above.

Opportunity Cost

Opportunity cost is the cost associated with additional travel time. This cost represents the cost of the additional time the road user spends on the alternative route instead of productive events such as employment. This is true for individuals who can substitute time for money, such as dentists, sales professionals, or farmers; where they have discretionary work schedules and can expect that their earnings will decline in proportion to time off. Retirees, students, or the unemployed do not exchange time for money, therefore it may overstate the time valuation (McKean et. al., 1995). Nonetheless, since the case study is in a rural, farming area and the telephone survey resulted in few retirees, substituting money for time is assumed valid.

To correctly represent opportunity cost on average, per capita income was divided by 2000 working hours in a year and by 60 minutes in an hour yields an average wage per minute. This is used as a proxy for opportunity cost. The opportunity cost of $.1633 per minute was determined based on Cass County per capita income of $19,596 in 1996 (Bureau of Census, 1996). Based on travel speeds of 40 mph and 55 mph on gravel and paved surfaces respectively, opportunity costs are estimated at $0.245 per mile for travel on gravel and $0.178 per mile for travel on pavement. It is assumed that the average vehicle occupancy for this study is 1.0, based on the results of the telephone survey. This is considerably lower than the national average vehicle occupancy of 1.6 for all trips (USDOT, *Our Nations Travel*, 1995). The opportunity cost for the postal route is not calculated and the opportunity cost for the school bus route is included in the VOC.

Township Road Maintenance Cost

The township road maintenance costs were derived from a five-year average of blading, snow removal, and gravel costs. Since the network is fairly homogeneous, it was assumed that the costs could be distributed over the entire system, even though certain segments of the network received more maintenance than other segments. The five-year average budget was calculated to be $20,769.80. This included the years of 1992-1994 and 1996-1997, with a range of $12,725 to $28,250. Maintenance costs per mile were calculated by taking the five-year average budget and dividing by the total miles of the original network. The Clifton township had annual maintenance costs of approximately $400 per mile on 51 miles of gravel roads.

Cass County is responsible for the upkeep of all bridges, with the exception

of some Federal Emergency Management Association funds for repairs due to flooding. These funds were kept separate from the calculation for the maintenance cost per mile.

Summary of Costs

Clifton township has county paved surfaces on the eastern border and through the middle going east and west. These paved county roads are very influential in the calculation of the routes because they provide higher travel speeds than gravel, lower operating costs than gravel, and are the financial and maintenance responsibility of the county.

User costs, or VOC and opportunity costs combined, were calculated for the origin/destination trips based on the results of the survey. It was assumed the results of the survey represent the actual trips on the township network in one week. Thus, the user costs were multiplied by 52 (weeks in a year) to get the annual costs.

The total cost of a particular trip from a residence to destination can be formulated as the sum of vehicle costs plus opportunity costs. This is represented by the equation:

$$TC = VOC + OC$$

where:

TC	=	total cost per mile
VOC	=	vehicle operating cost per mile
OC	=	opportunity cost per mile

Therefore, the total cost per mile is \$0.695 (\$0.45 + \$0.245) on a gravel road and is \$0.573 (\$0.395 + \$0.178) on a paved road.

The benefits of network reductions are the product of maintenance costs per mile and total miles eliminated from the network. This is represented by the equation:

$$TB = MC * (E_m - P_m)$$

where:

TB	=	total benefits
MC	=	annual maintenance costs per mile
E_m	=	existing network miles
P_m	=	proposed network miles

Alternative 1, 2, and 3 have a reduction of 18, 26, and 25 miles respectively (Figure 2 and 3), corresponding to an annual savings of approximately \$7,055, \$10,530, and \$10,080 (Table 1).

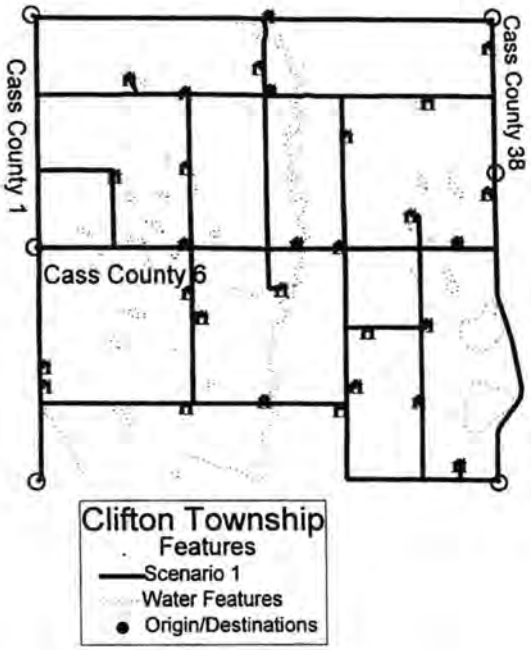


Figure 2. Scenario 1, Clifton Township Road Network Reduced by 18 Miles.

RESULTS

To conduct a benefit-cost analysis of closing or designating a minimum maintenance road segments from a network, all figures were converted to 1997 dollars using the Consumer Price Index. The annual net benefits are $6,038 for Scenario 1, $3,693 for Scenario 2, and $7,565 for Scenario 3, which correspond to a savings of 29%, 18%, and 36% of the average annual budget. Table 1 summarizes the benefits and costs for the three alternatives.

Table 1 Benefit/Cost Analysis

	Reduction in Miles of Township Road	Annual Resident Impact Cost	Annual Postal Route Impact Cost	Annual School Bus Route Impact Cost	Annual Reduction in Maintenance Cost (Benefit)	Annual Net Benefit
Alternative 1	18	$0	$381	$636	$7,055	$6,038
Alternative 2	26	$5226	$1354	$257	$10,530	$3,693
Alternative 3	25	$1247	$627	$641	$10,080	$7,565



Figure 3. Scenario 2 and 3, Clifton Township Road Network Reduced by 26 and 25 Miles, Respectively.

Interestingly, the addition of one mile to alternative 3, which also fit the criteria to eliminate, saved $3,979 in user costs and increased the annual net benefit by $3,872. This is critical for township officials to realize in closing or reducing maintenance on township roads. Road closures should be well planned and done progressively to determine how traffic levels shift due to the closure. General guidelines to consider when closing or reducing maintenance of roads is to remove road segments with the lowest percentage of daily traffic within the township, given the segment is not the only access.

SUMMARY AND CONCLUSION

This report shows a methodology to determine the level of township roads to provide adequate service and reduce road expenditures for maintenance. Through the use of GIS and transportation software, three scenarios for a case study revealed annual savings or benefits from $3,693 to $7,565. It also shows that some closures in a township result in substantial user costs and lowers the marginal benefits. For this case study, alternative 3 is the optimum solution that has the most benefits and has low user costs. While political or accessibility factors may override the actual decision to close or reduce maintenance of a township road, this report still shows that the elimination of unnecessary roads can result in lower road expenses for townships.

Proper implementation of this methodology requires detailed investigation of the township network and education of the residents affected by any changes. Although it is politically unpopular even to propose removing a segment from maintenance, the feasibility of this action based on economics should not be ignored. This analysis was developed from specific data from the case study location; while it may represent many townships in North Dakota and the surrounding areas, it is important to note that each township is unique and some consequential issues may exist in other townships that are not specifically defined in this report. For example, perennial winter conditions or flooding concerns need to be evaluated when applying this methodology to the township in question. In addition, analysis should be based on sound calculations to avoid eliminating segments that result in dramatic increases in travel length and time, as illustrated by alternative 3.

REFERENCES

Baumel, Phillip C., Hamlett, Cathy A., and Pautsch, Gregory R. *The Economics of Reducing the County Road System: Three Case Studies in Iowa.* DOT/OST/P-34/86/035, United States Department of Transportation, 1986.

Bitzan, John D., Denver D. Tolliver, and Daniel L. Zink. *Rural Road Financing Strategies Two New models Applied to N.D. Counties.* Mountain-Plains Consortium Report No. 92-13, North Dakota State University, Fargo, N.D., 1992.

Bureau of the Census. *Number of Inhabitants, North Dakota, 1980 Census of Population.* U.S. Department of Commerce. PC80-1-A36.

Bureau of the Census. *USA Counties 1996.* U.S. Department of Commerce.

Hough, Jill, Ayman Smadi, and Lance Shultz. *Gravel Shortage Options.* Mountain-Plains Consortium Report No. 96-65, North Dakota State University, Fargo N.D., 1996.

Lamberton, Charles E. *Alternative Road Networks for a South Dakota Township.* Economics Research Report 92-5, Economics Department, South Dakota State University, Brookings, South Dakota. June, 1992

McKean, John R., Donn M. Johnson, and Richard G.Walsh. "Valuing Time in Travel Cost Demand Analysis: An Empirical Investigation." *Land Economics.* 71(1): 96-105, 1995.

Rathge, Richard, and Shannon Terry. *North Dakota Population Projections By Age And Gender, 1995-2010.* North Dakota Census Data Center Report #21, North Dakota State University, Fargo, N.D., 1993.

United States Department of Transportation. Federal Highway Administration. *Our Nations's Highways.* Publication No. FHWA-PL-95-028, Washington, D.C., 1995.

United States Department of Transportation. Federal Highway Administration. *Our Nation's Travel: 1995 Nationwide Personal Transportation Survey.* Washington, D.C.,1995.

OPTIMIZATION OF REAL-TIME AIRCRAFT GATE ASSIGNMENT: MATHEMATICAL MODEL AND ALGORITHM

JIA-MING CAO[1] HENRY FAN and SOI-HOI LAM

School of Civil & Structural Engineering, Nanyang Technological University
Nanyang Ave, Singapore 639798

Abstract—Aircraft-Gate Assignment Problem (AGAP) is a well-known optimization problem. During daily airport operations the arrival and departure times of flights may fluctuate compared to their schedules. This may results in the reassignment to capture the dynamics of flights and gate status. For major airports it is usually very busy during arrival/departure peak hours and the operators must make the assignment decisions in short time to capture the dynamics well. In terms of optimization, service level and productivity, a real-time Decision Support System (DSS) will be very helpful for daily operations. This paper aims to set up the theoretical base for such a DSS. Firstly, the problem analysis concludes that an efficient DSS for real-time AGAP is proposed to be combination of a knowledge-based module and an optimization module. The first module aims to select the candidate gates for every coming flight, taking into account of gate and flight dynamics, requirements of the airlines, aircraft types, airport operation rules, etc. Based on the candidate gate sets, the paper presents a quadratic 0-1 programming model which captures very well the operation features such as flight connections, aircraft holding, optimization of passenger walking distance, baggage transferring distance and aircraft taxing distance, contribution of uncertain factors inferred by the knowledge based module, etc. An efficient approximation algorithm is also proposed. Sufficient computational experiments are conducted on two group of testing problems. The results show that the presented model and its algorithm meet the needs of real-time decision support even on microcomputers.

Keywords: aircraft-gate assignment, real-time decision support, optimization, quadratic binary program, passenger walking distance, baggage transfer

1. INTRODUCTION

Assigning aircraft to gates/stands is an important task in airport operations or so-called airline station operations. Although these activities take a smaller part of direct cost of airline operations compared to flight operations, sometimes they

[1] Tel. (65) 790-5076, Fax: (65) 791-0676, E-mail: cjmcao@ntu.edu.sg

may have a major impact on maintaining the flight schedules or even the flight networks. Normally, based on the flight schedules, the airport has an established assignment which allocates aircraft to gates as well as specifies the apron time of craft at gates. Nevertheless, in daily operations, it is usually unavoidable for the airport scheduler to handle some unforeseen delays caused by various factors. Thus, the scheduler usually needs to, based on the real-time dynamics and special requirements from aircraft/airlines, reassign the aircraft to gates for a specific period in future. Obviously, the scheduler has to finish this in short time so as to capture the dynamics well. On the other hand, in order to enhance the productivity and service level, the real-time assignment is expected to be optimal in terms of minimizing passenger walking distance, baggage transferring distance and aircraft taxing distance, etc. In this sense the problem further becomes a very hard combinatorial optimization problem. As a result, an efficient computer-based Decision Support System (DSS) would be very helpful for daily operations.

Tosic (1992) gave a good review on modeling Aircraft-Gate Assignment Problem (AGAP) before 1992. Actually, AGAP is a Quadratic Assignment Problem which is a type of well-known hard problem. Based on the established Operations Research (OR) techniques, the related works include Babic *et al* (1984), Bihr (1990), Mangoubi & Mathaisel (1985), Haghani & Chen (1998), etc., which directly applied the OR techniques to AGAP. These approaches have better guarantee in terms of optimization, but need a lot of time in problem solving due to the complexity of the problem. In addition, these approaches also have the weakness of traditional OR techniques in handling uncertain information and multiple performance criteria. As a way to overcome the shortcomings of OR-based approaches, some knowledge-based approaches have been developed, such as Brazile & Swigger (1988), Gosling (1990) and Srihari & Muthukrishnan (1991), etc. This type of approaches can capture well the operation features, handle uncertain information, meet needs of real-time decision support, etc., but have less guarantee in terms of optimization. The first work of combining knowledge-based and OR techniques is Cheng (1997) where the presented mathematical model is a liner Assignment Problem. As we know, this model is too simple to capture the features of AGAP, such as the avoidance of time overlap, etc. So most of the key issues still go back to the knowledge-based module.

This research aims to develop a DSS for AGAP effectively combining the knowledge-based and OR techniques. In next section, a framework of such a system is designed based on the analyses of real-time AGAP. As the second core part of the system Section 3 presents a mathematical model based on the results from a knowledge-based module (the first core part of the system), while the algorithm is expressed in Section 4. Section 5 reports the computational tests and concludes the computational scheme while Section 6 concludes the paper.

2. PROBLEM ANALYSES

There are may be more than one hundred of gates in a large airport, but usually not every gate is feasible for a specific aircraft. For example, some gates are not size-compatible for some aircraft, some assignments are prohibited by the operations regulations (e.g. to prohibit parking large aircraft side by side among some specific gates), etc. On the other hand, with given dynamics some assignments may be obviously non-optimal or preferred. For example, some gates are obviously non-beneficial for some flights, some flights may prefer specific type of gates (e.g. remote or aerobridge gates), etc. In response to above facts before formulating the problem mathematically, we establish an analysis module to determine the candidate gates for every flight so as to reduce the size of the problem. As expressed later we built an Expert System for this purpose.

On the other hand, the optimization model should capture following characteristics:

(1) If possible, assign the connecting flight adjacently.

(2) Synthesis of multiple objectives, including passenger walking distance, baggage transferring distance and aircraft taxing distance.

(3) To capture some buffers of expected times. For example, before proceeding to a gate, it is probably better for some aircraft to hold for a while after arrival (for arrival flights) or after the scheduled time (for those aircraft already staying at the station and going to take departure flights) while waiting for a better gate. The maximum holding times are limited by the permitted buffer time. As illustrated in Fig.1, suppose Gate 2 is the best one for Aircraft *j*. When Aircraft *j* arrives Gate 2 is still occupied. Although Gate 1 is cleared earlier, but it is not as good as Gate 2 for Aircraft 2. In this case, it may be worthy for Aircraft2 to wait a whole for a better gate. Therefore, a good model should cover this kind of probability. This causes an extra cost. (Previous literature supposes that aircraft immediately gets service upon arrival).

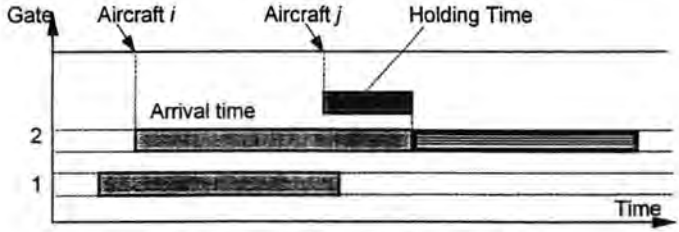


Fig.1. Aircraft waiting for gate upon arrival.

Taking into account the complexity of the problem we propose the DSS to be one of knowledge-based module + optimization module, as illustrated in Figure

2. The system contains two core parts: an expert system and a mathematical model and its algorithm.

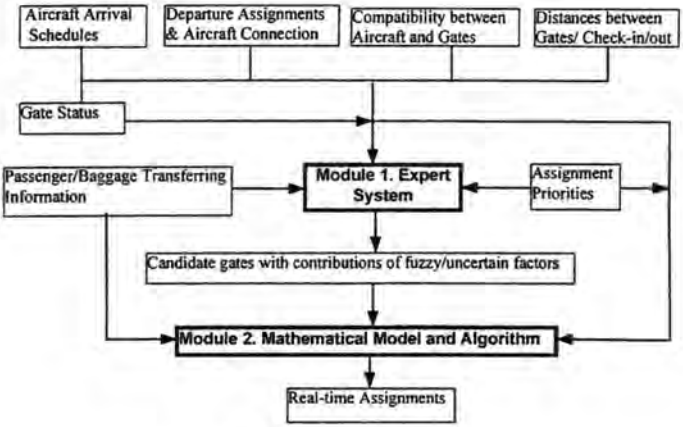


Fig.2. Flow chart of the system

The functions of the two core modules are:

- Module 1. *Expert System*: to find out the candidate gates for every aircraft. These gates are good to the aircraft considering the transferring passengers/baggage and transferring distance, operations rules as well as requirements from the Airlines, etc. This module aims to reduce the scale of the problem but is quite easier than to reason for a finally optimal assignment.
- Module 2. *Mathematical Model and Algorithm*: to get an optimal assignment within the size limited by the Expert System module. This guarantees the solution not worse than any one concluded directly by the Expert System.

3. MATHEMATICAL FORMULATION

Notations:

M : a very large positive number to generate penalty in the objective function.

G^f : the subset of candidate gates for Aircraft/Flight f.

H : the maximum time units that aircraft can hold compared to its previous scheduled time (if no aircraft holding is permitted, set H=0).

D^{ij} : walking distance of transfering passengers between gates/entrance. D^{i0} indicates the passenger walking distance between Gate i and the entrance/exit.

P^{ij} : number of transfering passengers between flights. P^{i0} indicates the number of terminating passengers with Flight i; P^{0i} denotes the number of departure passengers from entrance to Flight i.

L^{ij} : distance of baggages transfering between gates/entrance. L^{i0} is the baggage transferring distance between Gate i and the entrance/exit.

B^{ij} : number of transfering baggages between flights. B^{i0} and B^{0i} take the similar meanings of P^{i0} and P^{0i} respectively.

W^{ij} : taxing distance if Aircraft i is assigned at Gate j. This may refer to the distance between the runway and the gate or between the stay place (e.g. for the night-stopping aircraft) and the gate.

C^f : extra cost per time unit of Aircraft f holding. If the operation regulations do not allow aircraft holding after arrival, this cost is set to be M.

N^f, N^g : total numbers of aircraft and gates respectively.

T^{af}, T^{df} : arrival and departure times for Aircraft f.

Decision variables:

$$x_{ijt} = \begin{cases} 1, & \text{if flight } i \text{ is assigned to gate } j, \text{ starting at time } t \\ 0, & \text{otherwise} \end{cases}$$

where, i=1,2, ..., N^f, $j \in G^i$, $t = T^{af}, T^{af}+1, \ldots, T^{af}+H$.

If the operation regulations require aircraft to proceed to a gate immediately after landing, we can ommit the time subsripts in the variables (the assigning times are exactly the previous scheduled ones). In this case, the variables can be defined as x_{ij} in order to reduce the variable number.

2.1 Constraints

(a) Every aircraft/flight must be assigned to a gate, i.e.

$$\sum_j \sum_t x_{ijt} = 1, \quad i = 1,2,\ldots,N^f. \tag{1}$$

(b) To avoid time overlaps at every gate, i.e.

$$x_{ijt} x_{i'jt'} = 0; \qquad i,i' = 1,2,\ldots,N^f, \; j \in G^i \cap G^{i'}, \; t \le t' < T^{df}. \tag{2}$$

(c) Flight connection: if Flight i' is connection of Flight i, denoted by $R(i,i')$=1, and i' rerquires to be assigned adjacent to the gate to which i is assigned. Denote by A^j the subset of gates adjacent to j, this requirements can be formulated as,

$$x_{ijt} = \sum_{j' \in A^j} \sum_{t'} x_{i'j't'}, \quad \forall R(i,i') = 1. \tag{3}$$

2.2 Objective function

The objective function consists of four parts: (a) weighed sum of passenger walking and baggage transferring distance between the gates and the entrance/exit; (b) weighed sum of passenger walking and baggage transferring distance between flights (for transferring passengers); (c) weighed sum of aircraft taxing distance; (d) contribution of other factors than above three type of distances, this is based on the inferring results of the knowledge-based module (Module 1 of our system). Mathematically the objective function can be expressed as

$$OF(X) = \sum_i \sum_j \sum_{t=T^{ai}}^{T^{ai}+H} [C^i(t - T^{ai}) + (P^{i0} + P^{0i})D^{j0} + \alpha (B^{i0} + B^{0i})L^{j0}]x_{ijt}$$

$$+ \sum_i \sum_j \sum_t \sum_{i'} \sum_{j'} \sum_{t'} (P^{ii'} D^{jj'} + \alpha B^{ii'} L^{jj'}) x_{ijt} x_{i'j't'} + \beta \sum_t \sum_j \sum_t W^{ij} x_{ijt} - \sum_i \sum_j K^{ij} x_{ijt} \quad (4)$$

where, α and β are the weights of baggage transferring distance and aircraft taxing distance respectively compared to the passenger walking distance whose weight is set to 1. K^{ij} indicates the contribution, of other factors than various walking, transferring and taxing distances, to the objective if Aircraft i is assigned to Gate j. This parameter is determined in the knowledge-based module to reflect the contribution of some fuzy and uncertain factors, say, preferences, service level, banlance of gate utilization, ground traffic congestion, etc. The details will be stated in another paper.

In order to get a special structure of the model, we now put (2) and (3) in the objective function as penalty terms. Notice that (2) is equivalent to adding $Mx_{ijt}x_{i'ji'}$ to the objective function while (3) is equivalent to adding $M(x_{ijt} - \sum_{j' \in A^j} \sum_t x_{i'j't'})^2$ to the objective function. Thus, the model can be written as (denoted by (I)):

$$\text{Min } f(X) = \sum_i \sum_j \sum_{t=T^{ai}}^{T^{ai}+K} [C^i(t - T^{ai}) + (P^{i0} + P^{0i})D^{j0} + \alpha (B^{i0} + B^{0i})L^{j0}]x_{ijt}$$

$$+ \sum_i \sum_j \sum_t \sum_{i'} \sum_{j'} \sum_{t'} (P^{ii'} D^{jj'} + \alpha B^{ii'} L^{jj'}) x_{ijt} x_{i'j't'} + \beta \sum_i \sum_j \sum_t W^{ij} x_{ijt} - \sum_i \sum_j K^{ij} x_{ijt}$$

$$+ M \sum_i \sum_j \sum_t \sum_{i'} \sum_{t \le j' < T^{ai}} x_{ijt} x_{i'ji'} + M \sum_{R(i,i')=1} (x_{ijt} - \sum_{j' \in A^j} \sum_t x_{i'j't'})^2 \quad (5)$$

$$\text{s.t.} \quad \sum_j \sum_t x_{ijt} = 1, \ i = 1,2,\ldots, N^f. \quad (6)$$

$$x_{ijt} \in \{0,1\}, \ i=1,2,\ldots, N^f, \ j \in G^i, \ t=T^{af}, \ T^{af}+1, \ldots, \ T^{af}+H.$$

2.3 Scale of the model

The number of constraints is N^J in (I). If the number of candidate gates for every aircraft is CG and every aircraft can hold at most H time units, then, the number of variables is $N^J \times CG \times (H+1)$. For a 50 aircraft sample, if every aircraft has 10 candidate gates, and the maximum time units that every aircraft can hold before proceeding to a gate is set to 1, then, the model has 50 constraints and 1,000 variables. If the possibility of aircraft holding is not considered, the number of variables is $N^J \times CG$.

4. ALGORITHM

Model (I) is a quadratic program with special constraints, i.e., in Constraint (6) every variable appears exactly one time with coefficient of 1. Zhu (1986) defines this kind of constraints as *non-intersection* constraints.

For expression convenience let's consider the matrix form of (6) as follow:

$$AX = E, \qquad E = (1,1,\ldots,1)^{\mathrm{T}} \qquad (7)$$

Here we cite the concept of '*basic feasible solution*' for linear programming. Suppose X is a basic feasible solution to (6) and denote that

$$X = (X_B, X_N), \qquad A = (B, N),$$

where X_B is the subset of basic variables.

Substituting for relevant basic variables, in the objective function $f(X)$, with $X_B = E - NX_N$ will result in a function of X_N. Note that $x_{ijt} = x_{ijt}^2$ since $x_{ijt} \in \{0,1\}$, the function can be written as

$$F(X_N) = F_0 + C^{\mathrm{T}} X_N + \frac{1}{2} X_N Q X_N, \qquad (8)$$

where $C = (c_1, c_2, \ldots, c_n)^{\mathrm{T}}$, $Q = [q_{ij}]_{n\times n}$ with $q_{ii} = 0$, $i = 1,2,\ldots,n$.

Let

$$R_{ij} = \begin{cases} = 1, \text{ if variables } i \text{ and } j \text{ are in the same constraint equation in (6)} \\ = 0, \text{ otherwise} \end{cases}$$

Definition (Zhu, 1986): If S is a subset of X_N with $|S| = k$ and

$$W^S = \sum_{i\in S} c_i + \sum_{i\in S}\sum_{j\in S} (q_{ij} + R_{ij}M), \qquad (9)$$

then, S is called a k-order subset with weight of W^S. Furthermore, if $W^S < 0$, S is called a *negative-weight k-order subset.*

Obviously, a negative-weight subset indicates a descent direction. Thus, once (8) is given (after finishing iterations with a feasible basic solution), the

optimization procedure becomes the search of negative-weight subset. Once a negative-weight subset is found, by replacing the relevant variables we get a new feasible basic solution. After iteration we get the update of (8). Repeat the search of negative-weight subset, as so on, until no any negative-weight subset exists we get the optimal solution. During this procedure we need to expand the subsets to higher orders. Suppose we have finished the search for k-order subsets and found no negative-weight one, for every k-order subset S, the expanse can be expressed as

$$S' = S \bigcup_{X_i \notin S} X_i , \qquad W^{S'} = W^S + c_i + \sum_{X_j \in S} q_{ij} . \tag{10}$$

Thus, an approximate algorithm can be designed based on the search of negative-weight subsets. Starting with the search for 1-order negative-weight subset, at each order, once a negative-weight subset is found, then, update the basic solution to reduce the objective function, and repeat the search from the 1-order. If there is no negative-weight subset at current order, then, note down the first U subsets in the ascending order of weights (U is determined in advance), and carry out the expanse operation of (10) to expand the subsets to one order higher. As so on, until reaching the maximum order L set in advance.

Following is the detailed expression of an approximation algorithm starting with a given feasible basic solution.

Algorithm:

Step 0: Assign integers to L and U (L is the maximum order of variable subset the algorithm will search, U is the maximum number of variable subsets kept in each order). Carry out the iterations with the given basic variables to get (8). Go to Step 1.

Step 1: Set $S(i) = \varnothing, W^{Si} = M$, i=1,2, ..., U, p=0.

Step 2: $p \leftarrow p+1$.

for (k=1 to U)

{

$\forall X_i \notin S(k)$, expand $S(k)$ by use of (9). Denote the resulted (p+1)-order subset by $S'(k)$ and $W^{S_k'}$ respectively.

if ($W^{S_k'} < W^{S_U'}$)

{

replace subset $S'(U)$ with $S'(k)$, and sort the (p+1)-order subsets by ascending weights.

}

}

Go to Step 2.

Step 3: If $W^{S_1'} \geq 0$,

(a) if $p<L$, replace $S(k)$ with $S'(k)$ (k=1,2, ..., U), return to Step 2; otherwise, go to Step 4;
(b) if $p=L$, go to Step 5.

Step 4: Replace the relevant basic variables with variables in subset $S'(1)$, iterate with the new basic variables to update (8), return to Step 1.

Step 5: Terminate. Setting all basic variables to 1 gives the output solution.

For given L, the best solution given by above algorithm is called *the solution upon Level L* while L is called the *optimization level.*

5. COMPUTATIONAL EXPERIMENTS AND ANALISES

In the presented algorithm, the larger L is, the more probable that the solution given is the globally optimal solution. Theoretically, in the worst case, the maximum order of a negative-weight subset may be as large as N^f (this means that all current basic variables need to be replaced). It needs quite a lot of calculation if we have to set the optimization level to N^f. Fortunately, high order negative-weight subset is usually divisible, as explained in Fig.3, where the numbers inside the boxes indicate the subscripts of variables, the numbers by the boxes indicate c_i and those by the links indicate q_{ij} in (7). Fig.3(a) is a 5-order negative-weight subset. From the illustrations by Fig.3(b) and (c) we can see that there are two ways to achieve this 5-order negative-weight subset by searching only 1 and 2-order subsets. In Fig.3(b), {1,2} is a 2-order negative-weight subset, once this subset is picked out and the basic solution is updated, {4} will become a 1-order negative-weight subset, as so on, the other two negative-weight subsets are successively {5} and {3}, while in (c) they are successively {3,5}, {4} and {1,2}. The maximum optimization level needed to set in each of above ways is only 2. This needs much less calculation than to set the optimization level up to 5. Therefore, we can usually get the best solution for higher level even only lower order subsets are searched. The computation experiments exactly verify this phenomenon.

The Algorithm is coded in C++ and tested on various scale of problems. The scales of problem are defined by three numbers, i.e. N^f, N^g and CG (number of candidate gates for each aircraft). In this paper, we test the algorithm in two ways: (a) comparisons of various optimization levels; (b) experiments on a group of testing problems.

5.1 Comparisons of Various Optimization Levels

Table 1 summarizes the computational results on various levels of different scales. The distances between gates/entrance and the transferring passenger/baggage numbers are generated randomly, ranging from 0.1~0.5 kilometers and 5~100 persons/bags) respectively. Apron times of aircraft range

from 5~11 time units (per time unit lasts 5 minutes) which are appropriately set to guarantee at least one feasible assignment. The maximum holding time is H=1 (time unit). The initial assignment for iteration is supposed that every aircraft is assignment to Gate 1[1]. The computational results for each sample problem are characterized by two rows, one shows the objective function values upon various optimization levels, the other summarizes the corresponding running times. For test, we set maximum number of subsets stored at each order to 2,000, set the maximum optimization level up to 20. From Table 1 we can see that only one sample's best solution lies at Level 11, four lie at Level 6, while all of other 23 samples reach their best solutions for Level 20 after calculation of Level 5. Therefore, if the maximum level is set to 10, one can be very confident to get a solution good enough. Figure 4 illustrates the possibility of getting the best solution upon different optimization levels. For Example, among the 28 samples, if the optimization level is set to 6 we can get the best solution with possibility of 96.4%.

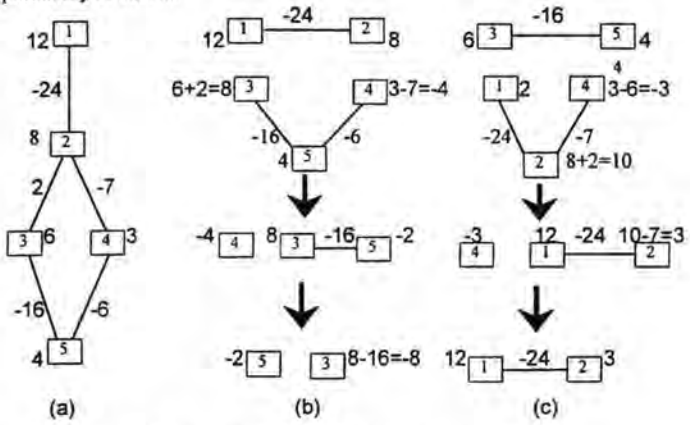


Fig.3 Division of a 5-order negative-weight subset.

On the other hand, similar to the optimization level the value of U, the maximum number of stored variable subsets upon each order, may affect the best solutions, i.e. the larger the U is, the more possible the globally optimal solution would be reached. How does the algorithm perform on various values of U ? With the same sample problems as of Table 1, Table 2 summarizes the

[1] This is not a feasible assignment in practice, but it is a feasible solution to Model (I), just with very high penalty. In practical applications, the algorithm can start with the pre-established assignment which is much better than this one for iteration.

computational tests on different U values. We can see that with U=200 there are 4 samples failing to get the best solution, while with U=500 only one sample (Problem1-17) fails to get the best solution.

We can learn from above experiments that setting U=1000 and L=10 can guarantee the solution to be good enough. Under this setting Figure 5 illustrates the relationship between average CPU and number of decision variables (=number of flights × number of candidate gates for each flight × maximum time units of holding). Note that the performances are for a PC-166HZ, we can see that the algorithm is fast enough for real-time decision support.

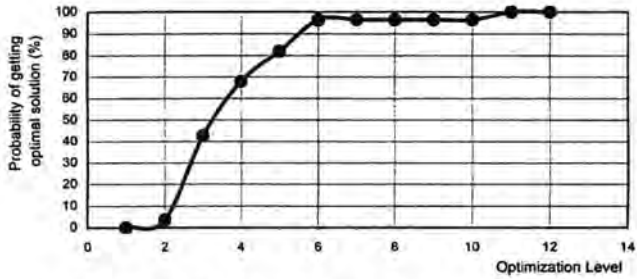


Fig.4. Probability of getting optimal solution vs optimization level.

5.2 Experiments on Testing Problems

In this subsection we will test the algorithm on a group of testing problems with known optimal solutions.

5.2.1. Construction of the testing problems

Here we suppose every testing problem satisfies that (a) the number of passengers = the number of baggage; (b) passenger walking distance = the transferring distance of the corresponding baggage.

Step 1: Set $G^i = G, i = 1,2,..., N^f$, G is the set of all gates.

Step 2: Generate such a feasible assignment that, (a) there is no overlap of apron time at each gate; (b) At every gate, the time gaps between two flights equals exactly to the minimum time interval requirements. This can be easily reached by appropriately choosing the apron times. As shown in Figure 6, the aircraft for Gate 1 are indexed as A11, A12, ..., as so on.

Step 3: Set all the distances between gates to 100 except:

$$D_{i,i+1} = D_{i+1,i} = 1 \text{ and } D_{ii} = 0,\ i=0, 1, 2, \ldots, N^g. \qquad (11)$$

Step 4: Suppose the passenger and baggage transferring rates are the same, set all of the transferring rates of passengers and baggage to the 0 except the cases illustrated by arrows in Figure 6. Set the numbers of transferring passenger along the arrows to be 100.

Table 1. Summary of Computational Results on Test 1 with U=2000 and H=1

No.	Scale *	Results	Level-2	Level-3	Level-4	Level-5	Level-6	Level-7	...	Level-10	Level-11	...	Level-20
1-1	20/4/10/4	F(x)	1288.96	1288.96	1248.38	1248.38	1206.41	1206.41	...	1206.41	1206.41	...	1206.41
		CPU **	0.00	0.30	1.18	1.48	3.75	4.08	...	5.15	5.53	...	9.10
1-2	20/15/5	F(x)	1290.71	1239.80	1125.24	1125.24	1125.24	1125.24	...	1125.24	1125.24	...	1125.24
		CPU	0.02	0.48	1.93	2.35	2.77	3.20	...	4.53	5.00	...	9.43
1-3	25/15/5	F(x)	2280.10	2130.87	2130.87	2130.87	2130.87	2130.87	...	2130.87	2130.87	...	2130.87
		CPU	0.07	0.68	1.18	1.72	2.23	2.78	...	4.43	5.00	...	10.63
1-4	25/20/6	F(x)	1886.91	1886.91	1886.91	1886.91	1886.91	1886.91	...	1886.91	1886.91	...	1886.91
		CPU	0.12	0.72	1.33	1.98	2.65	3.30	...	5.37	6.10	...	12.92
1-5	30/20/5	F(x)	3385.43	3135.05	3135.05	3135.05	3135.05	3135.05	...	3135.05	3135.05	...	3135.05
		CPU	0.05	0.78	1.38	2.00	2.62	3.25	...	5.22	5.87	...	12.27
1-6	30/20/6	F(x)	2580.52	2331.72	2331.72	2331.72	2331.72	2331.72	...	2331.72	2331.72	...	2331.72
		CPU	0.23	1.62	2.35	3.12	3.88	4.67	...	7.08	7.90	...	15.72
1-7	30/20/8	F(x)	2643.31	2627.90	2627.90	2627.90	2627.90	2627.90	...	2627.90	2627.90	...	2627.90
		CPU	0.42	1.77	2.78	3.83	4.90	5.98	...	9.30	10.43	...	20.88
1-8	30/20/10	F(x)	3127.20	3077.62	2842.61	2842.61	2842.61	2842.61	...	2842.61	2842.61	...	2842.61
		CPU	0.50	2.22	5.50	6.83	8.20	9.57	...	13.75	15.18	...	28.53
1-9	35/20/7	F(x)	4091.31	4091.31	4064.56	4064.56	4020.46	4020.46	...	4020.46	4020.46	...	4020.46
		CPU	0.18	1.20	3.40	4.45	9.43	10.52	...	13.80	14.93	...	25.55
1-10	35/25/9	F(x)	4602.77	4494.11	4494.11	4494.11	4494.11	4494.11	...	4494.11	4494.11	...	4494.11
		CPU	1.87	4.17	5.53	6.92	8.32	9.73	...	14.03	15.47	...	28.83
1-11	40/20/7	F(x)	6245.28	6245.28	6212.69	6212.69	6212.69	6212.69	...	6212.69	6212.69	...	6212.69
		CPU	0.83	1.98	4.80	5.98	7.18	8.40	...	12.13	13.38	...	24.97
1-12	40/20/9	F(x)	5894.41	5894.41	5894.41	5774.12	5774.12	5774.12	...	5774.12	5774.12	...	5774.12
		CPU	1.12	2.65	4.20	13.43	15.02	16.62	...	21.50	23.17	...	38.82
1-13	40/30/10	F(x)	5260.71	5193.12	5115.22	5115.22	5115.22	5115.22	...	5115.22	5115.22	...	5115.22
		CPU	1.67	3.60	8.10	9.85	11.62	13.40	...	18.85	20.70	...	37.87
1-14	50/20/8	F(x)	7087.53	6906.79	6678.45	6678.45	6678.45	6678.45	...	6678.45	6678.45	...	6678.45
		CPU	0.90	6.48	10.17	11.88	13.62	15.37	...	20.70	22.52	...	39.37
1-15	50/30/10	F(x)	8918.21	8694.96	8694.96	8354.18	8354.18	8354.18	...	8354.18	8354.18	...	8354.18
		CPU	2.47	6.55	8.72	23.08	25.28	27.50	...	34.27	36.55	...	57.67
1-16	50/30/12	F(x)	9032.67	8826.74	8826.74	8826.74	8826.74	8826.74	...	8826.74	8826.74	...	8826.74
		CPU	3.87	10.17	12.82	15.48	18.17	20.85	...	29.03	31.82	...	57.38
1-17	55/30/8	F(x)	19201.33	19163.54	19163.54	19163.54	1071.83	1071.83	...	1071.83	9264.20	...	9264.20
		CPU	2.20	5.52	7.38	9.27	11.18	13.10	...	18.97	37.08	...	55.38
1-18	55/30/10	F(x)	10971.30	10639.40	10639.40	10639.40	10580.73	10580.73	...	10580.73	10580.73	...	10580.73
		CPU	3.38	12.50	14.90	17.30	27.72	30.17	...	37.65	40.17	...	63.70
1-19	60/30/8	F(x)	21350.67	21122.03	21122.03	11277.21	11277.21	11277.21	...	11277.21	11277.21	...	11277.21
		CPU	1.95	8.82	10.85	18.98	21.05	23.15	...	29.50	31.65	...	51.72
1-20	60/40/10	F(x)	12092.69	12092.69	12013.68	12013.68	12013.68	12013.68	...	12013.68	12013.68	...	12013.68
		CPU	4.05	6.63	14.40	17.02	19.67	22.32	...	30.40	33.12	...	58.28
1-21	65/40/8	F(x)	13611.17	13113.38	12837.77	12837.77	12837.77	12837.77	...	12837.77	12837.77	...	12837.77
		CPU	2.70	8.97	14.43	16.65	18.88	21.15	...	28.05	30.35	...	51.98
1-22	65/40/10	F(x)	14382.33	13847.00	13847.00	13847.00	13847.00	13847.00	...	13847.00	13847.00	...	13847.00
		CPU	8.00	25.08	27.90	30.73	33.58	36.45	...	45.15	48.10	...	75.50
1-23	70/40/6	F(x)	36552.24	26345.56	26345.56	16551.21	16551.21	16551.21	...	16551.21	16551.21	...	16551.21
		CPU	2.20	5.02	6.72	12.82	14.55	16.30	...	21.60	23.40	...	40.20
1-24	70/40/8	F(x)	25476.63	25142.30	25101.46	25101.46	15214.16	15214.16	...	15214.16	15214.16	...	15214.16
		CPU	2.40	14.47	19.82	22.20	32.68	35.12	...	42.47	44.92	...	68.03
1-25	70/40/10	F(x)	16480.22	16462.09	16462.09	16462.09	16462.09	16462.09	...	16462.09	16462.09	...	16462.09
		CPU	5.07	8.77	11.78	14.83	17.90	20.98	...	30.35	33.50	...	62.97
1-26	80/50/6	F(x)	30691.76	20495.40	20495.40	20495.40	20495.40	20495.40	...	20495.40	20495.40	...	20495.40
		CPU	3.30	10.30	12.23	14.18	16.17	18.17	...	24.23	26.28	...	45.65
1-27	80/50/8	F(x)	18459.70	18378.56	18378.56	18378.56	18378.56	18378.56	...	18378.56	18378.56	...	18378.56
		CPU	5.40	8.58	11.28	14.00	16.73	19.47	...	27.85	30.68	...	56.92
1-28	80/50/10	F(x)	22771.22	22013.61	22013.61	22013.61	22013.61	22013.61	...	22013.61	22013.61	...	22013.61
		CPU	7.92	21.72	25.17	28.63	32.13	35.63	...	46.30	49.90	...	83.25

* $N^J / N^E / CG$, CG — number of candidate gates for every aircraft.

** Running time on PC-166MHz (minutes).

Obviously, the assignment generated by Step 2 is the optimal solution to the problem. Now, if we note down the optimal solution and hide the optimal clue the problem is still hard to the algorithm. So, we can evaluate the algorithm by

comparing the optimal solution and the result given by the algorithm. All tests we have conducted on this group of problems give the optimal solutions. Table 3 summarizes some of the test results. We can see that the algorithm performs very well with this test.

Table 2. Comparisons of computations with different values of U^*

No.	Scale	U = 2000			U = 1500			U = 1000			U = 500			U = 200		
		F(x)	LOB**	CPU	F(x)	LOB	CPU	F(x)	LOB	CPU	F(x)	LOB	CPU	F(x)	LOB	CPU
1-1	20/4104	1206.41	6	3.75	1206.41	6	2.93	1206.41	6	2.18	1206.41	6	1.13	1206.41	6	0.70
1-2	20/15/5	1125.24	4	1.93	1125.24	4	1.57	1125.24	4	1.09	1125.24	4	0.56	1125.24	4	0.31
1-3	25/15/5	2130.87	3	0.68	2130.87	3	0.55	2130.87	3	0.42	2130.87	3	0.27	2130.87	3	0.16
1-4	25/20/6	1886.91	2	0.12	1886.91	2	0.10	1886.91	2	0.08	1886.91	2	0.05	1886.91	2	0.03
1-5	30/20/5	3135.05	3	0.78	3135.05	3	0.53	3135.05	3	0.42	3135.05	3	0.25	3135.05	3	0.13
1-6	30/20/6	2331.72	3	1.62	2331.72	3	1.32	2331.72	3	0.93	2331.72	3	0.47	2331.72	3	0.21
1-7	30/20/8	2627.90	3	1.77	2627.90	3	1.37	2627.90	3	1.06	2627.90	3	0.55	2627.90	3	0.29
1-8	30/20/10	2842.61	4	5.50	2842.61	4	4.93	2842.61	4	2.86	2842.61	4	2.11	2842.61	4	1.02
1-9	35/20/7	4020.46	6	9.43	4020.46	6	7.44	4020.46	6	5.63	4020.46	6	3.06	4020.46	6	1.83
1-10	35/25/9	4494.11	3	4.17	4494.11	3	3.13	4494.11	3	2.20	4494.11	3	1.21	4494.11	3	0.56
1-11	40/20/7	6212.69	4	4.80	6212.69	4	4.02	6212.69	4	2.70	6212.69	4	1.56	6212.69	4	0.84
1-12	40/20/9	5774.12	5	13.43	5774.12	5	10.39	5774.12	5	8.73	5774.12	5	5.02	5774.12	5	2.62
1-13	40/30/10	5115.22	4	8.10	5115.22	4	6.34	5115.22	4	4.52	5115.22	4	2.73	5115.22	4	1.23
1-14	50/20/8	6678.45	4	10.17	6678.45	4	8.01	6678.45	4	5.38	6678.45	4	2.84	6678.45	4	1.76
1-15	50/30/10	8354.18	5	23.08	8354.18	5	18.26	8354.18	5	13.01	8354.18	5	7.23	8354.18	5	3.45
1-16	50/30/12	8826.74	3	10.17	8826.74	3	8.04	8826.74	3	5.23	8826.74	3	2.85	8826.74	3	1.34
1-17	55/30/8	9264.20	11	37.08	9264.20	11	30.29	9264.20	11	21.37	0421.8	4	4.21	0794.1	4	2.67
1-18	55/30/10	0580.7	6	27.72	0580.7	6	21.63	0580.7	6	15.65	0580.7	6	8.04	0984.8	4	3.87
1-19	60/30/8	1277.2	5	18.98	1277.2	5	14.29	1277.2	5	10.02	1277.2	5	5.38	1277.2	5	3.15
1-20	60/40/10	2013.6	4	14.40	2013.6	4	11.37	2013.6	4	8.16	2013.6	4	4.85	2013.6	4	2.36
1-21	65/40/8	2837.7	4	14.43	2837.7	4	11.42	2837.7	4	8.37	2837.7	4	4.92	2837.7	4	2.44
1-22	65/40/10	3847.0	3	25.08	3847.0	3	19.10	3847.0	3	13.68	3847.0	3	7.25	3847.0	3	3.18
1-23	70/40/6	6551.2	5	12.82	6551.2	5	10.13	6551.2	5	7.74	6551.2	5	4.20	7383.7	4	2.07
1-24	70/40/8	5214.1	6	32.68	5214.1	6	25.13	5214.1	6	17.33	5214.1	6	9.18	6727.7	3	3.12
1-25	70/40/10	6462.0	3	8.77	6462.0	3	6.82	6462.0	3	4.75	6462.0	3	2.50	6462.0	3	1.06
1-26	80/50/6	0495.4	3	10.30	0495.4	3	8.03	0495.4	3	5.85	0495.4	3	3.02	0495.4	3	1.44
1-27	80/50/8	8378.5	3	8.58	8378.5	3	6.63	8378.5	3	4.97	8378.5	3	2.61	8378.5	3	1.22
1-28	80/50/10	2013.6	3	21.72	2013.6	3	16.16	2013.6	3	12.34	2013.6	3	6.50	2013.6	3	3.02

* U — The maximum number of stored variable subsets in each order.
** LOB — Level of Getting the Best Solution.

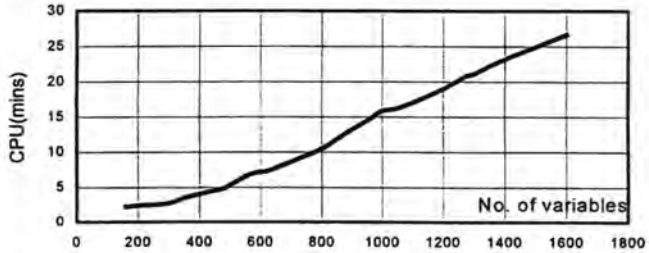


Fig.5. Average CPU vs number of variables with U=1000, L=10, H=1.

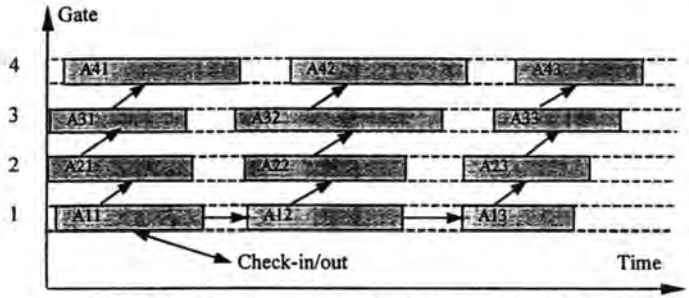


Fig. 6. Passenger/baggage transfers in the testing problems

5.2.2. Computational results on the testing problems

Table 3. Summary of Computational Results on Test 2 with H=1

Problem No.	Number of flights	Number of candidate gates	Level of getting optimal solution	CPU(minutes)
2-1	30	10	4	1.667
2-2	40	5	9	5.367
2-3	40	8	7	7.000
2-4	40	10	6	6.417
2-5	50	10	6	7.367
2-6	55	11	10	17.033
2-7	60	12	5	14.283
2-8	60	15	4	16.017
2-9	66	11	3	9.847
2-10	70	10	4	8.832

6. CONCLUSIONS

An efficient Decision Support System for real-time aircraft-gate assignment in airport daily operations is proposed to be combination of a knowledge-based module and an optimization module. The first module pre-infers and reduces the problem size based on the operation regulations as well as the dynamics, the second one optimizes the assignments within the reduced size. The paper presents a quadratic 0-1 programming model and its approximate algorithm as the second part of such a knowledge-based + mathematical programming system. The model captures the assignment features well, such as the flight connections, multiple objectives, aircraft holding, etc. The performance of the algorithm is related to two parameters: the maximum number of variable subsets in each order, U and the optimization level, L. The computational experiments on two group of sample problems and various values of U and L are conducted. The results show that setting U=1000 and L=10 can guarantee the obtained solution to be good enough, and the CPUs under this setting, as shown in Figure 5, are accepted for real-time decision support even on Personal Computers.

REFERENCES

Bihr, R. (1990) A conceptual solution to the aircraft gate assignment problem using 0,1 linear programming. *Computers & Industrial Engineering* **19**(1-4), 280-284.

Brazile, R.P. and Swigger, K.M. (1988) GATES: An airline gate assignment and tracking expert system. *IEEE Expert*, 33-39.

Cheng, Y. (1997) A knowledge-based airport gate assignment system integrated with mathematical programming. *Computers & Industrial Engineering* **32**(4), 837-852.

Gosling, G.D. (1990) Design of an expert system for aircraft gate assignment. *Transportation Research-A* **24**(1), 59-69.

Haghani, A. and Chen, M.-C. (1998) Optimizing gate assignments at airport terminals. *Transportation Research-A* **32**(6), 437-454.

Mangoubi, R.S. and Mathaisel, D.F.X. (1985) Optimizing gate assignment at airport terminals. *Transportation Science* **19**(2), 173-188.

Srihari, K. and Muthukrishnan, R. (1991) An expert system methodology for an aircraft-gate assignment. *Computers & Industrial Engineering* **21**(1-4), 101-105.

Tosic, V. (1992) A review of airport passenger terminal operations analysis and modeling. *Transportation Research-A* **26**(1), 3-26.

Zhu, S.-N. (1986) A quadratic 0-1 programming model and its algorithm for train formation problem. *Journal of Southwest Jiaotong University*, Additional Issue, 65-72.

Assessing the Socioeconomic Status of Airport Catchment Areas

Stephen R. Ellsworth
The Transportation Group
University of New Brunswick

Introduction

The responsibility of the airline industry is to provide an adequate level of service based on the needs of the consumer. The challenge facing air carriers in this process is attempting to describe and understand the travel tendencies of the customer. The results of a successful evaluation of the consumer market allow the airline to supply their product in an economic and efficient manner. The process of understanding customer behaviour is a difficult task, given the number of variables that influence a consumer's decision to fly. One effective method of defining the consumer base is to investigate factors which directly affect a population's propensity to fly, including social and economic factors such as employment and salary. When social and economic factors of a given population are illustrated in an index form, this information becomes easier to compare and analyze. One such index, the Blishen scale, created by Bernard Blishen in 1958, relates a socioeconomic index with a number of occupations based on census data. (1)

The Blishen scale provides the foundation for an efficient three-step model that evaluates the socioeconomic status (SES) for a given population. Once the SES has been determined, this information can be used within a given catchment area to determine the population's propensity to fly.

The first step of the model presented in this paper provides a method for defining the catchment area of an airport. Once the target population has been identified by the catchment boundary, its socioeconomic status is determined. Based on the weighted SES indices, the population's propensity to fly can be evaluated in the final step of the model.

To illustrate possible applications of this model, the demand for flight is determined for the population within the Fredericton Airport catchment area. The model is also applied to the Saint John Airport to illustrate that the model is not site specific. Rather, the model is generic enough that it may be used for any airport across Canada.

MODEL

Step 1: Defining the Catchment Area

The catchment area of an airport is a familiar term used within the airline industry which signifies the geographical area that an airport services. The population living within this geographical area is considered to be a user of the facility. Unfortunately, an airport catchment area is often difficult to define given the complex nature of passenger route choice.

Nevertheless, methods do exist which help determine the approximate boundaries of a catchment area. A familiar approach often encountered in urban planning fields involves the use of a gravitational model in order to identify catchment areas. Reilly's *Law of Retail Gravitation* is a mathematical model that defines the boundary based on a relationship between population and distance (2). The equation is typically expressed in the following manner,

$$GM = \frac{d_{AB}}{1 + \sqrt{\frac{Pop_A}{Pop_B}}} \qquad \text{Equation 1}$$

By inserting into Equation 1 the populations of centre A and centre B, as well as the straight-line distance between A and B, the model determines a breaking point where "one city exercises the dominating retail trade influence, and beyond which the other city dominates." (3) In order to establish a zone or boundary of influence surrounding centre A, its population remains constant while the remaining two parameters are varied as the gravity model is applied to surrounding centers. The imaginary boundary determined by Equation 1 can be applied to airport catchment areas where the population located within the boundary are considered to be attracted to the airport located at centre A.

It is important to note that the airport catchment area defined by Equation 1 may contain more than one airport within its boundaries. To accommodate for the effects created by multiple airports within the same catchment area, it is necessary to apply a factor to the Gravity Model calculations resulting from a ratio of enplaning/deplaning passenger trips between airports.

Step 2: Determining the Socioeconomic Status

Once the catchment area has been defined, the next step of this model is to determine the socioeconomic status of the population within that catchment area.

Socioeconomic status is a term that describes the social and economic levels of a group of people, taking into account factors such as occupation, income, gender, and age. In 1958, University Professor Bernard Blishen developed a simplified means of expressing the SES of a given population. Blishen derived a formula that calculated a numerical measure of SES for approximately 500 different occupations according to gender. The numerical scale, or index, was based upon "the level of educational attainment, income and prestige for each occupation." (4) This approach was established using 1951 Canadian census material and a prestige factor was added after preparing the scale following the publication of the 1961 census data (5). Blishen has updated his index for each decade as new census material has been produced.

To facilitate the application of the Blishen scale in the model presented in this paper, indices for 500 male occupations and 498 female occupations were aggregated using computer software to conform to 22 major occupational groupings outlined in Statistics Canada reporting (5). The 22 occupations and corresponding mean SES are presented in Table 2 according to gender.

Accordingly, the next stage in the SES model involves collecting census data for male and female working populations within a catchment area. Since census material is presented according to different levels of reporting (province, city, county and parish), it is important to select a reporting level prior to calculations. Once the data has been compiled, a weighted average is calculated based upon the working populations and corresponding SES values.

Step 3: Evaluating the Level of Propensity

An important consideration of any airline organization prior to beginning airplane service to a region is the determination of the market interested in air travel within that region. In technical terms, the population surrounding the facility must be evaluated for their level of propensity, or their tendency, to fly. This parameter is often difficult to predict due to the complexity involved with the human decision making process when selecting air travel as an appropriate method of transportation. The simplest and most direct means of assessing the market share interest typically involves focusing on the socioeconomic status of a population. To effectively evaluate the relationship between SES and the propensity to fly, the reasons why people fly must be considered.

According to most airline sources, the passenger market can be categorized into 3 general sectors: business, pleasure and compassionate travel. Those flying for business reasons can be further divided into urgent and non-urgent passengers. An individual who travels with no flexibility in their schedule is classified as an urgent passenger while a traveler who can afford to

remain at a destination for a period of time longer than anticipated is categorized as a non-urgent passenger. However, one must be cautious when addressing propensity in the context of business travel. Specifically, the propensity to fly will vary depending on the passenger's occupation. For example, the propensity of an individual to fly who owns a barbershop is quite low. However, if the occupation can be classified as highly technical, such as a software technician, it may be assumed that working relationships will be established in other areas of the world. Consequently, the propensity to travel for this occupation is likely to be quite high. The aforementioned example highlights the first key to accurately predicting the level of propensity: if the occupational status is known for a particular catchment area, a portion of airline demand related to business travel may be determined.

Pleasure travel can be subdivided into those passengers traveling for vacation purposes versus those traveling to visit friends or relatives. It is typically assumed that passengers traveling for pleasure have an adequate level of disposable income due to the cost involved with flying. Subsequently, income is the second key, or component, to predicting flight propensity. Similar to occupational status, if the general income levels are available for an airport catchment area, an additional portion of airline demand related to pleasure travel may be determined.

Similar to pleasure travel, compassionate travel encompasses passengers traveling to visit with friends and relatives. However, as the title suggests, these individuals are using air service for compassionate reasons, such as attending a funeral or visiting with a relative who is ill. While the reasons for compassionate travel are urgent and unpredictable, the choice of mode of transportation for these consumers is related to SES. Though these passengers tend to be considered a small proportion of the overall market, they too are an important factor when analyzing the consumer base. To determine the propensity to fly for compassionate travel, the income levels of the population within the catchment area must be known.

As one can see from the passenger market description, if the socioeconomic status of a population is known, the propensity to fly may be determined. The level of propensity to fly is typically expressed as low, medium or high, which unfortunately makes the evaluation process somewhat troublesome since the boundaries between these three categories tends to be subjective in nature. Subsequently, when dealing with the socioeconomic status of catchment areas, the propensity of a population must be rated in relation to the propensities of surrounding areas.

APPLICATION OF MODEL – Fredericton Airport

To provide a more concrete understanding of the theoretical model presented in this paper, this model was applied to the Greater Fredericton Airport and the surrounding area. The catchment area of the Fredericton airport was first defined, followed by an evaluation of the socioeconomic status of the population who use the facility. Based on the SES calculations, the propensity to fly of each census division was compared.

Defining Fredericton Airport's Catchment Area

To define the catchment area of the Fredericton airport, the population and straight-line distances between Fredericton and a number of surrounding towns and cities were determined. This information was inserted into the Gravity Model formula to establish a series of cut-off lines between centres (Figure 1). These boundaries defined the extent of population that would be attracted to Fredericton's facilities. As can be seen in Figure 1, the gravity model determined that the population within 48 kilometres of the distance between Fredericton and Saint John would be attracted to Fredericton. Conversely, outside of the 48-kilometre mark, the population would tend to gravitate towards Saint John. Table 1 displays the data and results used in the Gravity Model calculations for each centre. Finally, a line was drawn connecting the divisions between each centre pair. The solid green line in Figure 1 illustrates the boundary that is considered to be the Fredericton airport catchment area predicted by the Gravity Model.

Table 1 Gravity Model Calculations

Town/City	Population (1991 Census)	Distance to Fredericton	Gravity Model Result (km)
Bangor, Maine	32,145	212	96
Bathurst	14,409	212	76
Campbellton	8,699	244	74
Edmundston	10,835	216	70
Fredericton	46,466	-	-
Miramichi	12,255	177	60
Moncton	57,010	204	107
Saint John	74,969	108	60

Similar to most theoretical models, flaws can be identified in the process of using a mathematical model to predict real-life situations. The first problem associated with using the Gravity Model to determine the Fredericton airport catchment area is that this model does not account for geographical, political boundaries or physical structures. For example, the boundary in Figure 1 does not take into account topographic features such as dense forests, mountain ranges, or bodies of water which may influence attraction to the airport facility.

Another problem with the application of the model is that road systems are ignored when establishing the catchment area. Since automobile travel to the airport is the most common method of transport for customers, this variable must be considered when predicting the catchment boundary. According to Figure 1, the use of the Gravity Model produced a boundary oriented along a northeast by southwest plane. However, the road network in western New Brunswick is currently configured to move traffic from the northwest corner of the province towards Fredericton. Subsequently, it would be more realistic to orient the catchment area in a northwest by southeast fashion.

A final problem faced with using the Gravity Model to determine airport catchment areas is that the model does not take into account the possibility of another airport existing within a given catchment area. While passengers are typically more attracted to larger airports than smaller airports within a catchment area, the presence of another airport will affect the population's desire to travel to a given airport to use its facilities. This problem also implies that there will be an overlap in catchment areas of airports in close proximity to each other.

Within the context of this study, St. Leonard Airport is located near Edmundston, in the northwest corner of the Fredericton airport catchment area. In order to account for the presence of St. Leonard Airport in the Fredericton catchment area, an attempt was made to quantify the negative effect on airline traffic. The ratio of 1991 enplaned/deplaned passenger traffic between the two airports was calculated and this factor was applied to adjust the boundary produced by the Gravity Model. Unfortunately, this ratio was negligible, and it was determined that St. Leonard Airport had little or no impact on the population's use of Fredericton Airport from the overlapping catchment areas.

Despite minor flaws in its application, the Gravity Model is an effective and concrete means of identifying the Fredericton airport catchment area given the information currently available. To simplify the analysis of the socioeconomic status of the population within the catchment area, the catchment boundary was adjusted to match the outline created by the counties illustrated in Figure 2. It is important to note that for the purposes of this study, the small regions where the Gravity Model boundary extended beyond the county

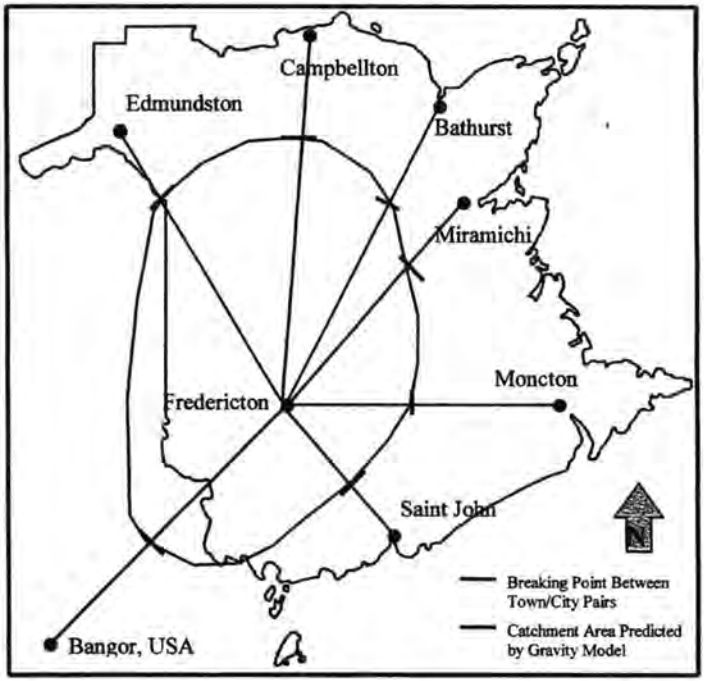


Figure 1 Fredericton Airport Catchment Area Determined by Gravity Model

boundary (in the northeast and southwest directions) were omitted due to negligible population.

The Fredericton Airport catchment area can ultimately be defined as the boundary established by the seven counties illustrated in Figure 2. According to the figure, the following county divisions will define the Fredericton Airport catchment and therefore become the basis of the SES analysis: Madawaska, Victoria, Carleton, York, Sunbury, Queens and Charlotte.

Calculating County SES

A socioeconomic index was determined for each county division within the Fredericton airport catchment area and each of these values are illustrated in Table 2. An example of the SES calculation process for York County is presented in Table 3. Finally, the weighted average SES values illustrated in Table 2 are graphically presented in Figure 3 of the report.

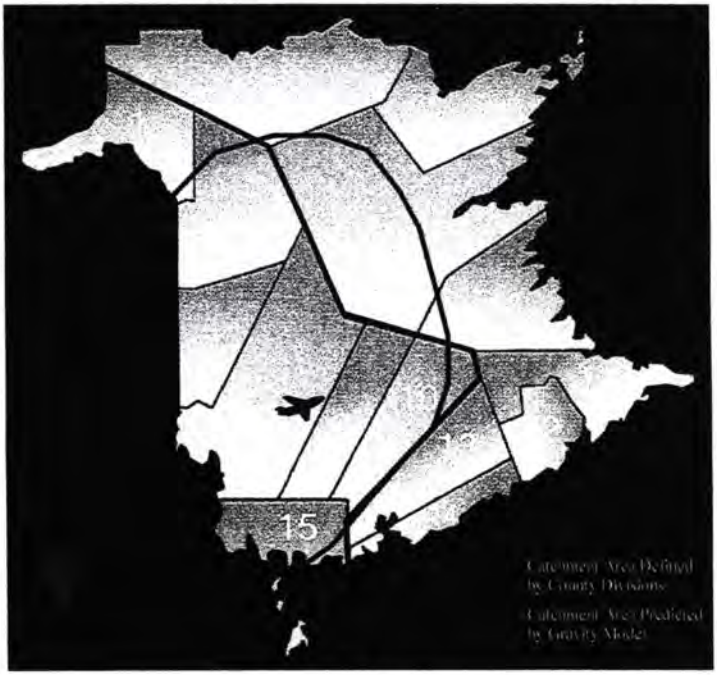
Table 2 Weighted SES Indices for Particular Counties in New Brunswick

Census Division	Female SES	Female Popn	Male SES	Male Popn	Weighted Avg. SES
Madawaska	45.9197	7195	42.4927	9120	44.0040
Victoria	46.0354	3910	40.8865	5240	43.0868
Carleton	46.1555	5225	41.6711	7160	43.5630
York	48.4760	20140	46.4834	24130	47.3899
Sunbury	45.3231	4955	40.3682	7605	42.3229
Queens	44.8303	2170	40.3569	3220	42.1579
Charlotte	44.1925	5575	39.1640	7070	41.3810
Saint John	47.7411	17815	43.6861	20990	45.5477
Kings	48.5564	12750	44.8466	17450	46.4128

As illustrated in Table 2, the SES averages in the given catchment area ranged from 47.4 in York County to 41.4 in Charlotte County. There appear to be no trends in the distribution of county averages except that Victoria and Carleton Counties as well as Sunbury and Queens Counties have similar SES values. It is not surprising that York County yielded the highest SES index since the majority of the population in this county occurs in the City of Fredericton, where most citizens are employed in occupations with high SES values such as management, engineering and teaching.

The calculations that produced the lowest average Blishen index occurred in Charlotte County. According to 1991 census data, the population in this county is evenly divided among the 22 major occupational groups. Unlike the other 6 counties within the Fredericton airport catchment area, there does not appear to be a large concentration of people employed in any one specific occupation. This diversity in occupations causes the overall weighted SES of

Figure 2 Comparison of Gravity Model Catchment Area and County Outline



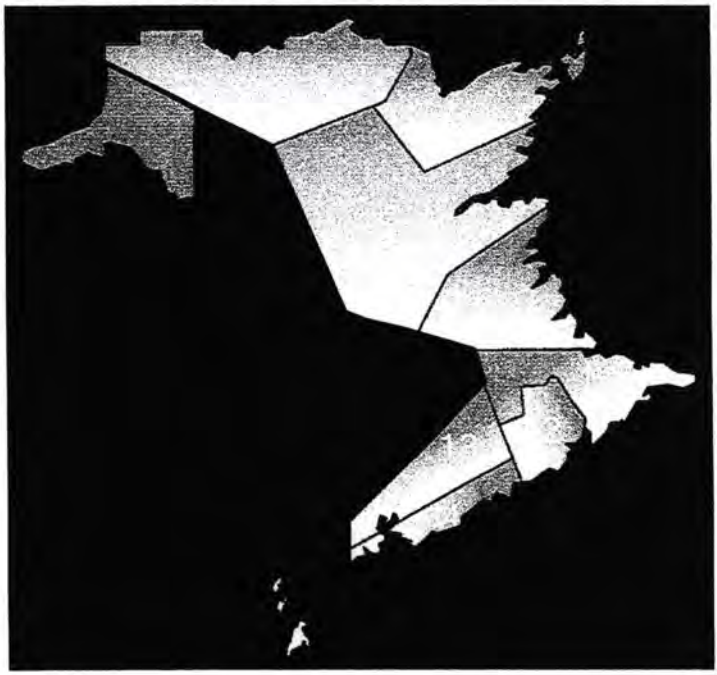
County Names

1.	Madawaska	8.	York
2.	Restigouche	9.	Sunbury
3.	Gloucester	10.	Queens
4.	Victoria	11.	Westmorland
5.	Northumberland	12.	Albert
6.	Kent	13.	Kings
7.	Carleton	14.	Saint John

Table 3 SES Calculation for York County

Occupation Code	Female SES	Male SES	Female Popn Employed in Occupation	Male Popn Employed in Occupation
11	61.1270	63.3318	2080	3385
21	63.5296	64.5905	515	2195
23	64.8324	59.9187	655	560
25	42.7393	44.2650	20	150
27	64.9685	61.2347	1490	1090
31	60.6451	54.9295	1800	325
33	51.1940	47.4725	280	460
41	44.6828	48.3605	6920	1590
51	44.7678	48.1782	1805	2170
61	36.4443	35.2172	3435	2465
71	32.8052	26.7042	170	595
73	23.2542	21.3906	15	25
75	31.9130	29.4937	95	790
77	42.9931	38.3205	0	55
81/82	30.7114	35.7460	185	735
83	29.7802	37.2215	10	355
85	30.1063	36.1464	215	1355
87	38.5906	36.6428	45	2900
91	43.2456	41.8881	115	1430
93	31.6589	33.4160	80	405
95	38.2526	48.6995	45	350
99	31.8535	31.6408	165	745
	Population Total		20140	24130
	SES		48.4760	46.4834
	Weighted CD SES		47.3899	

Figure 3 SES of County Divisions within Fredericton Airport Catchment Area



the county to be lower than other counties. Furthermore, the average male SES dropped below 40, thereby pulling down the weighted average for the County Division.

Evaluating Flight Propensity

The three-step model relies on the evaluation of SES characteristics of a given population to determine the relative propensity of that population to fly. A high SES index indicates that either that population has more disposable income available for recreational travel, or a greater number of occupations which would require business travel. In either situation, the propensity to fly for that population would be greater than for a population with a lower SES value.

According to Table 2, York County contains the highest mean SES value (47.4) using the Blishen scale. As such, the three-step model indicates that people within York County would be considered to have the highest propensity to fly and therefore provides the upper boundary for the Fredericton catchment area propensity scale. Conversely, Charlotte County contains the lowest SES value and therefore provides the lower boundary of the propensity scale for this catchment area. The propensities of the remaining counties will lie between the upper and lower boundaries established by York and Charlotte Counties respectively. According to Table 2 for example, an SES index of 44.0 was calculated for the people of Madawaska County thereby indicating a medium propensity level for flying.

Once the socioeconomic status and propensity to fly is defined for a given catchment area, an airline is able to develop appropriate marketing strategies and service levels. This information would be based upon the needs of the highest SES/propensity level within the catchment area. Therefore, if an airline were interested in providing service to the Fredericton area, the marketing style would be primarily oriented to promote interest within York County. Furthermore, level of service parameters such as airline frequency, destinations, and route servicing would be largely dependent upon the needs of York County residents.

Though the highest SES value determines important variables for airline service to the region, propensity levels of the remaining regions inside an airport catchment area should not be overlooked. Specifically, the population in these lower propensity areas should still be considered as potential customers even though they do not fully fit the profile of an ideal passenger market. In order to capitalize on the potential market available within the Fredericton Airport catchment area for example, an airline should alter their marketing strategy for each of the counties other than York, based on their needs or socioeconomic status.

Generic Application of Model

The procedure outlined in this research paper defines a process or model by which an airline organization can evaluate the interest or propensity to fly of a population within an area surrounding an airport. The model involves defining the catchment area for an airport, calculating the socioeconomic status of the region based upon the Blishen Scale, and finally, applying the SES values to determine the propensity to fly. The simple three-step process was used to evaluate the socioeconomic status of the Fredericton Airport catchment area. However, this model is not site specific, but rather it can be used for any airport across Canada. For example, the model was applied to the airport located at Saint John, N.B. The airport catchment area was defined to include Kings and Saint John Counties, and the SES values were calculated as displayed in Table 2. Using the propensity range established for the Fredericton airport catchment area as a baseline, it was determined that citizens in both Kings and Saint John counties had a slightly higher than medium propensity to fly. Subsequently, an airline could focus on this information in order to establish marketing and service levels for the Saint John airport.

It is important to note that when applying the model, if a catchment area is limited to only one county, census track data may be used. The procedure remains the same however the socioeconomic status and propensity levels of census tracks will be evaluated rather than those of the counties. Airlines should base their marketing and service level standards on the highest SES rating.

Conclusion

An important consideration of any airline prior to beginning service to a region is determining the general market share interested in air travel. An effective method of defining the potential consumer base is investigating factors which directly affect a population's tendency to fly, including social and economic factors such as employment and salary. A three-step model is presented in this paper that provides a quick means of assessing the socioeconomic status of an airport catchment area. Using the propensity evaluation method established by this model, airlines can more effectively target their advertising and service levels based on the consumers who are most likely to fly within a given airport catchment area.

As we enter a new millennium, the role and nature of the airline industry is rapidly changing. The need for innovative and personal marketing campaigns that target individual consumers is becoming more important as competition increases. Information allowing for specificity in marketing

campaigns and flight schedules will not only save valuable marketing dollars, but could entice customers to focus on a given airline thereby increasing its relative market share.

References

1. Blishen, B.R., "The Construction and Use of an Occupational Class Scale", *Canadian Journal of Economic and Political Science*, Vol. 24, 1958.

2. Berry, J.L., and Horton, F.E., "Geographic Perspectives on Urban Systems", Prentice-Hall, Inc., New Jersey, 1970, p. 537.

3. Chapin Jr., F.S., and Kaiser, E.J., "Urban Land Use Planning", 3rd Ed., University of Illinois Press, Chicago, 1979, p. 150.

4. Ircha, M., and Sundararajan, D., "Municipal Service Distribution: Equity Concerns", Journal of Urban Planning and Development, Vol. 110, No. 1, 1984, p. 36.

5. Blishen, B. R., "A Socio Economic Index for Occupations in Canada," *Canadian Review of Sociology and Anthropology*, Vol. 4, No. 1, 1967, pp. 41-53.

6. Ghallagher, M.R., "Evaluating the Equity of Urban Transit Service Distribution", MScE Thesis, University of New Brunswick, Fredericton, 1987, p 22.

Methodological Issues of Economic Impacts Studies:
"The Good, The Bad and The Ugly"

Canadian Transportation Research Forum, CTRF
34th Annual Conference, Montreal, Quebec
May 16-19, 1999

By

Scott J. Shurvell, Research Associate
Barry E. Prentice, Director

Transport Institute, University of Manitoba
CANADA

Tel: 204.474.9842
Fax: 204.474.7530

TRADE
TOURISM
LOGISTICS
TELECOMMUNICATIONS

E-mail: shurvell@ms.umanitoba.ca
barry_prentice@umanitoba.ca

METHODOLOGICAL ISSUES OF ECONOMIC IMPACT STUDIES: "THE GOOD, THE BAD AND THE UGLY"

Scott J. Shurvell, Research Associate
Dr. Barry E. Prentice, Director
Transport Institute, University of Manitoba

Abstract: Economic Impact Studies are widely undertaken, but seldom explained with precision. When explanations are offered, they are often incomplete and appear ad hoc. Often they are ad hoc. The geographic scope is inappropriate, the activity coverage is excessive and the measurement techniques are unsound. This paper attempts to clarify some of the methodological issues and provide a guide to researchers undertaking economic impact studies.

1.0 Introduction

A recent Economic Impact (EI) Study of North Carolina's 74 publicly-owned airports estimated total annual expenditures at $9.1 billion, labour income of $4.6 billion, and over 180,000 jobs. These figures suggest that the airport system in North Carolina generates substantial economic activity. But, how credible are the study results?

EI studies are criticized because they lack a consistent methodological underpinning. Often they attempt to incorporate impacts that are beyond the realm of quantification. That is, they capture anything and everything serving the purpose of promotion over economic objectivity. Harsh criticism must be tempered however by the realities of conducting these studies. Economic impact analysis is fraught with "gray" areas and a lack of consensus on what constitutes an impact, the scope of analysis and how some activities should be measured.

While promotion may be the primary impetus for funding EI studies, the potential exists to use this research for meaningful analysis of structure and growth. A methodological approach for EI studies is needed with guiding principles that can improve the level of confidence and consistency of results. It is beyond the scope of this paper to provide that methodology, but we may be able to provide some tentative steps toward that goal.

2.0 Geographical Scope

No subject causes more error or confusion in economic impact analysis than the selection of the appropriate geographical area of study. Geographical scope has important consequences for the economic multipliers and leakages underpinning EI studies. Depending on how the geographical is defined, the economic impacts will be internal or external to the area.

2.1 Case Study of a Port Economy

Ports are crucial to the economic prosperity of any region and country, but too often their contributions are overlooked because they do not produce tangible goods and their activities are not readily visible to the public. In British Columbia, Fraser Port's port-industry is made up of economic activities that are directly involved in the movement of cargo through Fraser Port. These activities include:

- Customs Brokerage
- Dredging Activities
- Freight Forwarding
- Pilotage Services
- Port-related Construction
- Rail Operations
- Ship Agents
- Ship Brokers
- Ship Chandlers
- Stevedoring
- Terminals
- Trucking
- Tugs & Towing

While the measurement of the direct economic activities in Fraser Port's port-industry sector are justified, the approach used to measure its port-associated industry – defined as economic activities that produced the goods shipped through Fraser Port – is of concern. A recent EI study divided the port-associated industry into import and export sectors.[1] The approach used to measure the export sector is unconvincing.

On the import side, the economic impact of international cargo could not be measured because the goods were produced outside of Canada, and their forward linkages in Canada are impossible to trace using Input-Output analysis. On the export side, the study examines the national impact over the provincial impact because production of goods shipped through the Port did not necessarily occur in B.C., but were produced by production units located all over Canada.

---

[1] Chen, J.S., Fraser Port Economic Impact Study, *Fraser Port Harbour Commission, September, 1998.*

The study makes the assumption that without Fraser Port, the established port-associated industries (i.e., steel, agri-product, chemical, lumber, motor vehicle, etc.) would cease to exist. It is also a fallacy to assume that without Fraser Port, no alternative or newly built port facility could support the export sector. The study is a classic example of erroneous assumptions used to define geographical scope.

3.0 Methodological Approaches

Inconsistent use of terminology and method leads to skepticism about the validity of EI study results. Terms are either loosely defined or simply left without definition. EI methods are inadequately explained and often lack references that justify approach. To put it bluntly, many EI studies are "un-scientific" at best. This makes comparisons across studies difficult.

Four principle approaches are used to measure the economic impact of major infrastructure facilities:

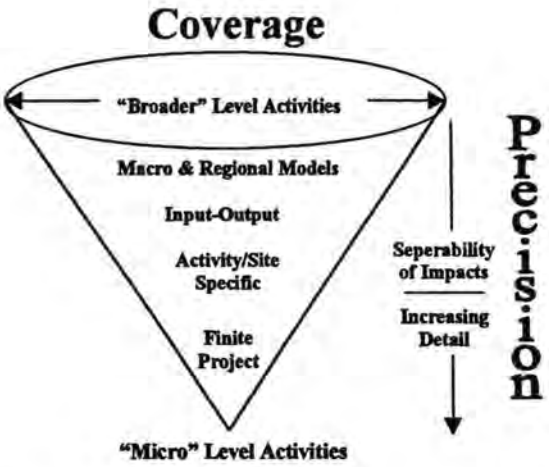
- Macroeconomic and regional models
- Input-Output Models
- Activity and site specific models, and;
- Finite Project approach,

Despite similarities of approach, noticeable differences in method can lead to divergent estimates of economic impacts. The measurement of direct impacts is typically based on site-specific surveys of employment and labour income in various economic sectors. The differences revolve around treatment of indirect and induced impacts; degree of geographical and sector disaggregation; and the ease with which results can be understood and defended publicly.

3.1 Model Typology

Figure 1 presents a typology of the four methodological approaches. A funnel illustrates the economic impact tradeoff between coverage and precision. As one moves away from Macro & Regional Models to Finite Project analysis, the level of micro-level detail and precision is increased at the expense of inclusiveness.

Figure 1 Economic Impact Tradeoff – Coverage vs. Precision



3.1.1 Macroeconomic and Regional Models

Macro models measure economic activity at the broadest levels of geographical and sectoral detail. The use of such models is limited in the assessment of economic impacts of "micro" level activities, such as airports and other transportation infrastructure.

In macro models, the direct impacts are regarded as exogenous "shocks" to the economic system and provide the basis for estimating the indirect and induced impacts. These models are designed specifically to capture the simultaneous nature between all activities within an economy. The problem of using such models is that interdependencies of indirect and induced effects result, making it difficult to separate out any individual impacts.

3.1.2 Input-Output (I/O) Models

Input-output models evaluate the economic transactions that take place within a local economy and how impacts in one sector are transmitted throughout the economy. The models translate output of each industry into consumption by other industries and sectors, while at the same time showing the inputs to each

industry from other industries and sectors. I/O models are suited for indirect measurement.

An I/O table traces the linkages of inter-industry flows of goods and services within a given country, region or province. The I/O model yields "coefficients" that are used to calculate the amount of inputs (units in quantity or value) required from each industry in the economy to produce one unit of output (or one dollar's worth of output) for a specific industry. The I/O table is like a *"recipe"* of all the ingredients going into and out of the economy.

Limitations

Weaknesses of the "macro" I/O approach are due to the regionalization of such models and the size of the sectors they contain:

- Regional models are derived from national I/O models and are forced to rely on established national coefficients. But, regional and national coefficients can differ because of variations in industry and product mix.[2] To develop an I/O table for a region, precise data on imports and exports of each industry or sector in that region would be required.

- Regional models fail to incorporate the true nature of firms supplying services to a transport facility. The majority of firms are national or international with company headquarters located in areas other than the immediate region where the specific airport, port or intermodal services are being supplied. These purchases are not made from the local economy surrounding a specific facility.

  For instance, airline purchases (fuel, uniforms, etc.) and airport purchases (heavy machinery/trucks) will not accurately represent the local indirect expenditures of major firms providing direct services at an airport.
- The segments of an I/O model are too large to accurately and defensibly represent the expenditures of firms supplying direct services to a local transport facility. For example, most regional I/O models have a transportation sector, which includes a myriad of separate and distinct activities.

---

[2] An economic impact study of Fraser Port's port-industry sector on the Province of British Columbia and Canada required the use of provincial and national multipliers. Since the national I/O model does not contain induced multipliers, they were estimated using the proportions of the B.C. multipliers by factoring in the difference between the B.C. impact and the national impact. *See Fraser Port Economic Impact Study, (Chen, J.S., 1998).*

The transportation sector contained in Washington State's I/O model, used to assess the economic impact of the Port of Seattle (1982) included the following activities: freight forwarding (domestic and international for air, truck, rail and waterborne cargo), airlines, steamship lines, trucking, rail, warehousing, steamship agents, terminal operators and stevedores. Because each of these industries had very different operations and expenditure patterns in the purchase of supplies, the use of "macro" I/O coefficients to estimate the indirect impacts of activity at a specific airport (i.e. Seattle International Airport) was inaccurate, unrealistic and naive.

The belief that it is possible to trace the regional expenditure patterns of firms providing services to the airport in order to estimate indirect and induced impacts is false.

- The data necessary to update an I/O model can be prohibitively expensive and time consuming.[3] While the cost of survey work is avoided through their use, the accuracy I/O models demand constant attention and substantial funding, raising doubts about their intrinsic cost effectiveness.

- The I/O approach does not specify a time dimension.

3.1.3 Activity/Site Specific Models

The weaknesses of the I/O model led to the development of this new methodology. The qualities of this approach – the use of activity-specific sectors and multipliers – provide the basis for its name.

- It measures economic activity at the industry sector level, but unlike I/O models – structured according to SIC[4] – it focuses on economic sectors most relevant to the activity of interest.

- Avoids the use of I/O analysis because of the difficulties of allocating indirect impacts to specific site locations. It relies instead on multipliers for measuring secondary impacts.

This approach can appear arbitrary and un-scientific – a mix of approaches without a common and unifying theoretical foundation. However, it is the most common approach. The methodology is based on the fact that a transportation facility generates separable types of impacts (i.e. employment, labour income,

[3] For example, an input-output model for the Atlantic provinces in 1965 took seven years to develop.
[4] *Standard Industrial Classification.*

revenue and taxes) and the business sectors of a facility's economy are defined in which it generates economic activity.

Under this approach, direct impacts are estimated from surveys of firms in each business sector. Re-spending impacts or induced income is estimated using provincial income multipliers. Multipliers are applied against the direct impacts to estimate the affect of re-spending throughout a region by those directly employed by the transportation facility in question, such as an airport.

3.1.3.1 Case Study of an Airport Economy

Airports have been the subject of many EI studies and provide a useful example for analysis. The airport economy has been disaggregated into primary and secondary to account for different types of activities that take place. Primary linkages are defined as *"aviation-related"* and are usually located either on-site or in the immediate vicinity of the airport. Secondary linkages encompass organizations that are either *"airport-related"* (but not aviation-related), or for which their business is derived from air passengers.

Primary Linkages

(i) **Air Carriers:** All companies offering scheduled air service within a particular province or state, or to other points in a country from a specific airport.

(ii) **General Aviation:** This classification includes:
- air charter service;
- corporate aviation organizations;
- aviation-related organizations or educational institutions; and,
- government aviation.

(ii) **Air Support Services:** This category includes companies whose business is primarily or wholly aviation-related, or who provide "**direct**" support to air carriers or general aviation businesses. This includes: couriers and freight forwarders;
- aircraft maintenance services; aircraft repairs;
- fueling services;
- aircraft parking and storage operations;
- aircraft rental or leasing businesses; and
- other general services.

(iii) **Airport Operations and Administration:** These activities consist of all organizations involved in the direct operation of the airport (e.g.

Airports Authority Group, Area Control Centre), that provide for its overall administration, support services (e.g. atmospheric information, customs, immigration) and any contract services (e.g. security, police, janitorial, valet parking).

Secondary Linkages

(i) **Commercial Services:** All retail and personal service businesses operating on the airport site (e.g. duty free shops, newsstands, gift stores, coffee shops, and other concessions).

(ii) **Ground Transportation Services:** Operations that transport passengers to the airport are classed as ground transport services.
- car rental;
- taxi and limousine service; and
- bus transportation

(iii) **Accommodation Industry:** This sector includes all airport-dependent hotel/motels.

For each type of airport activity, the economic impacts can be separated into direct, indirect and induced categories. Direct impacts include the initial spending and employment generated at the airport or in direct support of the airport's activities. Indirect impacts are produced from activities that occur off-site but which supply services, materials and inputs to firms involved in the direct activity. For example, the expenditures of an airport snack shop become the revenues of a food wholesaler. Induced impacts are the successive rounds of spending in the economy that begins with the consumption spending of individuals involved in the direct and indirect activities. The result is increased employment and income over and above the levels for which the direct and indirect activities are responsible.

3.1.4 Finite Project Approach

This approach measures the economic impact of a specific project (i.e. construction of a cargo facility, bridge etc.). It does not measure the economic impact of on-going activity over time since the project is finite in nature. For instance, the cleanup or remediation of a waste disposal site is not an ongoing activity because there is a start and an end to the cleanup. Not unlike the other methods, indirect and induced levels of activity are calculated.

Similarities also exist between this approach and those projects calculated using a cost-benefit method. In fact, it would not seem inappropriate to obtain its net

present value by discounting expenditures occurring in future years over the life of the project. However, the choice of the appropriate discount rate is another issue. It is also questionable whether one should take into account discounted indirect and induced levels of activity.

4.0 Multipliers

Indirect and induced effects of transport related activities are difficult to measure. Indirect effects would require surveying a large number of firms whose transport activity accounts for only a small portion of their overall business. Similarly, measuring the induced effects would require surveying the entire economy. Instead, economists resort to using economic multipliers to calculate these impacts.

While the mechanics of multiplier use is rather straight forward, the inappropriate use often invalidates the end result. Familiarity with data and multipliers is critical in order to avoid common pitfalls, such as using incorrect multipliers or applying them incorrectly. For example, there are cases where studies have applied multipliers to calculate the total impact and then have proceeded to add this total to the direct impact. Understanding what the multipliers represent and what their limitations are is also very important.[5] Multipliers are not as precise as researchers would like them to be.[6]

5.0 Incorporate Expenditures Not Revenues

"Double-counting" is often alleged in EI studies. Many EI studies lack a methodological foundation because measurement errors are incorporated into the direct impacts. Gross revenues, a measure widely used to measure economic activity, double-counts and leads to an overestimation of total impacts. In the case of an airport, the receipts from the sale of aviation fuel and catering services to air carriers are included in the measure of total economic output. But, while these revenues constitute intermediary firm revenues, they are an expense to the final users (air carriers). If these expenses are not deducted from airline revenues, the true magnitude of economic activity would be inflated. The

[5] Provincial I/O models from which multipliers are derived are static and do not recognize production capacity limits. Furthermore, they are based on average technologies and average costs at a fixed point in time.

[6] Traditional industry multipliers are broken down for forty-six industry classifications. The classifications are very broad and make it difficult when identifying multipliers for specific activities. For example, do activity linkages for air carriers, general aviation and air support services fall under transportation or transportation equipment classifications?

inclusion of revenues makes it difficult to account for where the economic impact is being absorbed. That is, are the revenues injected into the local economy or removed as leakages?

A more appropriate indicator of airport economic activity is to capture airport-related expenditures. Expenditures – the actual purchases of locally produced goods and services – provide an improved measure for capturing direct impacts because they are easier to identify and eliminate double-counting. Also, firms are more likely to disclose information on expenditures (rather than revenues) due to the confidential nature of commercial operations.

6.0 Survey Based Approach

In order to collect site-specific information, firms and organizations located at and around a transport facility are surveyed. The survey is also targeted at firms located off-site but who rely on the facility as their prime source of activity.

Care must be taken when conducting survey based approaches since many firms are subsidiaries of other firms or have merged with other companies. Precautions must be taken to avoid the double-counting (i.e. sampling more than once) of firm activity. This involves identifying firms that are subsidiaries of larger companies or affiliated with other organizations.[7]

Another concern of survey based studies is the overall response rate. Quite often readers base the validity of EI studies on the magnitude of the response rate. That is, they tend to criticize the results if the response rate is low. But, the response rate alone cannot be used to assess the overall success of the study. Clearly, what is more important are the relative impacts of those firms that respond and those that do not. While a complete enumeration is never likely, an impact study will be more credible and possess more weight if it captures the "major players" involved in the activity, despite a low overall response rate. For instance, the majority of airport-related activities were accounted for in a 1998 study on the "Economic Impact of Winnipeg International Airport". The study captured the majority of air carrier and cargo operations despite a modest overall response rate of 68.1 percent.

[7] For instance, in Canada, due to co-terminalization restrictions, U.S. integrated express carriers (i.e. Federal Express, UPS, etc.) must contract out overnight delivery service to Canadian all-cargo carriers (i.e. Morningstar Air Express) for domestic delivery between Canadian points. Aggregating the economic activity (i.e., expenditures, cargo volume, etc.) of both carriers would overestimate the total impact.

The low response rate in the air support services linkage (50 percent) was due to the large share of small firms common to this type of operation. (e.g., freight forwarders and custom brokers). Competition among these small businesses is fairly intense so that many firms were reluctant to provide any information concerning their operations.

But, statistical validity is dependent on the number of respondents. It is naive to assume that the 1988 EI Study of Edmonton International Airport was credible when only 14 of 65 questionnaires were returned, representing a response rate of 22 percent. To estimate the activity of non-respondents requires substituting data of a comparable respondent or, by using the average in each business linkage (i.e., air carriers, general aviation, air support services, ground transportation, airport operations & administration, etc.). There is no reason to conclude that the total impacts in the study constitute a representative sample since there is no way of knowing whether all the critical linkages have been established. Without these linkages, there is no meaningful way to calculate the impact of the non-respondents.

7.0 Grey Areas and Reality Checks

Airlines derive their revenue from ticket sales, but it is difficult to determine what portion of revenues would end up as a local economic impact. A study by Prentice and Yeow (1990), considered the revenue impact problem associated with airline ticket sales. The study suggested that the use of ticket sales as an economic impact at airports is without logical foundation: "Airlines revenues which are available for a particular airport represent the revenue from the sale of tickets originating at the site, to their destination or point of transfer. It is not reasonable to assume that all this revenue is attributable to the point of transfer". Airlines sell a transportation service from origin to destination, yet it is impossible to allocate any portion of revenues to the O-D segment.

In 1989, Transport Canada commissioned airport EI studies across Canada. The methodology used in these studies included air ticket sales at each airport as part of the local impact. This was incorrect because a large part of these revenues were used to compensate for aircraft purchases and fuel, that were not produced locally. Moreover, airports with more international travel (higher ticket prices) were inflated relative to airports with mainly domestic services.[8] Clearly, incorporating air ticket sales as a revenue impact is conceptually flawed, resulting in a grossly inflated economic impact at any airport.

[8] For example, the revenues that an airline would receive from a Winnipeg-London (U.K.) ticket could be four times the revenues of a Winnipeg-London (Ontario) ticket, while the economic activity generated at the Winnipeg airport might be identical.

Since travel agents derive a substantial portion of their income from air ticket sales, capturing this income would aid in determining the economic impacts of locally earned commissions attributable to an airport. Travel agent ticket sales information is available from IATA[9] under the Bank Settlement Plan (BSP) that transfers funds from travel agents to airlines. The BSP system produces an *Agent Air Product Summary Report* where provincial ticket summaries and locally earned commissions can be obtained.

Some airports have the distinctive feature of providing joint military/civilian operations. Although commercial and military traffic is handled simultaneously, the military traffic should be counted as a separate economic impact. Conceptually, the military activity could be transferred by political decree with no economic consideration of the local community. Furthermore, military activity does not pay landing fees or other compensation for use of airport infrastructure.

Given the inconsistency of approaches and methods, how can one compare the economics of similar activities? Revenues are unlikely to be as comparable as employment numbers because revenues include profit margins, may double-count economic activity and are less likely to be revealed accurately by respondents. In contrast, employment is a tangible measure that most firms are willing to disclose. A comparison of employment at different locations is a reliable means to assess whether the overall impacts are in line.

8.0 Static vs. Dynamic Impacts – "One Trend is Worth A Thousand Reports"

EI studies identify and measure the economic significance of activity at a fixed point in time. Such studies are limited by their static nature. Lack of consistency in EI methodology and statistical reporting often make comparisons difficult, but the assumption that future impacts are constant is equally misleading.

EI studies have been used more for advocacy than analysis. However, EI studies that use a consistent methodology for measuring economic impacts yield reliable data concerning trends in composition and levels of activity, provided that they are repeated periodically.[10]

---

[9] *International Air Transportation Association*

[10] A consistent methodological approach was used to quantify the economic impacts of Winnipeg International Airport (YWG) over an eight-year time span. The results show that dynamic economic impacts have interesting cumulative effects revealing changes in composition that are not possible in a static framework. See Shurvell, S.J. and Prentice,

Providing an assessment of transportation infrastructure benefits (employment, income, taxes, etc.) from port, airport, intermodal operations etc., at various points in time helps to determine whether such benefits are shrinking, remaining constant or growing. Impact analysis that is conducted only at a single point in time virtually always assumes that the level of benefits will continue into the future at the current level. This assumption can mislead decision-makers as to the true level of benefits.

EI studies that provide a snapshot of existing time and events exclude the dynamics associated with changes in local trade, technology, facilities and organizational structures. Such studies are not equipped to deal with the dynamics of structural change, such as the introduction of new industries and the disappearance of others. They measure short-term effects that tend to become dated very quickly. Yet, such analysis provides a great deal of information when examined in a dynamic context. That is, EI studies can be used to measure the long-term "cumulative effect". Efforts taken to consistently update EI studies every few years can reveal a comparative analysis of past and present impacts.

9.0 Conclusions

Economic Impact (EI) studies play an important role in assessing economic activity. Yet the research community continues to be skeptical on the results of these studies. Unless EI studies can defend their methodological approach, they will always remain suspect. The need to develop a standardized approach is critical, especially if one is to compare and contrast EI studies.

In the case of Canadian airports, EI studies will become more important to local airport authorities and their surrounding communities as "benchmark studies" used to evaluate the effects of post-commercialization of Transport Canada's airport devolution policy. A consistent methodological approach is required to be able to compare and contrast EI studies

Endnotes

The authors would like to acknowledge Todd F. Harrison of Canadian Pacific Railway, for his insight regarding EI analysis. Todd was a former research affiliate of the Transport Institute.

B.E., "Static And Dynamic Airport Economic Impacts", *Journal of The Transportation Research Forum, 1999.*

References

Airports Council International – North America (ACI-NA), *Summary Report*, "The Economic Impact of Canadian Airports", pp. 1-20, 1999.

Bison, B.G., Mazerolle, T.M., "A Methodology for Airport Economic Impact Studies", *Proceedings of the 24th Annual Canadian Transportation Research Forum (CTRF), pp. 462-74, 1989.*

Chen, J.S., Fraser Port Economic Impact Study, *Fraser Port Harbour Commission, September, 1998.*

Cowan, J., Brooks, M., "Port Economic Impact Studies: An Examination", *Proceedings of the 30th Annual Canadian Transportation Research Forum (CTRF), Alymer, QC, pp. 400-13, 1990.*

Duebal, T., A Study on the Economic Impact of the Edmonton International Airport on the Local and Provincial Economy, *Commissioned by Transport Canada and prepared in cooperation with The Management Advisory Institute, May 1988.*

Economic Development Research Group, "A Primer on Economic Impact Analysis", *www.edrgroup.com.*

Harrison, T.F., "Economic Impacts and Benefits of Site Remediation: Methodology and Case Study of the Domtar Site, Transcona, *1996.*

Marketing And Economic Development Study For L.B. Pearson International Airport, Toronto, Economic Impact Final Report, Volume 1, *IBI Group in association with Hickling Lewis Brod Inc., Gerald Grant Associates and SH&E, June, 1996.*

Prentice, B.E., Yeow, S., "A Comparative Analysis of the Economic Impact Studies at Canadian Airports", *Proceedings of the 25th Annual Canadian Transportation Research Forum (CTRF), Saskatoon, SK, pp. 58-75, 1990.*

Shurvell, S.J., Prentice, B.E., "Static And Dynamic Economic Impacts", *Journal of the Transportation Research Forum (TRF), 1999.*

Shurvell, S.J., Prentice, B.E. and Harrison, T.F., "Economic Impact of Winnipeg International Airport". Prepared for Winnipeg Airports Authority Inc. (WAA), *Transport Institute, University of Manitoba, Study Report No. 1, September 1998.*

Shurvell, S.J., "Economic Impact of a Night Restriction at Winnipeg International Airport: A Time Trend Analysis Measuring Potential Impacts", *Proceedings of the 33rd Annual Canadian Transportation Research Forum (CTRF), Edmonton, AB, pp. 563-78, 1998.*

Stuart, Alfred. W et al, "Economic Impact of Publicly -Owned Airports in North Carolina. *North Carolina Department of Transportation, Division of Aviation, University of North Carolina at Charlotte, Department of Geography and Earth Sciences. Charlotte NC. June 1996*

A PLACE IN THE SUN, OR A SHELTER IN THE STORM? A STUDY OF PARKING SERVICES.

Victor Rueda
Transport Institute, University of Manitoba.

Introduction

Revenues generated by parking services are one of the major sources of income for airports around the world. Small or big, all airports have the necessity to provide their users with conveniently located parking facilities and functional services. Although the airports have a natural "local" monopoly in parking service, increasingly, private park and fly businesses have been created just outside the airports' boundaries. Consequently, airports have a more cost competitive and customer service oriented parking supply.

Airports need to be adapted to the physical and geographical conditions in which the facility operates. Climate plays a big role in the design of facilities and services of an airport. Cities with warm, dry, climates do not require tunnels to connect the terminal to parking areas or in many cases covered parking. Colder and wetter environments need to have facilities that make everyday activities convenient and efficient.

Winter in Winnipeg experiences temperatures of –30 Celsius and colder. The Winnipeg International Airport has ample short term and long term parking facilities and competitive prices with the only "Park and Fly" operator. The disadvantage of the airport is that its parking lot is totally outdoors, while the competitor has a heated covered facility.

This parking facilities study was conducted at the Winnipeg International Airport to assess user's opinion and attitudes towards the construction of a covered parking lot at the airport. It was already clear from anecdotal evidence that people wanted to have a covered parking facility. Several comments such as the following were recorded:

> *"A covered parking lot is necessary at the Winnipeg Airport. Some Canadian cities with warmer climate than Winnipeg's have this facility. A covered parking lot has to be available where most needed".*

Besides issues related to the construction of a covered facility, the airport wished to assess the potential market for different parking lot services.

Study Objectives

Respondents might be positive about having a covered parking lot at the Winnipeg Airport, but are they willing to pay enough to justify its cost? The first object was to determine the parking fare users are willing to pay for parking on this facility on a daily, weekly and monthly basis.

If the Winnipeg Airport Authority decides to build a covered parking lot, there are several additional car services that could be implemented to enhance its parking facilities. The second object was to determine the appeal of these ancillary services. The degree of acceptance given by respondents towards these services is analyzed, as well as the extent to which they will make users park at the airport's facilities instead of at the competitors'. These services are oil change, car wash, tire service, greater amount of security, decrease in price, free parking on weekends, and valet parking.

Methodology of the Study

Soon after the Winnipeg Airport decided on the project's goals, the development of the research instrument (questionnaire) and its testing took place. Next, the data was collected through personally interviewing 360 passengers at the gate areas of the Winnipeg Airport. The collected information was analyzed using the statistical package for social sciences (SPSS). Having a clear understanding of the analyzed information, the project's report was completed and a presentation of research results for the Winnipeg Airports Authority was conducted.

A comparison was made with its main competitor, Air Park, on the following areas: Security, manoeuvrability, walking distance to terminal, price, and overall service. The performance of airports that are already providing ancillary parking services was analyzed to assess the potential for success and profitability. The airports under study are the ones in Calgary, Edmonton, Halifax, Montréal, and Ottawa.

Finally, based on the analysis and interpretation of results, the Transport Institute presented a set of recommendations to the Winnipeg Airports Authority, outlined at the end of this paper.

A shelter in the storm, degree of acceptance and price to charge

58.3% of respondents under study strongly support the idea of having a covered parking lot at the Winnipeg Airport. The main argument for such strong support is the need to come to the airport during wintertime, when passengers have to walk to the terminal from the parking lot under cold temperatures.

People who disagree with this idea mention that, even though a covered facility greatly improves the airport's facilities, they prefer the status quo for fear of a dramatic parking cost increase.

For those people who strongly support the construction of a covered parking lot, the next issue to be addressed is the amount of money they would be willing to pay for parking on this facility.

Respondents were presented parking rate ranges for daily, weekly and monthly parking. For daily parking, fares range from $6.00 to $11.99. Most respondents consider a fair price to be in the lower end of the scale, between $6.00 and $6.99. Even though respondents desire a covered parking lot, they are not willing to pay for its cost, at least on a daily basis.

In terms of weekly parking, rates ranged from $30.00 to $59.99. One-half of the sample under study would pay between $30.00 and $34.99. However, a good portion of respondents considers a fair price to be higher than the lowest presented fare. 21.3% of respondents would be willing to pay between $35.00 and $39.99, and 25% would pay between $40.00 and $54.99. This information shows that respondents who use the long term parking service at the airport have a better understanding of the costs and benefits associated with the construction of this facility, and therefore would pay more than those who use would use this facility only on a daily basis.

For monthly parking, the parking fare range provided for customers is between $120.00 and $209.99. Most users (65.4% of the sample) consider a price on the lower end of the scale to be fair, between $120.00 and $134.99. Another 23.9% would pay between $150.00 and $179.99.

In summary, although most people want to have a covered parking lot at the airport, they are not willing to pay higher parking rates to help finance it. It is clear that passengers like this idea, but are unwilling to support higher parking rates.

Ancillary parking services to be introduced at the Winnipeg Airport

If the Winnipeg Airport decides to build a covered parking lot, there are several additional services that can be implemented to enhance its facilities. These services are studied in two dimensions: The degree of acceptance given by respondents to them, as well as the extent to which they will make customers use the airport's facilities instead of parking with the competitors located outside the airport. These services are oil change, car wash, tire service, greater amount of security, decrease in price, free parking on weekends, and valet parking.

Auto services: In terms of oil change service, research findings show that most respondents think this service will not make customers increase their usage of the airport's parking facilities. In fact, many users see the addition of this service having no effect on their parking usage. As for representing a

competitive advantage with respect to Air Park, a small number of users believe that the introduction of this service makes a difference when deciding what parking provider to use.

Responses are quite different for car wash services. Although a small number of respondents see themselves increasing their usage of the airport's parking facilities due to the introduction of this service, it clearly gives some competitive advantage to the airport.

Tire service received the least amount of support from respondents. More than half of interviewees view this service as unnecessary to be introduced at the Winnipeg Airport. This service has a very low support rate even in terms of representing a competitive advantage for airport management.

A conclusion regarding car services is that respondents view them as exclusive services offered by business dedicated and specialized in them. Hence, it is a new concept, at least for Winnipeg Airport users, to have these services available at the parking facilities. Therefore, it will be risky to invest in equipment to provide them at the airport with such low expected acceptance rates recorded from respondents.

Security: Offering more security appears to make a difference in users' parking choices. Almost all respondents support the idea of having a greater amount of security at the airport's parking facilities. Unexpected by airport management, most respondents agree that parking facilities at the airport have a lack of security. The Airport Authority mentions it has enough personnel and equipment to look after its parking facilities and the overall airport. The problem is that users seem not to perceive them. An additional issue that accounts for this perceived lack of security is that the airport's parking facilities are totally outdoors.

The short-term solution to this problem is to make security visible through signs mentioning that there is equipment and personnel operating 24 hours a day. As for representing a competitive advantage for the airport, it is clear that security makes a significant difference on users' parking preferences.

Price sensitivity: To find out consumers' sensitivity towards changes in price, the extent to which a decrease in parking fares will make the Winnipeg Airport customers' first parking choice was studied. Results show that the Winnipeg customer is very price sensitive. This high degree of consumers' elasticity can be used to the advantage of the airport by introducing seasonal fares supported by strong publicity. In terms of time frame, the airport can introduce reduced fares in certain times of the day, months, or a given season. In summary, price differences can represent a strong competitive advantage.

Free parking on weekends is one of the ancillary services that has the strongest impact on consumers' usage degree. The introduction of this feature improves people's perception of the airport and at the same time it represents a

strong competitive advantage. Although free parking on weekends represents several benefits for users, it does not help the airport management in terms of financing the covered parking lot. The construction of this facility will represent a significant investment for the airport. Therefore, it will be difficult to introduce free parking on weekends with such a large expense.

Valet parking: The Winnipeg Airports Authority is considering the introduction of valet parking service. The following information from the research instrument deals with valet parking service:

*Currently the airport is considering introducing **VALET PARKING** service. When departing from Winnipeg, the passenger would drop off his/her car at the door of the terminal and provide the valet attendant with information about his/her returning flight. When back in Winnipeg, the passenger's car will have been safely stored, warmed up, and ready to go, once again at the door of the terminal.*

a) If available, would you use this service?
[ ] Yes [ ] No

*b) What do you think would be a **FAIR** price for valet parking service? How much would you be willing to pay? (not including the cost of parking)?*

[ ] under $5.00 [ ] $6.00-$6.99 [ ] $8.00-$8.99
[ ] $5.00-$5.99 [ ] $7.00-$7.99 [ ] Over $9.00

In terms of valet parking service usage, 43.6% of the sample mention they would use valet parking service if available at the airport, compared to 56.4% who would not use it. As for gender of respondent, females are more likely to use valet parking than males. From the sample in favor of valet parking, 46.8% of females say they would use this service, compared to 41.1% of males. Few negative comments were made regarding valet service. Some people (mostly males) argue that they dislike the idea of allowing somebody to drive their car, even if it is only from the airport terminal to the parking lot.

As for how much to charge for valet parking service, 43.1% of respondents mention it should not cost more than $5.00. 25.6% of respondents would pay between $5.00 and $5.99, close to 18% mention they would pay between $6.00 and $7.99. It is clear that respondents are willing to pay the least possible amount this service.

Most users mention that valet parking service will not represent a major difference in terms of their current usage of the airport's parking facilities.

However, opinions are quite different in terms of the competitive advantage this service represents. The majority of the sample under study agrees with the introduction of this service placing the Winnipeg Airport's parking services ahead of the competition.

In summary, several aforementioned services represent a potential opportunity for the airport to improve its image and offerings, but others clearly do not seem to make any difference. The construction of a covered parking facility is what makes the greatest difference for all respondents. However, a small number of people are against the construction of a covered lot for fear of a dramatic increase in parking fares.

Comparing the Winnipeg Airport's parking services with its main competitor

Most airports have a natural monopoly in its parking services. However, recently there has been an increase in the development of independent parking service outside the airport area, operating with a shuttle going back and forth to the airport terminal. This service represents a competitor for the airport, therefore driving business activities towards a more market-oriented approach and customer-driven decision making.

The Winnipeg Airports Authority has a strong parking competitor located outside the airport: Air Park. Respondents who have had the opportunity to use both services were asked to rate them on the following parking lot attributes: Security, manoeuvrability inside the lot, walking distance to terminal, price (long-term), and overall service. It is important to find how the Winnipeg Airport's parking services are rated with respect to Air Park. Such information will aid in determining the potential strengths of the airport, as well as areas of opportunity.

Security: In terms of security, research findings show that Air Park is perceived as a safer parking lot than the Winnipeg Airport by a significant difference. This is an improvement area for the airport, and one of the major causes of this discrepancy in perceived security against the airport is the totally outdoor environment in which its facilities are.

Maneuverability: The Winnipeg Airport is perceived as having better facilities than Air Park in terms of the manoeuvrability users have inside the parking lot. The difference between both services is fairly small. However, this difference exists and is in favor of the airport.

Walking distance: It is clear that the Winnipeg Airport has a significant advantage with respect to its competitor in terms of walking distance to the airport. Being closer to the terminal, the Winnipeg Airport has a better location than its parking competitors. It is possible to say that Air Park is satisfying a demand that is composed by customers demanding an extra in parking services,

an added value for their money. If the Airport Authority satisfies this group of customers, certainly the existence of parking facilities outside the airport will be threatened.

Long-term parking: The airport's long-term parking prices are rated better than Air Park's. In fact, the airport's long-term prices are better than the competitors'. This is an important advantage in favor of the airport, since research findings show that Winnipeg Airport's parking users are very price sensitive. In order to take advantage of this issue, it is necessary to promote this price difference in favor of the airport as much as possible.

Overall service: Even though the parking services offered by the airport are rated better than Air Park services in manoeuvrability inside the lot, walking distance to terminal, and price, Air Park appears to be perceived as having a better overall service than the Winnipeg Airport. 32.95% of respondents who have used both parking facilities consider Air Park's overall service better than the airport's, compared to 24.53% of respondents doing so for the airport. It is clear that customers who have used both services feel Air Park has served them better.

In summary, the greatest disadvantage of the airport's long-term parking lot came to be its perceived lack of parking security with respect to Air Park. Given the high degree of support towards the construction of a covered parking lot, it is predicted that the availability of such facility will make users shift in favor of the Winnipeg Airport. The implementation of services that provide some kind of competitive advantage to the airport (free parking on weekends, decrease in price, greater security, and valet parking) will make a difference on perceived overall service ratings given to the airport in the future.

Ancillary parking services offered at different Canadian airports

Several airports across Canada offer services that the Winnipeg Airport is pursuing to implement. Services under study are short and long-term parking facilities conditions (covered or uncovered), short-term, daily, weekly, and monthly parking prices, valet parking services, additional car services, and parking promotions. The airports studied are those located in the cities of Calgary, Edmonton, Halifax, Montréal, and Ottawa.

Results of the study are summarized in the following table:

SERVICES / CITIES	Short-term	Long-term	Short-term price	Daily price	Weekly price
Calgary	covered	uncovered	$1.25 per ½ hr, up to $10 p/day	$10	$70
Edmonton	covered	uncovered	$1 per ½ hr, up to $10 p/day	$7	first two wks $30, additional wks $15
Halifax	uncovered	uncovered	$1.35 per hr, up to $7.50 p/day	$7.50	$32.10
Montréal	covered	uncovered	$1 per 10 min, up to $15 p/day	$9.50	$45
Ottawa	uncovered	uncovered	$2 per ½ hr, up to $10 p/day	$10	$47
Winnipeg (currently)	uncovered	uncovered	$.25 per 10 min	$7	$35

Table 1- Comparison of parking services offered by different Canadian airports.

SERVICES / CITIES	Monthly price	Valet parking	Additional services	Parking promotions
Calgary	$280	$20 1st day, $13 additiona l day	oil change, car wash, engine tune-ups, muffler changes, windshield repair	$2 flat fee from 5:30 p.m. to 12:00 a.m.
Edmonton	$90	$9		discount coupons, AMA[1] 10% off, CAA[2] 10% off
Halifax	$128.40			
Montréal	$180	$9		
Ottawa	$188		battery boost (free)	first 4th day free
Winnipeg (currently)	$140		battery boost (free)	free parking on Saturday morning

Table 1 (cont'd)- Comparison of parking services offered by different Canadian airports.

[1] Alberta Motor Association.
[2] Canadian Automobile Association.

A comparison of the studied airports with the Winnipeg Airport is made in the former table. Relevant points for the objectives of the Winnipeg Airports Authority are discussed next.

Valet Parking in Calgary is charged together with the parking price. Valet parking service can be charged like the Calgary Airport does, instead of charging individually for it. In addition to valet parking service, the Calgary Airport offers five different car services: Oil change, car wash, engine tune-ups, muffler changes, and windshield repair. There are important points to understand the way these services operate in Calgary, as well as to analyze their applicability at the Winnipeg Airport:

- The airport offers these additional services only for those users of valet parking services.
- All additional services offered by the Calgary Airport Authority are charged on top of the parking price, which includes the valet parking cost as well as the long-term parking rate.
- The Calgary Airport Authority opened a tender for different car businesses to offer their services at the airport. One of these businesses won the tender, and is satisfying the airport's demand for car services in addition to its own demand. This is the most cost-effective way of providing car services, in terms of the investment-free in facilities in which the Calgary Airport offers them. A customer's vehicle that requires any of the offered car services is driven to the place in which the independent contractor has its operations.
- There is an average demand for valet parking service of 80 cars per day, of which one-third gets all car services available. In brief, both the Calgary Airport Authority and the independent contractor are getting good profits out of this agreement. This can be the way in which car services can be introduced at the Winnipeg Airport.
- In terms of advantages the availability of these services have, they make the Calgary Airport look like a first class institution. In addition, these services help building a relationship with the customer and improve users' perception of the airport. As for disadvantages, the Calgary Airport Authority mentions there are no disadvantages associated with these services.

As for parking promotions in Calgary, The Calgary Airport Authority decided to implement a $2 flat fee for those times in which the airport has the least amount of people, 5:30 p.m. to 12:00 a.m. The Winnipeg Airport can implement a similar promotion adapted to its own rush and slow periods during the day.

Valet Parking in Edmonton and Montréal costs $9, and is charged on top of the parking price. Current demand at the Edmonton Airport is on average 7 cars per day (the service is three months old, as of August 17, 1998), and the

Montréal Airport has on average 75 valet parking customers per day. Airports offering this service have good demand, therefore it is profitable.

The weekly parking price in Edmonton offers the first two weeks of parking for $30 each and any additional week for $15. The objective of this parking promotion is to encourage people use the weekly long-term parking at the airport, something that can be used as a model to be applied in Winnipeg.

The Edmonton Airport Authority offers discount coupons available on a temporary basis, as well as a 10% discount to the Alberta Motor Association and the Canadian Automobile Association.

Short-term parking price in Montréal is $1 per 10 minutes, up to $15 per day. The daily long-term price is $9.50. If planning to stay at the airport longer than 1 hour and 40 minutes, it is better to use the long-term daily price than the short-term rate.

The Ottawa Airport Authority has the following promotion: The first 4th day is free. For example, it is possible to park for four days and pay $30, or five days paying $40. Beyond five days, it is better to use the weekly parking rate of $47.

Several of these parking services and promotions can be implemented in Winnipeg as they work in airports that already offer them, or can be modified to adapt them to the needs and facilities of the Winnipeg Airport.

Recommendations for the Winnipeg Airports Authority

Having studied the existing support for a covered parking lot, the degree of acceptance of several parking services that are likely to be implemented at the Winnipeg Airport, as well as the competitive advantage they provide, it is possible now to outline several recommendations for the Winnipeg Airport. These suggestions will assist the airport to get a better assessment of its current services and facilities, and therefore make more focused decisions.

1. *If financially feasible, build a covered parking lot:* A covered parking facility will improve the airport's image and will provide users with a facility that is highly supported by users and needed in Winnipeg. In terms of how much to charge on a daily, weekly, and monthly basis, the following are the suggested rate ranges to charge for long-term parking. The suggested rates are compared with the current rates of the Winnipeg Airport and with Air Park's rates.

Parking time	Current rates, Winnipeg Airport (uncovered lot)	Air Park rates (only daily parking offers a covered lot)	Suggested rates Winnipeg Airport (covered lot)
Daily	$7.00	$11.00	**$7-$9**
Weekly	$35.00	$38.20	**$40-$45**
Monthly	$140.00	$152.80	**$160-$180**

For daily parking, Air Park rate is more expensive than the highest rate suggested to the airport. It is expected that the availability of a covered parking lot at the Winnipeg Airport will attract several Air Park customers who use daily parking. For weekly and monthly parking, the suggested rates for the airport seem to be higher than Air Park's. The difference is that the airport is offering a covered lot, representing better protection for vehicles and overall better service. It is clear that the construction of this facility is expensive. However, the degree of support for it is very high, and therefore the airport will be in good conditions to financially recover.

2. *Introduce valet parking service, if feasible between $6 and $8:* This service has to be supported by a strong marketing campaign. In the long run many people will be willing to use this service if available. Valet parking represents an advantage over the competitors. As for price to charge for valet parking, a rate between $6 and $8 will be reasonable. The studied Canadian airports that offer this service agree with its positive performance and profitability.
3. *Respondents appear unaware of free parking on weekend morning, Publicize or extend it:* Very few people are aware of the availability of free parking on weekend morning at the Winnipeg Airport. It is important to publicize this service and, if financially feasible, extend it for a longer period of time during the weekend. This parking feature will certainly make customers start or increase their usage of the airport's parking service. As well, free parking on weekends gives the Winnipeg Airport a strong competitive advantage over Air Park. It will be difficult for the airport to introduce this feature while building a covered parking lot or soon after its completion. Hence, the airport will have to find the degree to which the adoption of this service is feasible.
4. *Introduce/publicize greater amount of security at the airport's parking facilities:* When comparing the Winnipeg Airport's long-term parking service and Air Park, security came out to be the most outstanding feature. Air Park is perceived as having better security than the Winnipeg Airport. This lack of security at the Winnipeg Airport is more a perception issue than a true lack of security. The best course of action is to make the available security as visible as possible, using signs or all kinds of promotional material. If the airport in fact considers it does not have enough security, it is important to get more personnel and equipment, and therefore improve users' perceptions of the parking facilities at the airport.
5. *Analyze the possibility of providing car services with an independent contractor:* The best way for the Winnipeg Airport to offer car services such as oil change, car wash, and tire service, is through a business fully dedicated to this activity and sharing profits with it on a percentage basis.

This is the way in which Canadian airports that offer these services operate. It is possible to introduce car services for a testing period of time. If these services are profitable, the airport can decide to carry on offering them. If the services are not successful, the airport can stop offering them without having invested a significant amount of money. This is the best approach to deal with the opportunity to make profits by providing car services at the parking facilities of an airport.

6. *Introduce more parking promotions at the Winnipeg Airport:* It is important to have more marketing activity at the Winnipeg Airport. Promotions improve the image of the airport and make parking rates more attractive to the user. The following are some examples that can be implemented in Winnipeg, as well as in any other airport that is working towards the modernization and improvement of its parking services:
   a) Discount hours: $2 flat fee from 7:00 p.m. to 10:00 p.m.
   b) Weekly rates offer: First two weeks $50, additional weeks $40.
   c) Daily rates offer: First 5th day free
   $1.50 per half-hour, up to $9 per day

   Airports should not limit its marketing activities to parking services. Instead, it is convenient to introduce marketing promotions in every possible area airport management involves.
7. *Promote free battery boost service:* This service represents a great aid in situations in which battery problems arise in wintertime in Winnipeg. The free availability of this service improves the airport's image. It is important to promote free battery boost service (since most users do not know its existence) and hence let users know what benefits are available for them at the airport at no cost.

Conclusion

After conducting research on parking facilities issues at the Winnipeg Airport, several opportunities, strengths, and areas of improvement that have been identified will aid the airport authority in improving the satisfaction of its parking customers. The Airport Authority is now able to make a more focused assessment of its parking service and facilities, and therefore make the best possible decisions.

There is a significant amount of information in this study that can help improve parking facilities and services at different airports, with the objective of providing a better service to their users.

Recognition of Public Objectives in the US bus industry as a response to ISTEA

J. Nolan[1], P.C. Ritchie[2] and J.E. Rowcroft[3]

[1]University of Saskatchewan, [2,3]University of New Brunswick

Section 1: Introduction

In 1991 the United States Intermodal Surface Transportation Act (ISTEA) was enacted. The Act delineated public objectives as a rationale for continued government funding and intervention. This paper examines the extent to which bus companies appear to comply with the ISTEA requirements and whether differences in compliance can be used to explain variations in technical (operating) efficiency between different companies or regions.

There are numerous organizations throughout the world sponsored, or run, by government, to provide goods and services to the public. The rationale for these organizations is that without government intervention provision of these goods and services would not meet the social objectives of the public. Numerous studies have examined the efficiency with which these organizations function, that is, the efficiency of the conversion of inputs to outputs. For example, Puigy-Junoy [1998], Bates [1997] and DeBorger and Kerstens [1996].

Although there is a rich field of theoretical research regarding public goods, social welfare and government intervention [see Cornes and Sandler, 1986, for a comprehensive discussion] empirical efficiency studies tend not to address the underlying question of how efficiently the social objectives are being met. One of the major problems in testing for efficiency in this sphere is the lack of clearly enunciated public policy objectives.

While the question of how efficiently publicly funded organizations operate is extremely important, if they are not meeting the objectives intended, then their efficiency is spurious. Therefore, it is crucial to determine their effectiveness in meeting the social objective function.

The overall purpose of this paper is to begin to develop a method for evaluating the efficiency of public organizations in meeting social objectives. The United States busing industry has been chosen as the basis of this study due to the

satisfaction of two major information requirements: clearly stated social objectives from the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) and comprehensive operating data available on-line from the U.S. Department of Transportation.

In Section 2, ISTEA 1991 is examined to infer social objectives and related operational variables which may be extracted, or deduced, from the Act. In Section 3, a two step data envelopment analysis (DEA) model is developed to examine overall efficiency in the U.S. bus industry. Step one of the model is a pure technical efficiency test; step two of the model takes the efficiency measure from step one as in input to a second analysis of each firm's efficiency in meeting the social objective function defined by ISTEA. Section 4 provides details of the data used in the study. The period of study is 1990-1995, thereby covering the immediate pre-ISTEA era, allowing for external shocks on efficiency as a result of ISTEA, and stabilization thereafter. Results are presented in Section 5 and Section 6 provides some concluding comments.

Section 2: ISTEA

The information in this section is drawn from two sources Gifford, *et al* [1994] and the Transit Fact Book [1993].

ISTEA was a redefinition of the structure of transport funding and regulation in the U.S. Its stated overall objective was to increase national productivity through the efficient movement of goods and people, thereby reducing the time and cost of production and hence increasing overall productivity. As with most public policy statements, the overall stated objective is comprehensive and cannot be used directly to operationalize an empirical test. Three contingent social objectives are provided: to develop a transportation system which (i) is low polluting, (ii) is safe, and (iii) provides necessary public services.

Further, more operational, breakdowns of these objectives are provided in the act (no ranking is implied through the ordering below):

-reduction of energy consumption
-reduction of air pollution
-rational development: with high capacity access available
-enhanced mobility: ensuring access by those who cannot, or will not, drive and in case of public emergency
-expansion of the consumer base
-reduced congestion
-job creation

Although the above list is still extremely general, appropriate data collection would allow study of the change in these areas over time, which in turn would allow testing of how effective the regulations now governing transport provision in the U.S. are in meeting the stated social objectives of the U.S. Government.

In general, public provision of transportation services is through government subsidy to cover a portion of carrier costs. Hence another objective which must be considered (although not stated in the Act) is the financial sustainability of the operators.

Section 3: Social Objectives Efficiency

Much of the efficiency measurement literature is concerned with the issue of measurement and less with explanations of why particular decision-making units (DMU's) are better or worse than others at input/output transformation. If every aspect of the firm's decision-making process could be incorporated into an empirical model of efficiency measurement, these measures would be complete in the sense that the scores would represent absolute (full information) efficiency.

Even without knowledge of the objective function of the DMU's, DEA can be used to investigate relative efficiency. DEA relies on the assumption that the common objective of public firms is technical efficiency. However this is still only one of several potential objectives possessed by a public sector firm. Other goals may influence the operations of a given firm. What appears to be inefficiency in a public firm may be an alternate allocation of resources compared with other firms in the sample, an allocation driven by different objectives.

In this paper, through a two-step DEA process, a modification of standard radial efficiency analysis is proposed, which identifies two major components of inefficiency; i) that part actually due to inefficient production, and ii) that part due to differences in complying with the social objective function between those firms on the efficient frontier and those not on the frontier.

The first step in this model is evaluating the technical efficiency of each firm via a standard form of DEA. The efficiency measure for each firm is then the input variable to the second DEA. This step evaluates how efficiently each firm uses its remaining resources to meet the social objective function.

The two step DEA model is intended to examine how effectively the ISTEA social objectives are being met by the regulated firms. These firms are subsidised rather than fully funded. Hence, in order to continue operations, they

must be viable at the technical level. Once the firm has met these technical needs, they are then able to expend resources toward meeting social objectives.

Thus, step one of the model is a purely physical measure of efficiency, applying the usual production inputs and outputs. The efficiency measure resulting from this analysis, indicates what resources remain available to apply toward other objectives, of which social objectives may play a role. In step two the efficiency measure from step one is the only input to the DEA – it indicates the full resources available to meet the remaining objectives. The outputs at this stage are the social objectives. In this case the objectives that we are able to capture given data availability are:

Non-diesel fuel: each firm's movement away from diesel fuel into other types is tracked. Since diesel is the most polluting of the various fuels, a movement toward other sources indicates a commitment toward the reduction of air pollution.

Labour: at the technical efficiency level, labour is an input to minimize in the analysis. From a social objective perspective, increasing employment is a positive benefit. Thus, one of the social objectives measurable is increased employment in the industry.

Safety incidents: a change in the number of accidents or other safety events reported measures the movement toward the social objective of increased safety in the industry. Since the safety measure requires minimisation, the inversion approach of Fare, et al [1989] is used to incorporate this measure in the same function as the above two.

Route miles: from a social objective perspective, increasing the number of route miles is a positive benefit to the public. Thus, one of the social objectives measurable is increased route miles.

The output from the second step DEA suggests the relative extent to which the different firms divert resources from private technical efficiency to meeting the social objective function. That is, the relative impact the ISTEA regulations have in the four areas to which the data apply.

Section 4: Data

The data for this study were drawn from the FTA on-line data base, for the years 1990-1995, thereby capturing a period both pre and post ISTEA. To prevent bias introduced by size, only mid-size carriers from across the country were chosen for this study. Only firms with complete data sets were retained for this study. Thus the following firms composed the study set:

West Coast	Mid-West	South East	East Coast
Olympia-IT	Canton-RTA Proline	Savannah-CAT	Providence-RIPTA
Santa Cruz-METRO	Toledo-TARTA	Ft.Lauderdale - BCT	Hartford-CT Transit
Santa Barbara-MTD	NW IN-Gary-GPTC	West Palm-CoTran	New Haven-CT Transit
Monterey-MST	Champaign-Urbana-MTD	Tampa-Hartline	Wilmington-DART
	Little Rock-CAT		Raleigh-CAT
	Dallas-DART/ATE		Charlotte-CTS

For the step one DEA (the technical efficiency model) annual data were collected for three input variables: total fuel consumption, number of vehicles in fleet, and total labour; and for two output variables: total vehicle revenue miles, and total vehicle miles. The step one efficiency measure is the input to the second DEA, with non-diesel fuel, labour, safety incidents and route miles as the output variables representing pollution, employment and public service objectives.

Total labour and total vehicle miles appear in both models. The firm has conflicting objectives with respect to labour. For technical efficiency, the firm should minimise the amount of labour being used, however increased employment is one of the social objectives for which the subsidies are supplied to transit. Thus, a technically efficient firm may ignore the employment objective, or may use resources to maintain technical efficiency while attempting to achieve the social objectives, whereas a technically inefficient firm be applying resources to fulfilling social objectives. Hence, labour appears as a variable in both models, as a minimised input for technical efficiency and a maximised output for social objective efficiency.

Firms require an expanding consumer base in order to continue growth – which normally leads to expanding profit. The regulatory agency sees route expansion as helping to decrease overall congestion, pollution and energy consumption while at the same time helping to expand access and mobility of residents. The joint product nature of this variable means that it appears as a maximised output for both steps of the DEA.

Section 5: Results

Both stages of the DEA were run with and without the assumption of constant returns to scale. Since appreciable economies of scale appeared to be present in each model variable returns were assumed for technical and social efficiency. The final analysis also used a cumulative data set to increase the size of the reference set. On the assumption that a method which was feasible in the past remains available in the future, the performance of each firm was compared with performance of all firms in the current and preceding years. Thus 1992 data are compared with data for the three-year period, 1990-1992, 1993 data with the four years 1990-1993, and so on.

A summary of the results from both DEA steps is provided in Table 1 and illustrated in Figures 1-4. Also included is a simple cost measure, passenger miles per dollar. The variability of this measure compared with the DEA results emphasises the problems of relying on a single, price-sensitive quantity as a measure of efficiency. While a number of the firms are technically efficient, few appear to place consistent emphasis on the social objective efficiencies. In general the larger firms seem to be somewhat more "socially efficient".

Subsequent to ISTEA 1991, few firms show an increase in social objective efficiency suggesting that generally the provisions of the Act were either anticipated or ignored (or both). A related source of difficulty may be the appropriateness of the fleet size for two different sets of objectives. Economies of scale may be captured in a DEA framework by comparing the efficiency under the assumption of constant returns to scale (in which all firms enter all comparison sets) and under variable returns to scale (in which a firm is compared only with units of a similar size). The ratio of the two scores (VRS/CRS) is shown in Figure 5 for the technical and social efficiencies. A score of 1 indicates a firm operating at optimum size, whereas a lower score indicates inefficiency due to sub-optimal size. For clarity only one year's data is shown since all years are similar. Notably the ratios track each other closely except at the extremes suggesting that fleet sizes of 90-150 experience significant diseconomies of size, technically and socially.

The cross country consistency of these results, and the apparent lack of consistent exogenous change in the environment, may be the result of a recognition on the part of these firms that the regulatory body has made little headway in finding ways to evaluate the efficiency of these firms in meeting social objectives.

Section 6: Conclusion

The results of the step two DEA should be considered with caution. The variables used in this step are imperfect proxies for the underlying social objectives. Furthermore, only a very limited examination of the ISTEA objectives has been possible due to data limitations. For regulation to be evaluated effectively the objectives must not only be defined in such a way that they can be tested, the information must also be collected to allow such evaluation.

The lack of clearly identified social objectives together with the lack of relevant data collection underscores the importance of building appropriate accountability measures and collection procedures into public policies.

References

Bates, J. M. (1997). "Measuring predetermined socio-economic 'inputs' when assessing the efficiency of educational output", *Applied Economics*, vol. 29:1, pp. 85-93.

Cornes, R. and T. Sandler (1986), *The Theory of externalities, public goods, and club goods*. Cambridge University Press.

DeBoger, B. and K. Kerstens (1996), "Cost efficiency of Belgian local governments", *Regional Science & Urban Economics*, vol. 26:2, pp. 145-170.

Fare, R., S. Grosskopf, C.A.K. Lovell and C. Pasurka (1989), "Multilateral productivity comparisons when some outputs are undesirable: A nonparametric approach", *The Review of Economics and Statistics*, pp. 90-98.

Gifford, J.L., W.J. Mallett, and S.W. Talkington (1994). "Implementing intermodal surface transportation efficiency act of 1991: Issues and early field data", *Transportation Research Record* vol. 1466, pp. 14-22.

Puig-Junoy, J. (1998), "Measuring health production performance in the OECD", *Applied Economics Letters*, vol. 51:4, pp. 255-259.

Transit Fact Book 1993 (1993), American Public Transit Association: Washington, D.C.

U.S. Department of Transportation, *FTA on-line*.

Table 1: First and Seond Stage DEA Scores

Company/state/1990 size	1990	1991	1992	1993	1994	1995	
Olympia-IT	1.43	1.43	1.43	1.10	1.19	1.16	pax mile/$
WA	1.00	1.00	0.90	1.00	0.88	1.00	technical
40	1.00	1.00	1.00	0.98	1.00	1.00	policy
Santa Cruz-METRO	1.67	2.00	2.00	1.51	1.61	1.70	pax mile/$
CA	1.00	1.00	1.00	1.00	1.00	0.91	technical
75	0.52	0.52	0.44	0.51	0.43	0.43	policy
Santa Barbara-MTD	2.50	2.50	2.50	2.84	2.54	2.34	pax mile/$
CA	1.00	1.00	1.00	1.00	1.00	0.94	technical
53	0.49	0.39	0.37	0.26	0.27	0.25	policy
Monterey-MST	2.50	2.50	2.00	2.10	2.00	2.12	pax mile/$
CA	1.00	1.00	1.00	1.00	1.00	1.00	technical
40	0.36	0.35	0.33	0.34	0.32	0.33	policy
Canton-RTA Proline	1.11	1.00	1.00	0.90	0.96	0.87	pax mile/$
OH	1.00	0.95	1.00	0.95	1.00	1.00	technical
32	0.71	0.70	1.00	0.67	0.50	1.00	policy
Toledo-TARTA	1.67	1.67	1.67	1.60	1.43	1.40	pax mile/$
OH	1.00	0.97	0.96	0.95	0.95	0.93	technical
179	0.69	0.68	0.63	0.68	0.63	0.67	policy
NW IN Gary-GPTC	1.25	1.11	0.71	0.82	0.75	0.73	pax mile/$
IN	1.00	0.91	1.00	0.91	1.00	0.94	technical
30	0.25	0.23	0.20	0.21	0.17	0.21	policy
Champaign-Urbana-MTD	2.50	3.33	3.33	2.90	3.23	2.87	pax mile/$
IL	0.89	0.85	0.89	0.85	0.89	0.83	technical
50	0.24	0.22	0.25	0.21	0.22	0.24	policy
Little Rock-CAT	2.00	2.50	2.00	2.03	1.89	1.65	pax mile/$
AR	1.00	1.00	1.00	1.00	0.99	1.00	technical
48	0.29	0.28	0.26	0.26	0.26	0.27	policy
Dallas DARTE/ATE	2.50	3.33	2.50	3.20	3.16	2.19	pax mile/$
TX	1.00	0.98	1.00	0.97	1.00	1.00	technical
213	0.92	0.88	0.80	0.84	0.79	1.00	policy

Table 1 continued: First and Second Stage DEA Scores

Company/state/1990 size	1990	1991	1992	1993	1994	1995	
Savannah-CAT	3.33	2.50	2.50	2.13	2.06	1.69	pax mile/$
GA	0.88	0.86	0.91	0.86	0.91	0.93	technical
48	0.31	0.29	0.29	0.27	0.26	0.26	policy
Ft. Lauderdale-BCT	2.50	2.00	2.50	2.59	2.63	2.66	pax mile/$
FL	1.00	1.00	1.00	1.00	1.00	1.00	technical
159	1.00	1.00	1.00	1.00	1.00	0.89	policy
West Palm-CoTran	2.00	2.00	2.00	1.91	1.72	1.64	pax mile/$
FL	1.00	1.00	1.00	1.00	1.00	0.97	technical
61	0.32	0.31	1.00	0.30	0.50	0.37	policy
Tampa-Hartline	2.50	2.00	1.67	1.99	1.91	1.90	pax mile/$
FL	1.00	1.00	0.91	1.00	0.91	0.90	technical
140	1.00	1.00	1.00	1.00	1.00	0.99	policy
Providence-RIPTA	2.50	2.50	2.00	2.02	1.91	1.71	pax mile/$
RI	1.00	0.98	1.00	0.98	1.00	1.00	technical
187	0.82	0.82	0.83	0.82	0.81	0.70	policy
Hartford-CT Transit	2.50	2.50	2.50	1.99	2.05	2.04	pax mile/$
CT	0.86	0.83	0.85	0.83	0.85	0.85	technical
193	0.95	0.94	0.90	0.94	0.90	0.96	policy
New Haven-CT Transit	2.00	1.67	1.67	1.39	1.43	1.63	pax mile/$
CT	0.82	0.80	0.82	0.79	0.82	0.81	technical
85	0.40	0.39	0.39	0.37	0.35	0.38	policy
Wilmington-DART	2.00	1.67	1.67	1.39	1.43	1.63	pax mile/$
DE	0.82	0.80	0.82	0.79	0.82	0.81	technical
87	0.40	0.39	0.39	0.37	0.35	0.38	policy
Raleigh-CAT	1.43	3.33	3.33	3.32	3.03	2.81	pax mile/$
NC	1.00	0.92	0.95	0.92	0.95	0.93	technical
43	1.00	0.84	0.43	0.48	0.41	0.24	policy
Charlotte-CTS	3.33	2.50	2.50	2.64	2.89	2.53	pax mile/$
NC	0.85	0.82	0.83	0.82	0.82	0.76	technical
133	0.53	0.52	0.52	0.51	0.51	0.56	policy

Figure 1: West Coast Efficiencies

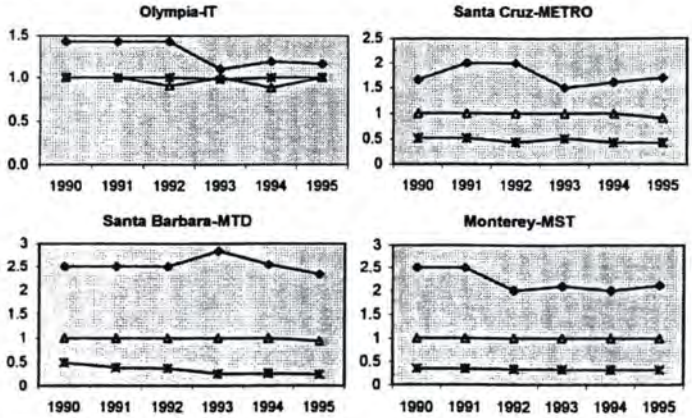


Figure 2: South-Eastern Efficiencies

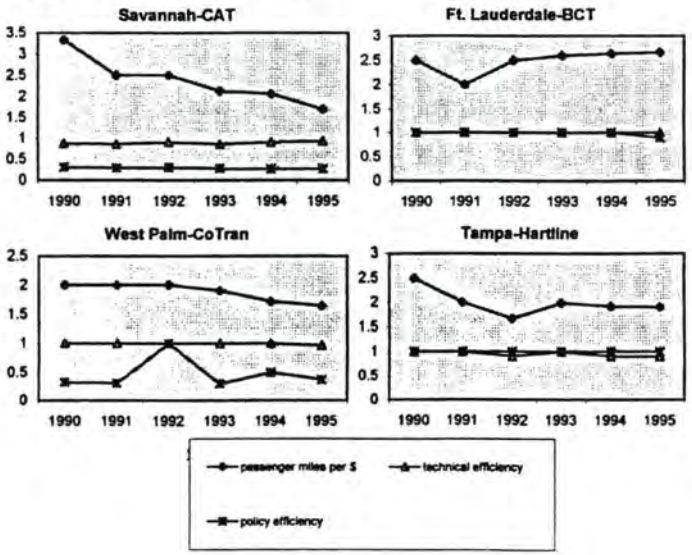


Figure 3: Mid-West Efficiencies

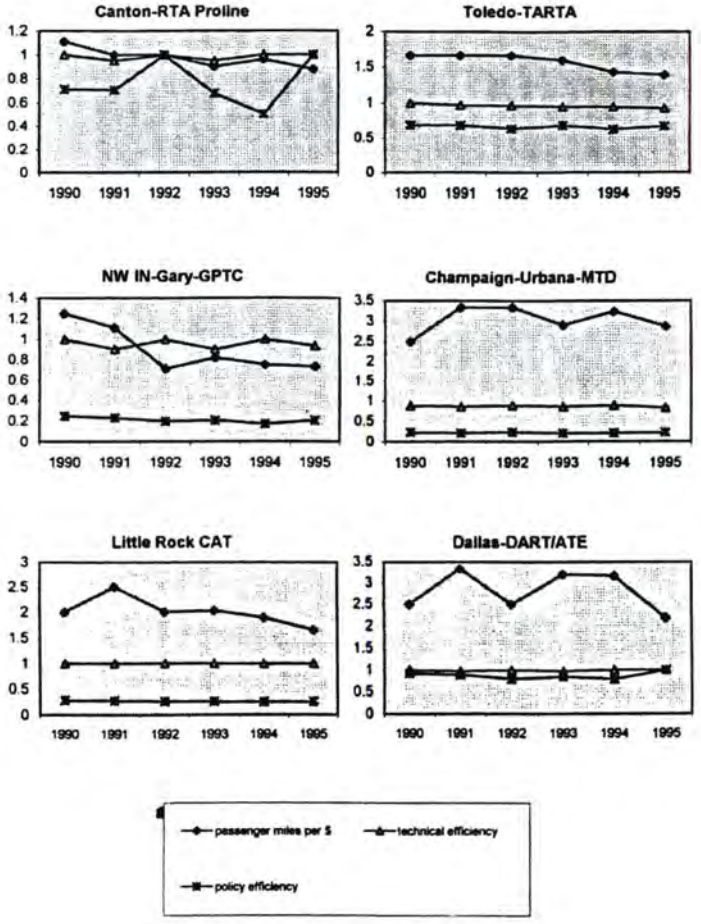


Figure 4: East Coast Efficiencies

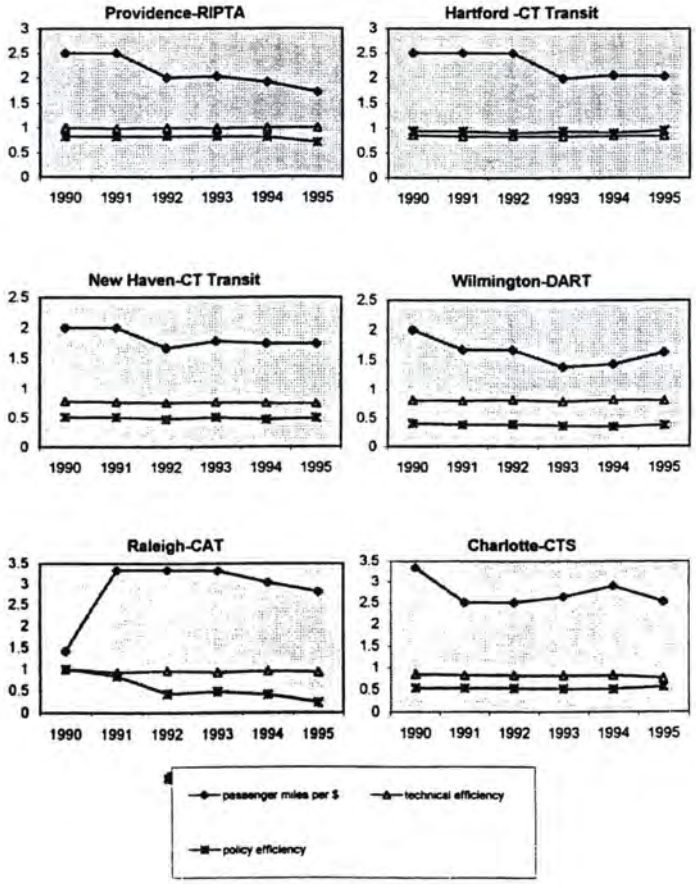


Figure 5: optimal fleet sizes

INFRASTRUCTURE BANKS: INNOVATIVE FINANCING FOR TAPPED-OUT TRANSPORT BUDGETS

Michael A. Crockatt – Research Affiliate
Dr. Barry E. Prentice – Director
Transport Institute, University of Manitoba

Introduction

With limited public funding for programs of all types, maximum value must be realized for each dollar of government spending. This is especially true for transportation infrastructure, which is extremely expensive to fund.[1] Traditionally, Canadian governments have paid for transportation infrastructure through direct payments of unallocated general funds. This has provided governments with flexibility to pursue its policies, but in the case of transport, the federal government must now return to transport more of what it takes. The National Highway System alone requires $17 billion in investment (Infrastructure Council of Manitoba, 1999), while municipal infrastructure requires $44 billion in investment to reach an "acceptable condition" (Strategic Infrastructure Reinvestment Policy, 1998, p. 15).[2]

Some Canadian transportation projects have been funded through innovative financing means. Toronto's suburban Electronic Toll Route 407 is an example of a public/private partnership that works in a congested urban area. Similarly, there are toll sections of the Trans-Canada Highway in Nova Scotia and New Brunswick and on the Coquihalla Highway in British Columbia.[3] However, toll highways only work in areas of high demand. Many of Canada's infrastructure needs have insufficient utilization to support tolls (Apogee/Hagler Bailly, 1998).

---

[1] Transportation infrastructure is also lumpy, meaning that it must be built in large portions. A road that goes halfway to its destination is no better than having no road at all.

[2] The infrastructure deficit is widening. In 1985, the Federation of Canadian Municipalities estimated Canada's infrastructure gap to be $12 million (Strategic Infrastructure Reinvestment Policy, 1998).

[3] In Nova Scotia, truck traffic is mandated to use the toll highway rather than secondary routes where tolls could be avoided.

Canadians must search for more innovative financing strategies to lever public financing.

The U.S. appears to have appreciated the need to reinvest in transportation much earlier than Canada. In 1993 for example, total public spending on US highways and bridges was $40 billion. The United States Department of Transportation (USDOT) estimated that an additional $16 billion was required annually to maintain – not improve – the condition of American highways at that level (Chafee et al, 1996). The Texas Department of Transportation (TxDOT) estimated that it could only meet 40% of its annual needs with traditional financing methods. Non-traditional methods of financing transportation infrastructure became necessary by 1993.

Canadian infrastructure needs have not been less than in the United States, but federal initiatives in Canada have focused mainly on transportation deregulation and privatization. As pressure is growing in Canada to fund infrastructure renewal, we should examine innovative financing models.

The State Infrastructure Bank Program

In 1995, the Federal Highway Administration (FHWA) – a branch of USDOT – created a pilot program through which ten states would be allowed to establish State Infrastructure Banks (SIBs). Since that time, the SIB program has experienced three different stages. The original SIB pilot program consisted of ten states and is referred to as SIB 95. More states joined the program in 1996. This expansion phase is referred to as SIB 96. Federal funding for SIB 95 and SIB 96 was discontinued in 1998, and a new pilot program – SIB 98 – was established.

State revolving funds and bond bank models were the precedents for State Infrastructure Banks. Like private banks, SIBs required initial capital to get started. Each state was permitted to place into its SIB up to 10 percent of its federal-aid highway appropriations *and* up to 10 percent of its federal transit funds for two years (fiscal years 1996 and 1997). These federal grants provided the "seed money" for the initial capitalization of the SIBs

The FHWA defines a SIB in two ways:[4]

- "an infrastructure investment fund established to facilitate and encourage investment in eligible transportation infrastructure projects sponsored by the public and/or private entities"

[4] These definitions are from the FHWA web site: www.fhwa.dot.gov.

- "an investment fund at the State or regional (multi-state) level with the ability to make loans and provide other forms of credit assistance to public and private entities to carry out highway construction and transit capital projects".[5]

State Infrastructure Bank funds can be used to provide low-interest loans or credit enhancements.

Loans can further be broken down into four sub-categories.

- *Subordinate loans* are made to finance other project debt, thereby allowing that project to obtain less expensive financing on its other debt.
- *Short term construction loans* help with cash flow during construction phases.
- *Interest only loans* can be provided during construction and in the initial years after construction while the project begins to earn money.
- *Low interest loans* can be made to help finance projects that could not otherwise obtain funding.

Credit enhancement, through which SIBs provide third party guarantees for external project loans, can be divided into five categories.

- *Letter of credit or loan guarantees* for project loans commit the SIB to make debt service payments if a project defaults on payments to investors. Financing costs are lower because bonds covered by a SIB receive the SIB's rating instead of the project's.
- *Lines of credit* can be extended to cover construction cost overruns or revenue shortfalls.
- SIBs can fund a debt service *reserve fund* for a project. The SIB must replenish the fund if it is drawn upon.
- *State-aid intercept* can reduce project financing risk. In some states the SIB can intercept state transportation aid to a specific project and redirect it to pay bondholders. Each state may decide whether to give its SIB this ability.
- SIBs can be given the authority to *pool debt issues*. Aggregating small debt issues into one large debt issue through the SIB enhances credit quality and lowers interest rates.

By leveraging their capital the SIBs can extend the total capital available to infrastructure projects. A SIB is leveraged when its total potential liabilities exceed its liquid assets. The amount of assistance can be levered through two methods:

---

[5] Although the SIB program authorized the creation of regional or multi-state SIBs, only single-state SIBs have been formed to date.

- by issuing debt on its own behalf (as in the precedent set by state bond banks); and
- by guaranteeing or otherwise assuming liability for others' debts in an amount greater than the SIB's own cash.

Leveraging has been found (through experience with the EPA's SRFs) to substantially increase the funds available for lending (Chafee et al, 1996). At the outset of SIB 95, each dollar of SIB assistance was expected to generate nearly five dollars in project investment from non-federal sources. The traditional ratio of federal-aid projects was 1¼:1.

A SIB can issue debt on its existing assets in combination with anticipated project revenues. This is most logical when demand for SIB assistance is greater than the available amount of cash. In this case, a SIB would pay interest on the bonds it issues but would lend out bond proceeds to individual projects (Chafee et al, 1996). Under the second leveraging method, a SIB could assume liability for others' debts in excess of its own cash by providing credit enhancement rather than loans. Not all SIBs exercise the option to leverage funds.

The innovative financing benefit of SIBs is that the funds are recycled for new loans. As first-round projects pay back loans, these receipts can finance other projects. SIBs allow states to provide more funding to more projects. Some of the money is used only as credit enhancement and not as direct funding. Often, projects that would have been put off for years can be moved forward with the assistance of a SIB. The FHWA states that SIBs were designed to fund projects that fill a particular niche:

- "locally and regionally significant projects that have access to dedicated revenue streams, but need flexible financial assistance to clear hurdles that would otherwise obstruct or delay their construction".

Federal funding is more effectively employed through the SIB program. Each state has scope to encourage investment in transportation infrastructure where its resources can be used most effectively.

Each project must be able to repay the loan received from the SIB through a dedicated revenue source associated with the project. This revenue source can be direct tolls for the use of the infrastructure, shadow tolls, fees from commercial rest stops, or taxation revenue resulting from improved economic circumstances due to the new infrastructure.

Some problems arose in terms of the creation of SIBs. No new federal funding was devoted to SIB 95. Money placed in a state's SIB still would have been allocated to that state for transportation projects.[6] New York declined to participate in the SIB pilot program because all available federal and state funds had been fully committed to planned projects leaving none available to capitalize a SIB.[7] Other states had concerns that they would not be able to fund enough projects with dedicated revenue streams for repayment to make the SIB program worthwhile. Chafee et al (1996) provides the following list of factors that diminished states' interest in the SIB program:

- no new funds to capitalize a SIB;
- not enough projects with potential revenue;
- legal/constitutional problems;
- state legislative approval doubtful;
- public and/or legislative opposition to debt financing;
- insufficient state of knowledge of SIBs; and
- lack of state expertise to start a SIB.

These problems are important to note because similar barriers may exist when establishing SIBs in Canada.

By November 30, 1998, SIBs across the United States had received $456 million in federal funding and had signed loan agreements for 54 projects (www.fhwa.dot.gov, January 26, 1999). Overall, SIBs offer and fulfill the promise of helping to close the gap between transportation needs and available resources.

The Current State of Canadian Transport Infrastructure

Canadian transportation infrastructure may not be in crisis condition, but important parts of Canada's transportation infrastructure network require drastic improvement. Some examples are the network of rural roads serving Western Canada, sections of the Trans-Canada Highway (e.g. Northern Ontario), and most urban centres. A modified version of the SIB program could help improve the status of Canadian transportation infrastructure.

The Canadian federal government does not invest as much in transportation infrastructure – especially highway and transit infrastructure – as its American

[6] Some states decided not to pursue the idea of SIBs because all federal and state transportation funding for FY 1996 and 1997 had already been allocated to projects. This is discussed in a later section of this paper.

[7] Some states circumvented this problem by bringing projects that already had financing planned under the SIB program for funding.

counterpart. However, the Canadian federal government's relationship with the provinces is similar to the USDOT's relationship with the states. According to Canada's Constitution, the responsibility for highways is assigned to the provinces under the class of "Local Works and Undertakings" (Hicks, 1996). The federal government is involved in highway infrastructure through four major activities:

- financial contributions to the provinces and territories for highway construction;
- ownership of federal highway and bridge facilities (on native reserves, on federal properties, and in the National Capital area);
- regulation of international crossings; and
- other related highway services such as research and development, and safety.

The main form of interaction between the federal government and the provinces – as it is between the USDOT and the states – is federal grants to the provinces for highway construction and upgrading. There are, however, three main differences between the US system and the Canadian system.

First, in Canada, federal highway contributions follow the National Highway Policy (NHP) of 1974. This program focuses resources toward highway projects with regional economic development implications.[8] Transportation funding in the United States is based on a multitude of factors including land area, postal route mileage, rural population and urban population (Apogee/ Hagler Bailly, 1998).

Second, when Canadian highway infrastructure projects are cost-shared between the federal and provincial governments, the split in funding is approximately equal. For example, under the Canada-Manitoba Infrastructure Works Program, projects are cost-shared equally by the federal government, provincial government and local partners. In the United States, the states' portion of funding is only required to be 20 per cent compared with an 80 per cent share for the federal government.

Canadian transportation infrastructure has some examples of innovative financing, such as Confederation Bridge linking Prince Edward Island with New

[8] For example, for FY 1995/96 to FY 2002/03, the Atlantic Provinces of Newfoundland, Nova Scotia and New Brunswick – despite their smaller sizes and populations – will each receive more federal funding for highways than either Quebec or Ontario. Prince Edward Island, Canada's smallest province, will receive more funding than any province west of Ontario (Hicks, 1996).

Brunswick. Few transportation projects in Canada have dedicated revenue streams. The SIB concept may enhance innovative financing efforts in Canada.

Third, the Government of Canada does not force its provinces to follow federal labour and environmental laws. The Davis-Bacon Act, originally enacted in 1931, requires that every labourer working on a federally funded project has to be paid no less than the locally prevailing wage for similar projects (www2.dol.gov, December 1, 1998).[9] Any first-round projects funded by SIB 95 and SIB 96 had to follow federal Davis-Bacon Act regulations. The second-round projects, funded with repayments from local sources, were no longer subject to the Davis-Bacon Act, but only to the more lenient state guidelines. Many considered second-round projects – and any subsequent funding under SIBs – still to be using federal money. Therefore, each project funded by a SIB – no matter which "round" funds it – should be subject to the federal Davis-Bacon Act rules.

The National Environmental Policy Act (NEPA), established in 1969, also affects all projects funded by federal money. NEPA ensures that the federal government considers "environmental factors through systemic interdisciplinary approach before committing to a course of action" (www.fhwa.gov). Generally, the NEPA environmental guidelines for federally funded projects in the United States are stricter than state regulations. If a project has met federal environmental standards, it has also met state guidelines in most cases.[10] In fact, NEPA (ceq.eh.doe.gov/nepa/regs/40/20-29.HTM, December 1, 1998) refers to state environmental regulations "little NEPA" laws that can be included in a NEPA Environmental Impact Study. Like the Davis-Bacon Act, second-round projects of SIBs (under the SIB 95 and SIB 96 programs) were no longer subject to the NEPA guidelines, but only the state regulations. The argument was made that *all* projects funded by SIBs should be subject to NEPA rules because the majority of the money originally came from the federal government.

---

[9] The actual wording of the Act reads that "every contract over $2000 to which the United States or the District of Columbia is a party of the construction, alteration, and/or repair of public buildings or public works ... shall contain a provision stating the minimum wages to be paid to various classes of laborers and mechanics" employed under the contract (www2.dol.gov, December 1, 1998).

[10] John Overman, an environmental specialist with the Texas Transportation Institute, points out that some states have specific regulations that federal rules do not cover. For instance, the state of Texas has its own endangered species list that differs from the federal endangered species list. Therefore, a project may meet all the federal regulations, but it may affect the habitat of one of Texas' endangered species that does not appear on the federal list.

Table III shows the funding transportation by the federal government of Canada. The most notable figures are the grand total and the percentage of total federal expenditures: both have decreased considerably between 1991 and 1998. Table IV shows that provincial government expenditures on transportation have also been decreasing.

Table III – FEDERAL GOVERNMENT GROSS EXPENDITURES ON TRANSPORTATION IN CANADA ($ Millions)

	92/93	93/94	94/95	95/96	96/97	97/98
Transport Canada	2,894	3,096	2,977	3,448	2,501	2,422
Other[11]	1,108	1,033	1,050	1,046	791	679
Total	**4,092**	**4,129**	**4,027**	**4,494**	**3,292**	**3,101**
Total transport expenditures as a percent of total federal expenditures						
	2.5	**2.4**	**2.4**	**2.8**	**2.0**	**1.9**

Source: Transport Canada, 1997.

Table IV – PROVINCIAL GOVERNMENT EXPENDITURES ON TRANSPORTATION ($ Millions)

	92/93	93/94	94/95	95/96	96/97
Air	99.3	90.0	89.3	105.0	102.7
Water	142.5	126.0	131.4	100.5	92.5
Rail	15.5	21.8	19.3	26.7	10.8
Highways	5885.0	5801.8	6079.1	6214.2	5787.8
Transit	1212.8	1214.7	1308.0	1286.9	1275.3
Multimodal	207.6	208.0	196.3	198.9	164.6
Gross Trans. Expenditures	**7562.7**	**7462.4**	**7823.4**	**7932.1**	**7433.7**
Less federal transfers	126.1	232.6	265.3	329.1	264.8
Net Trans. Expenditures	**7436.6**	**7229.8**	**7558.1**	**7603.0**	**7168.8**
% of Prov. Expenditures	4.9	4.8	4.9	4.8	4.7

Source: Transport Canada, 1997.

Canadian Infrastructure Banks

If adapted for implementation in Canada, SIBs have four functions that could help define potential projects. SIBs can:

[11] Includes Canadian Transportation Agency, Transportation Safety Board, Aviation Safety Board, Civil Aviation Tribunal, and transportation expenditures by other federal departments.

- serve as an alternative to pay-as-you-go financing;
- replace higher interest debt;
- improve sponsors' access to external debt financing; and
- reduce interest rate for external debt financing (fhinter.fhwa.dot.gov, August 22, 1997).

A recent Transport Canada report indicated that funding for highways in Manitoba should be directed toward bridge and pavement rehabilitation (Blanchard 1996). While the infrastructure bank concept may be applicable for some rehabilitation projects, the focus is generally on construction projects.

An infrastructure bank program for Canada has the potential to be a tremendous economic engine. A Canadian version of SIBs could produce benefits by attracting additional investment, reducing project cost, and accelerating projects (fhinter.fhwa.dot.gov, August 22, 1997). Funding from the federal government's infrastructure program could be redirected toward a Provincial Infrastructure Bank (PIB)[12] to be used for infrastructure investment in the provinces and territories. A PIB program would also fit the NHP by enhancing regional economic development through improved transportation infrastructure in problem regions.

Case I: Highways and Agricultural Truck Routes

An infrastructure bank could immediately target segments of extra-provincial and intraprovincial highways. Grade separations would improve traffic flows and increase average speeds – thus improving efficiency along these routes. Where cross traffic would be eliminated, farm-oriented and other resource vehicles would be redirected from a controlled-access highway to frontage roads or other routes in order to ensure safety. Converting the key links of the Trans Canada Highway to freeway status would help strengthen the traditional east-west Canadian trade corridor. Similarly, maintaining the quality of intraprovincial feeder routes will support regional growth.

The discontinuation of railway branch lines in Western Canada is creating an acute infrastructure problem in rural areas. Most rural roads are not engineered to withstand the loads posed by large tractor trailers. In addition to larger grain trucks, the increase of value-added processing and livestock feeding is leading to

[12] The term Provincial Infrastructure Bank will be assumed to include possible Territorial Infrastructure Banks as well. However, the likelihood of the territories establishing infrastructure banks is smaller than it is for the provinces. It is very unlikely that the territories could identify projects with sufficient revenue streams to repay loans received from such a bank.

further truck traffic. The cost of improving all gravel roads to the required standard is neither supportable nor necessary. The PIB could be used to upgrade "federal" grain routes where new facilities could be zoned to locate.

The provision of federal funds to support rural roads is recommended by the Honourable Willard Estey (1998).

> It is recommended that the federal and provincial governments collaborate to apply some part of the considerable fuel tax collections to the construction, maintenance and repair of the municipal grid roads and secondary provincial highways (being those highways in the grain-producing lands which are not built to Trans-Canada Highway standards) in the three prairie provinces where those roads and highways are an integral part of the roads from farm to market.
>
> Recommendation 11

If the federal and provincial governments matched funds in a PIB, rural municipalities could borrow to build federal grain truck routes, and pay back, say 20% of these funds.

Case II: Airport Development

Airport infrastructure is another good candidate for infrastructure bank investment. Assume that an air cargo operator wishes to expand its service by bringing in larger aircraft. Its current facility at the airport can not handle the increased amount of freight and apron space is insufficient for the larger aircraft. Expanding this service provides more jobs or at least more hours for existing jobs. It also increases agglomeration advantages for other air cargo operators, which increases their profitability and efficiency. With assistance from a PIB, the local airport authority could provide these facilities to avoid the risk of losing this carrier's business. PIB funding could be justified because the entire regional economy benefits from this investment. The airport could take advantage of lower interest rates and possibly deferred repayment until the project begins to earn money. Ultimately, the airport would receive rents from the carrier to liquidate the capital investment debt.

Staying with airport infrastructure, business parks adjacent to airports have become economic growth poles. In order to attract major firms to undeveloped areas, modern infrastructure is necessary.[13] The PIB could provide a loan to the

[13] Again, infrastructure is a prerequisite for economic development. It will not directly result in development, but without infrastructure, no economic development will occur.

municipal government to extend water, sewer and electrical services and adequate roadways to the area of the proposed business park. The provision of infrastructure, combined with abatements or incentives, and proper marketing, the Airport Business Park could reach the critical mass necessary to achieve agglomeration advantages and become a real magnet for firms to relocate to community.

Case III: Multi-User Intermodal Facilities

Consolidated intermodal container facilities are another transportation venture that could be an ideal project for PIB assistance. If funding were made available to a third-party containerport operator, the railways may be more open to the idea of sharing operations at a common facility. A combined container terminal would provide numerous advantages and efficiencies for the railways and local shippers.

Case IV: Marine Infrastructure

Marine infrastructure in Canada also needs a new credit facility to finance their growth. A port may be adequate for dealing with large volumes of freight but lacks the infrastructure to compete on costs. Alternatively, some ports (Prince Rupert, Churchill, Thunder Bay) have no intermodal container facilities, while others like Halifax need major investments to accommodate the Post-Panamax container ships. As the Canadian government is devolving its responsibility for port investments, more must be done to assist port authorities to finance opportunities. This does not mean that careful benefit-cost analysis is ignored. Only projects that can demonstrate long-term viability deserve to be financed.

Conclusion

As long as there is a way to repay the money borrowed from the PIB, many projects could be good candidates for investment. Highways may need to collect tolls, or if the government wishes to keep highways free, shadow tolls may be used. An airport authority can used its increased revenue from improved and expanded service to repay the loan it would receive from the PIB. Similarly, the operator of a common container facility could use its revenues to repay its loan and the port authority could use its revenue from improved service to pay the PIB.

Infrastructure banks are one of many potential innovative financing methods for use in Canada. All possible programs for improving transport infrastructure should be considered with the costs and benefits of each weighed carefully. One thing is certain: doing nothing is ***not*** an option. The state of transport

infrastructure funding must be addressed in Canada and a solution must be sought.

The level of federal funding would have to be substantial for an infrastructure bank program to be implemented in Canada.[14] Some changes to Canadian law are likely necessary to facilitate the creation of SIBs in Canada. This is an area that requires further study. The authors have not investigated what changes are necessary, and leave this to the experts in the civil service where this new possibility lies.

Although the American SIB program financed mostly local government projects as opposed to larger projects,[15] Canada may be better served by investing in projects that could improve overall provincial or regional economies. While many small and medium-sized communities in Canada could benefit from infrastructure bank programs, it is questionable as to whether or not some projects would be able to repay the funds borrowed from the PIB.

[14] One report states that the amount of federal funding should be comparable to the current level of support for the national infrastructure program – at least $2 billion (Apogee/Hagler Bailly, 1998).

[15] However, TEA-21 did not ignore projects of larger significance. The *Transportation Infrastructure Finance and Innovation Act* (TIFIA) provides Federal credit assistance to major transportation investments of critical national importance, such as intermodal facilities, border crossing infrastructure, expansion of multi-State highway trade corridors, and other investments with regional and national benefits. For more information, see the TIFIA Fact Sheet at www.fhwa.dot.gov/tea21/factsheets/tifia.htm.

References

Apogee/Hagler Bailly. *New Mechanisms for Funding Highways: Prepared for Transport Canada.* Ottawa: 1998.

Blanchard, Ghislain. *Highway Benefit-Cost Analysis: A Review of Evidence.* Ottawa: Transport Canada, 1996.

Chafee, The Honorable John H. *Safe Drinking Water Act: Progress and Future Challenges in Implementing the 1996 Amendments.* Washington: United States General Accounting Office, 1999.

Chafee, The Honorable John H., The Honorable Max S. Baucus, The Honorable John W. Warner. *State Infrastructure Banks: A Mechanism to Expand Federal Transportation Funding.* Washington: United States General Accounting Office, 1996.

Council on Environmental Quality, United States Department of Energy. ceq.eh.doe.gov

Czerwinski, Stanley J. *Clean Water Act: Use of State Revolving Funds Varies – Testimony Before the Committee on Appropriations, Subcommittee on VA, HUD, and Independent Agencies, House of Representatives.* Washington: United States General Accounting Office, 1996.

D'Amato, The Honorable Alfonse, The Honorable Edward M. Kennedy, The Honorable Jeff Bingaman, The Honorable Martin T. Meehan, The Honorable Christopher Shays, The Honorable Bob Franks. *Economic Development Activities: Overview of Eight Federal Programs – Report to Congressional Requesters.* Washington: United States General Accounting Office, 1997.

Estey, Willard Z. *Grain Handling and Transportation Review: Final Report, Submitted to the Honourable David Collenette, Minister of Transport.* December, 1998.

Federal Highway Administration, United States Department of Transportation. www.fhwa.gov, www.fhwa.dot.gov, fhinter.fhwa.dot.gov

Hicks, Brian. *A Historical Look at the Federal Government's Involvement in Highway Infrastructure.* Ottawa: Transport Canada, 1996.

Infrastructure Council of Manitoba. *Canada's Physical Health Ignored Again*. Winnipeg: Press Release, February 17, 1999.

Overman, John. Personal Communication, September 1998 to December 1998 (several occasions).

Strategic Infrastructure Reinvestment Policy. *Strategic Infrastructure Reinvestment Policy: Report and Recommendations*. Winnipeg: 1998.

Transport Canada. *Annual Report 1997*. Ottawa: Transport Canada, 1997.

United States Department of Labor. www.dol.gov, www2.dol.gov

United States Department of Transportation. *State Infrastructure Banks: A Primer*. Washington: United States Department of Transportation, 1995.

United States Department of Transportation. www.dot.gov

Weatherby, Cynthia. Personal Communication, September 1998 to February 1999 (several occasions).

THE LOGISTICS AND ECONOMICS OF MANITOBA'S MARINE CONTAINER TRAFFIC

Jake Kosior[1] and Linda Christian[2]

Introduction

The *Manitoba International Overseas Shippers Survey (MIOSS)* was undertaken to ascertain the characteristics of Manitoba's marine container traffic and corresponding supply chain impediments. The MIOSS database incorporates statistical information with interviews from over 2,000 shippers that conduct international commerce. While Manitoba's marine container traffic has increased significantly, exports through Vancouver have grown disproportionately in relation to imports. The growth in Manitoba's container exports to Asia has exacerbated an already significant import/export imbalance, impacting the logistics of container transport from the province.

Especially problematic for shippers and carriers is the "shortage" of marine containers. Referring to the problem of container repositioning, one analyst of international container traffic observes that, "the biggest cargo moved in containers today is...fresh air."[3] For Manitoba shippers, obtaining the right containers at the right time at cost competitive rates is a primary issue. The time sensitivity and seasonality of products impact the freight rate/competitive structure of the major corridor routes regularly used by shippers. The cost of relocating containers from ports to Manitoba, particularly specialty ones, forces Manitoba shippers to use alternative methods that may not be the optimal choice. These problems expose the need for improved management of existing services.

Manitoba Import/Export Container Traffic Volume by Commodities

Figure 1 illustrates the projected growth of imports from 1992 to 2000. Manitoba's import container traffic is growing steadily. The province imported 6,000 TEUs in 1992 and should exceed 10,000 TEUs by the year 2000, a growth

---

1 Senior Reseach Associate, The Transport Institute, University of Manitoba.

2 Research Affiliate, The Transport Institute, University of Manitoba.

3 "Tackling container imbalance problems," *World Cargo News*, March 1997, pp 24-25.

rate of 67 percent. General goods (hardware, small parts, etc.) represents the largest proportion of imports at 56 percent, with a projected growth rate of 113 percent by the year 2000. The garment trade consists of 20 percent of imports, followed by vehicle parts at 13 percent, consumer goods at 10 percent and chemicals at 1 percent. Despite economic uncertainties in world markets, Manitoba's aerospace, transit and commercial bus, agricultural implement and garment manufacturers appear to be prospering. In addition, Manitoba is home to several retail chain outlets that utilize a single centralized warehouse strategy for national distribution. These chains source merchandise from suppliers all over the globe. A single warehouse strategy minimizes the total cost by balancing inbound to outbound logistics in terms of distance and cost.

Figure 1: Manitoba Containerized Imports 1992 - 2000

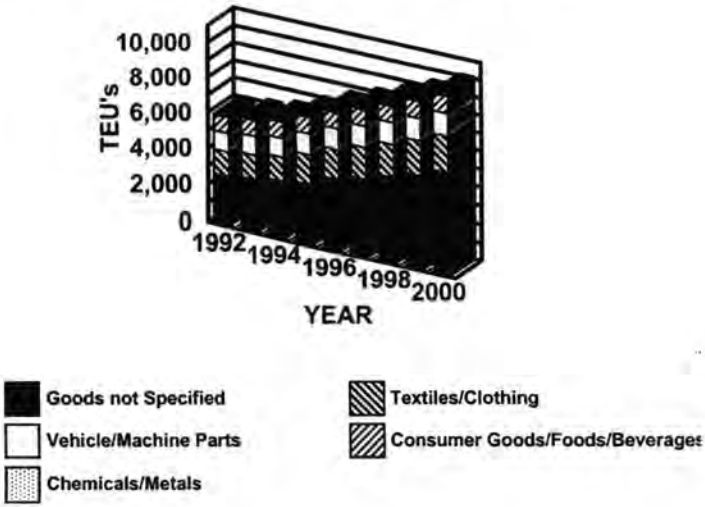
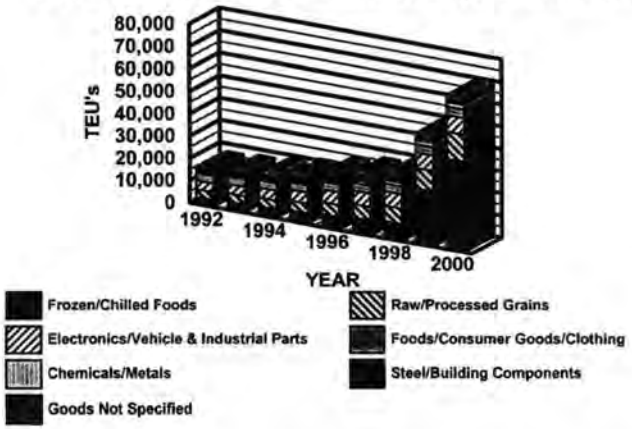


Figure 2 provides data on Manitoba's containerized exports from 1992 to 2000. The explosion of Manitoba's export traffic is primarily due to value added food processing, namely pork and french fries. Manitoba has the dubious honor of becoming the hog capital of Canada and is rivaling Prince Edward Island for potato production. Exports that previously left the province as bulk grains prior to 1995 are now leaving in reefer containers. Seeded acreage was once devoted to wheat

Figure 2: Manitoba Containerized Exports 1992 - 2000



and other coarse grains has dropped by 20 percent in favor of pulses, special crops, feed peas, and forages. These commodities will require diversified equipment from forty foot refrigerated units to twenty foot dry containers. For example, Brandon's Maple Leaf Plant will increase exports of chilled and frozen pork by 58.8 percent of the current total provincial container TEU output (an absolute growth rate of 510 percent in under three years). Semi processed "agri" products are anticipated to grow by 210 percent, followed by containerized grains, pulses and special crops at 52.1 percent. In addition, manufacturers of consumer goods and agricultural components are anticipating an additional 12.5 percent growth by the year 2000.

The characteristics of Manitoba's containerized imports and exports necessitates different equipment, leading to problems balancing container flows. Manitoba imports are primarily manufactured goods shipped to the province in 40 foot

containers while exports involve mostly grain, semi-processed agricultural goods and agriculture based manufactured products that are, for the most part, best shipped in 20 foot containers. The resulting "equipment" imbalance adds significantly to the cost of transporting goods from the province. For example, a Manitoba shipper who receives a 20 foot container from Vancouver incurs a repositioning charge of approximately $495. The cost is about $950 for a 40 footer. However, container carriers often waive the "repo" charges for very large shippers and freight forwarders with significant volumes. This is a privilege not enjoyed by smaller shippers. The repositioning of containers through supply channels is so frequent, that roughly 20 percent of all moves can be described as such. The global cost for such moves is estimated to be close to US $2.5 billion per year.[4]

Equipment imbalances are exacerbated by the discrepancy between Manitoba import and export volumes. Exports drastically exceed imports. Manitoba's IMPEX[5] ratio was approximately 1:3 until 1998. The IMPEX ratio is anticipated to rise to 1:6 by the end of 2000. Predictions of an unprecedented rise in value added processing were fulfilled when Manitoba received an investment of $ 750 million in the post-WGTA[6] era.[7] The Maple Leaf hog plant in Brandon scheduled to open in late 1999 will add 2,000 jobs to the Manitoba economy. The majority of the new traffic will be pork and french fries moved in 40 foot "reefers" with the anticipated rise in pulses and specialty crops exports moved in 20 foot containers. In certain instances, ocean carriers are provide incentives for select shippers to move 40 foot containers back to port position with product that normally would move in 20 footers. Shippers usually take this option when it is provided to them. This tactic is utilized by ocean carriers to expedite the cycle time for 40 footers that is used for premium freight.

The "shortage" of marine containers is a problem that occurs throughout supply chains but its greatest impact is felt in inland regions. Ocean carriers prefer not to send containers inland. When containers are not supplied for source loading at a cost competitive rate, alternate channels are selected. The choices for shippers

---

4 *Ibid.*

5 Imports to exports ratio.

6 *Western Grain Transportation Act.*

7 Barry Prentice, Jake Kosior and Bob McLeod, *Agriculture Trucking in Manitoba*, University of Manitoba Transport Institute Research Bulletin No.16, September 1996.

includes domestic container, various trailer chassis, hopper car and pool car. The loads are moved by either rail or truck and transloaded to marine container at dockside.[8] Shippers prefer to either source load marine containers for export or stuff them at facilities in Manitoba because transloading at port carries the risk of damage and might involve the added cost and delay of reinspection. In addition, if the freight sits, there can be additional storage costs. Container "shortages", short time frames and the lack of stuffing facilities in the province mean that goods from Manitoba tend to be shipped to port by whatever mode is available rather than by "one-stop" source loading. While alternative channels mitigate problems in getting goods to dockside, they are poor sisters compared to the preferred option of source loading. Better and more stuffing facilities, customs inspection services and more equitable and reliable container allocation would reduce handling.

Manitoba shippers' inability to secure the right containers at the right time is already impeding economic growth. For example, a Manitoba agricultural and farm implements manufacturer uses high-cube and open containers for a product that must be source loaded. This necessitates advanced production and shipping commitments that prevent the company from participating in "spot" markets. Similarly a Winnipeg manufacturer exporting 'residential goods' to Asia, Eastern Europe and the Oceania Region, reports that he sells in a globally competitive market. The goods are shipped in specialty 'high top' containers that, in addition to being difficult to obtain, are priced at a premium. The growth of the business depends on acquiring the right equipment at a competitive price. The shipper stated that if the containers were available at a price that enabled him to compete, his international sales would double.

The Seasonality of Container Traffic and Equipment Balancing

Table 1 shows how the seasonality of Manitoba's container traffic aggravates the equipment balancing problem. The majority of 20 foot containers are required in the "post harvest" season from late September to early November when 38.2 percent of crops are shipped. The seasonal spikes for 40 foot containers occur in spring and early fall when Manitoba's garment promotes its spring/fall clothing lines. A less pronounced spike occurs in mid-November when merchandise arrives for the Christmas season. An exception to the rule is when Manitoba malt producers provide product for the beer industry during summer months. In general, there is a lull in activity in January and February. This economic cycling is not unique to Manitoba and demonstrates the additional difficulties in equipment

8 See Mike Butt and Jill Ogston, *Manitoba's Marine Container Traffic: Trends and Developments in the 1990s*, 1999 CTRF Annual Conference Proceedings.

provision by carriers for shippers.

Table 1: Manitoba 1997 Import/Export Container Traffic Seasonal Movements				
Source Loaded Marine Container Movements by Quarter (in TEU's)				
Traffic Direction	**Annual Quarter**			
	1st	**2nd**	**3rd**	**4th**
40 ft. Import	781	708	742	739
40 ft. Export	1,890	1,899	1,895	1,917
20 ft. Import	211	211	218	208
20 ft. Export	775	676	676	1,249
All Traffic-All Modes by Quarter (in TEU's)				
Imports	2,324	1,858	1,985	1,890
Exports	5,201	5,788	5,101	6,423
Import Movements by Quarter by Commodity (in percent)				
Commodity				
Frozen/chilled Foods	25.0	25	25	25
Consumer Goods	24.4	25.6	25.6	24.4
Vehicle/Aircraft Parts	25.0	25.0	25.0	25
Chemicals/Metals	25.0	25.0	25.0	25
Textiles/Clothing	27.2	22.8	29.5	20.5
Foods/Beverages	26.1	26.1	26.1	21.7
Industrial Parts	25	25.0	25.0	25
Goods not Specified	25	25.2	24.9	24.9
Export Movements by Quarter by Commodity (in percent)				
Commodity				
Grain	22.5	18.8	20.5	38.2
Processed Grains	20.1	29.9	29.9	20.1
Frozen/chilled Foods	25.0	25.0	25.0	25
Consumer Goods	14.7	14.7	14.7	55.8
Electronics	25.0	25.0	25.0	25
Vehicle/Aircraft Parts	22.4	26.1	26.1	25.4

Chemicals/Metals	25.0	25.0	25.0	25
Steel/Pre-fab Homes	26.5	24.5	24.5	24.5
Textiles/Clothing	25.0	25.0	25.0	25
Foods/Beverages	25.0	25.0	25.0	25
Industrial Parts	25.0	25.0	25.0	25
Goods not Specified	24.6	24.9	24.9	25.6

Transport Cost Impacts by Commodity Group

In the *MIOSS* survey, Manitoba exporters were asked two questions: 1) What proportion of the selling price of the product was freight costs, 2) If freight rates were reduced by 10 to 30 percent, what would be the expected increase in export sales? The results are presented in Table 2. Not surprising was the high percentage of freight cost to total cost of the product for raw and semi-processed grains at 31 and 28 percent respectively. Both these categories also showed a wide standard deviation. Pulses and special crops can vary from $300 to over $1,200 per tonne, depending upon the commodity. These two categories have highly elastic responses to freight rate reductions. At a rate reduction of 30 percent, traders felt that in some cases they could *double* their international sales.

Frozen/Chilled foods, Consumer goods, Steel/Pre-fab homes, and raw textiles were the next tier of freight with a freight cost to total cost of the product ranging from 17 to 22 percent. Products in these categories demonstrated a lower elastic response to freight rate reductions, but nonetheless exports could increase with lower rates.

The last group of freight such as electronics, vehicle and aircraft parts, chemicals/metals and industrial parts have a low proportion of freight cost to the total cost of the product. In most cases it was below 6 percent. These goods were price inelastic, and service dominated the concerns of these shippers. A freight rate reduction would not necessarily increase sales.

While transport costs as a proportion of the total cost vary with each commodity, the high demand elasticities of Manitoba exports indicates that lowering transport costs could lead to significant increases in demand for Manitoba products. The price elasticities of Manitoba's primary export commodities indicates that Manitoba's export potential depends not only on the reduction of transport costs, but the realization by ocean carriers of the opportunity to reduce empty miles

between regional markets by incorporating Manitoba in a global network strategy.

Table 2: Manitoba Containerized Export Traffic - Transport Costs and Freight Rate Elasticities as Percent of Selling Price

			Freight Reduction	
Commodity		**Transport Costs**	**10%**	**30 %**
Grain	Average	30.9%	10.0%	37.7%
	Std. Dev.	22.5%	9.9%	28.9%
Processed Grains	Average	28%	11.0%	31.5%
	Std. Dev.	15.7%	6.8%	9.4%
Frozen/Chilled Foods	Average	20.4%	1.8%	11.9%
	Std. Dev.	12.1%	1.9%	7.4%
Consumer Goods	Average	17.3%	5.9%	25.9%
	Std. Dev.	14.5%	8.5%	27.7%
Electronics	Average	6%	4.0%	12.0%
	Std. Dev.	2.9%	4.3%	13.0%
Vehicle/Aircraft Parts	Average	8.8%	0.7%	3.1%
	Std. Dev.	8%	2.5%	4.7%
Chemicals/Metals	Average	4.0%	n/a	n/a
	Std. Dev.	3.1%	n/a	n/a
Steel/Pre-fab Homes	Average	20.8%	1.3%	15.0%
	Std. Dev.	8.2%	2.2%	3.5%
Textiles/Clothing	Average	22.4%	8.0%	21.5%
	Std. Dev.	17.6%	9.3%	17.6%
Foods/Beverages	Average	n/a	n/a	n/a
	Std. Dev.	n/a	n/a	n/a
Industrial Parts	Average	6.5%	n/a	n/a
	Std. Dev.	1.7%	n/a	n/a
Goods Not Specified	Average	15.6%	2.1%	9.6%
	Std. Dev.	13.8%	2.0%	8.4%

Service Rates by Corridors

Table 3 provides rates for the various Canadian corridors used by Manitoba importers and exporters. The tariff rates shown are discounted according to

Table 3: Winnipeg Import/Export Blended Inland Transport Tariff Rates Via Canadian Ports (FAK dry freight, non-perishable, non-hazardous goods)

Rates Expressed are SUS	Vancouver		Montreal		Halifax	
	Import	Export	Import	Export	Import	Export
Truckload 48 ft. Tandem Trailer	$1,320	$1,828	$1,434	$1,637	N/A	N/A
Truckload 53 ft. Tridem Trailer	$1,496	$2,003	$1,567	$1,805	N/A	N/A
20 ft. Marine Container on Truck Chassis	$1,342	$1,641	$1,306	$1,753	N/A	N/A
40 ft. Marine Container on Truck Chassis	$1,417	$1,828	$1,399	$1,716	N/A	N/A
20 ft. Marine Container on Flatcar	$997	$895	$965	$965	$1,212	$1,212
40 ft. Marine Container on Flatcar	$1,379	$1,320	$1,602	$1,602	$2,008	$2,008
Domestic Container on Flatcar	$1,175	$1,645	$833	$1,473	N/A	N/A
Trailer on Flat Car	$1,190	$1,210	$850	$1,480	$1,900	$2,012
Hopper Car*	N/A	N/A	N/A	$3,003	N/A	N/A
Boxcar	N/A	$2,689	N/A	N/A	N/A	N/A

Note: The Halifax rail rate is the CN tariff rate as CP does not quote this lane. Rail rates include a $60 and $82 terminal charge for 20 ft. And 40 ft. Containers respectively. All rates are terminal to terminal and do not include local drayage charges. *Hopper car is food grade quality and the rate is for non-CWB commodity at commercial rates.

shippers' volumes, freight characteristics and equipment needs.[9] Inland rates

9 Carriers and freight forwarders enter into confidential contracts with shippers that are wholly dependent upon the dynamics of trade patterns and shippers product characteristics, volume and equipment requirements.

reflect the nature of freight volume by corridor and direction, but are subject to change as trade patterns shift.

The least cost modes in the Montreal to Winnipeg import lane are Domestic Container on Flatcar (DOFC), Trailer on Flat Car (TOFC) and 20 foot Marine Container on Flatcar (MOFC2) rates. Tariff rates are less than $1,000 for each of the three modes. 20 Foot Marine Container on Truck Chassis (MOTC2) and 40 foot Marine Container on Truck Chassis (MOTC4) are more expensive at $1,300-$1,400, followed by truckload at $1,434 and $1,567 for 48 and 53 foot trailers. 40 foot Marine Container on Flatcar (MOFC4) was the highest at $1,602. For exports, the rates were generally higher by $200-$600 for each mode. MOFC2 and MOFC4 were identical for both directions.

The premium on east bound freight from Manitoba results from the imbalance of export movements over import shipments. In the Vancouver to Winnipeg import lane, rates were higher than for Montreal by $100-$200 except for MOFC2, MOFC4 and truckload 48 and 53 foot trailers. The lower truck rates reflect the backhaul status of truck moves from Vancouver to Manitoba.[10]

Traffic Time Sensitivities and Inland Modes of Transport

"Time sensitivity" of a product is dictated by a combination of the perishability of the product or the value of time to the customer. Products such as chilled meats and fresh foods do not have a long shelf life. Buyers of certain industrial or retail goods may place a high value on expedited transport service because of volatile markets, or are operating under Just-In-Time (JIT) inventory practices and desire to keep pipeline inventories to a minimum. Manitoba importers and exporters are no exception. Table 4 shows the time sensitive nature of Manitoba's import/export container traffic by commodity category, time sensitivity and traffic volume comparisons for 1996 to 2000.

As expected Manitoba's exports of chilled pork, french fries are highly perishable products. The clothing industry places a high value on time since demand for fashion is often fleeting. When a particular item is "hot", air transport is used for high demand markets. In general, these products will move in 40 foot containers mostly by road, but approximately 30 percent by rail. They also move by truckload and are transloaded at port when 40 footers are in short supply. A noteworthy

10 Jake Kosior and Barry Prentice, *International Container Traffic of Manitoba: Volumes, Gateways and Modes*, University of Manitoba Transport Institute, April, 1997.

observation is time sensitive traffic will grow by 473 percent from 1996 to 2000, This single category of traffic will be greater than the entire provincial TEU throughput in 1996.

Table 4: Manitoba Import/Export Container Traffic
Time Sensitivities by Commodity and Volumes (% of Traffic)

Commodity	Unknown	Time Sensitive	Non-Time Sensitive	Customer Dependent	
Grains			100.0%		
Processed Grains		2.6%	97.4%		
Frozen/Chilled Foods		100.0%			
Consumer Goods		13.8%	10.5%	75.8%	
Electronics			100.0%		
Vehicle/aircraft parts		5.5%	69.1%	25.5%	
Chemicals/Metals		0.9%	26.1%	73.0%	
Steel/Pre-fab Homes			18.3%	81.7%	
Textiles/Clothing		75.4%	22.7%	1.9%	
Foods/Beverages		37.9%	62.1%		
Industrial Parts		4.1%	95.9%		
Goods Not Specified	1.1%	1.4%	30.6%	66.9%	
Time Sensitivity by Traffic Volume 1996 to 2000 (TEU's)					
	1996		2000		
	Volume	Percent	Volume	Percent	Growth
Unspecified	103	0.3%	78	0.1%	-24.3%
Time Sensitive	8,111	25.3%	46,525	58.7%	473.6%
Non-Time Sensitive	14,147	44.2%	21,649	27.3%	53.0%
Customer Dependent	9,680	30.2%	11,023	13.9%	13.9%
Totals	32,041	100.0%	79,275	100.0%	147.0%

Grains, pulse and special crops and semi-processed agricultural goods are not time sensitive and are shipped to port in either 20 foot containers or railcars and domestic containers that are transloaded at port. Most of the remaining commodity

groups are also not time sensitive. Agricultural, aircraft, and automotive components are not time sensitive as these products are inventoried by dealers. However, when one of these parts are desperately needed, air will be utilized. Electronics that are containerized are usually transformers or commercial oriented. Since these components are of high monetary value despite low time utility, they are source loaded and shipped in 20 and 40 foot marine, domestic containers, truckload or LTL. Likewise for industrial parts. These products tend to be either heavy, bulky or both and are shipped by boxcar or domestic container to bring transport cost down and weight factors up. On occasion it goes LTL or is source loaded in 40 foot marine containers and sent by rail.

Consumer goods, Chemicals/metals, and pre-fab buildings are classed as customer dependent, meaning the customer makes the call on "delivery windows". Pre-fab building manufacturers are dependent upon the availability of "high-top" or open top containers. This equipment is often booked months in advance and at a premium price. If this equipment were available at lower cost and shorter time frames, Manitoba manufacturers would be able to compete more effectively in global markets. As for consumer goods, product demand fluctuates with erratic consumer buying habits. This category of traffic will move in all modes, including LTL.

From 1996 to 2000, Manitoba's container traffic will have increased by 147 percent with time sensitive, value added chilled/frozen foods at nearly 60 percent of total throughput. Non-time sensitive and customer dependent traffic will have grown by 53 and nearly 14 percent respectively as well. The fundamental observation is that in under four years since the abolishment of the crow rate, Manitoba's container traffic has shifted from low value and volume goods to that of high value and demand for value-added products.

Gateway Winnipeg ?

Manitoba's container throughput is expected to grow at an annual rate of 5 to 10 percent for the next 10 to 15 years based on shippers evidence. If these optimistic predictions are realized, the provincial throughput will be nearly 160,000 TEU's by 2015. Winnipeg's outdated intermodal facilities will require capital investment to handle the traffic growth or two scenarios may unfold. Either Manitoba's containerized traffic will be transloaded at Vancouver, Calgary or Edmonton, or activity may be stifled. In either case, Manitoba's full economic potential is not realized.

The confluence of CN and CP mainlines at Winnipeg from the West and fanning

to the East and South, coupled with a highly price elastic containerized freight potential at a central point indicates that a mutual opportunity exists for shippers and carriers alike to increase traffic. The concept of a multi-user, consortia financed intermodal facility in Manitoba has been the topic of thirty years of debate. While the MIOSS survey focused on international container traffic, the inclusion of domestic intermodal traffic appears to provide the traffic volume to justify a business case for establishment of such a facility.

Table 5: Manitoba Container Traffic by Company Size (1996)			
Manitoba Container Traffic by Company Size - All Traffic			
Company size (Employees)	Nr. of Companies	Total (TEU's)	% of Total
0-25	50	12,679	39.6
26-50	17	1,873	5.8
51-100	21	2,133	6.7
101-200	15	2,461	7.7
200+	29	12,897	40.2
Total	132	32,043	100
Manitoba Container Traffic-Forwarder Traffic Excluded			
Company size (Employees)	Nr. of Companies	Total (TEU's)	% of Total
0-25	40	512	3.7
26-50	17	82	0.6
51-100	21	1,784	13
101-200	15	995	7.2
200+	29	10,407	75.5
Total	122	13,780	100

However, table 5 provides evidence on one fundamental problem regarding the multi-user intermodal facility concept for Manitoba. The Manitoba market is polarized between smaller shippers with less than 25 employees who account for 40 percent of traffic while another 40 percent is concentrated in the hands of large corporations[11]. The remaining 20 percent of traffic is generated by mid-sized firms with less than 200 employees. Excluding forwarder controlled traffic points to another market characteristic, the smaller shippers rely almost exclusively on the

11 Of the 29 firms indicated in table 5, the lion's share is generated by Maple Leaf, McCain's, Mid-West Foods, Inco, Palliser Furniture.

top six international freight forwarders[12] for logistics. In essence, a dozen firms generate or control 80 percent of Manitoba's containerized international traffic. Unless mutual benefit can be realized for these 12 firms in utilizing a multi-user intermodal facility, they will continue to move traffic through separate logistics channels.

Conclusions

Since the abolishment of the crow rate, Manitoba's container traffic will have increased threefold to 80,000 TEU's from 1995 to 2000, fulfilling predictions of a shift from exports of raw grains to that of value-added, processed "agri" products. Despite economic uncertainty in global markets, Manitoba shippers remain optimistic with an anticipated growth rate between 5 to 10 percent per annum for the foreseeable future. This will increase container traffic to 160,000 TEU's by 2015. In 1995 the import to export traffic ratio (IMPEX) was 1:3, and is expected to increase to 1:6 by 2000. Exports drastically exceed imports.

The Manitoba International Overseas Shippers Survey (MIOSS) indicates that Manitoba's containerized exports have a moderate to high elastic response to freight rates and additional traffic could be generated. Freight costs as a percent of total costs of a product ranged from 17 to 40 percent, with statements from shippers that output could double in some cases with freight rate reductions up to 30 percent.

The establishment of a multi-user, consortia financed intermodal facility is touted as one answer to lower container handling costs and thus increase economic activity. The second suggestion is to forge a Manitoba Shipper's Alliance (MASA) on a provincial scale and thereby provide the clout in negotiating with ocean carriers for favorable rates. Shippers "associations" are commonplace in other industry sectors. A market structure analysis revealed that 12 firms control over 80 percent of Manitoba's total container traffic. Unless mutual benefit can be realized for these companies in utilizing a multi-user intermodal facility, they will continue to use separate logistics channels.

However, should a public/private consortia agree to finance a multi-user, intermodal facility for a Manitoba Shippers Alliance, then some forwarders and ocean carriers may abandon the Manitoba market. The double-edged sword of lower costs versus logistical options must be weighed by Manitoba as a whole.

---

12 Panalpina, Danzas, Locher-Evers, Kuehne & Nagel, GEO-Logistics (formerly LEP), Shenker.

An Economic Comparison of the American and Canadian Domestic Air Transport Industries Since Deregulation

Bonnie-Lynn Robertson
The University of Western Ontario

The North American air transport industry has been regulated since the days it began to provide passenger service. This was continued until the late 1970's when a program of deregulation began, initially in the United States and later in Canada. There is possibly no other industry in which regulation has had such a substantial impact and deregulation has caused such radical and controversial changes (Viscusi, Vernon, and Harrington, 1992). This is true in both Canada and the U.S.. What cannot be assumed, though, is that deregulation has had the same impact, and of the same magnitude, in the two countries. This is because of differences in the size of the two markets, the population density, the degree of government ownership, and the differential impact of the Canadian charter carriers.[1]

Geographically, Canada is much larger than the U.S. but its market is only one tenth the size. Furthermore, 80 percent of the population lives in six cities that are within 200 miles of the U.S. border (Rowan, 1996). Historically, the Canadian air transport industry has been a duopoly dominated by one Crown Corporation, Air Canada, and one privately owned company, CP Air (recently renamed Canadian Airlines International, CAIL). In addition, Canadian regulation was more widespread than in the U.S. as it covered flight frequency, capacity, and equipment usage, along with price, entry, and exit. Furthermore, charter carriers have had a much greater presence in Canada (Gillen, Oum, and Tretheway, 1985).

---

[1]Charter carriers differ from scheduled carriers in their licensing, pricing, and marketing strategies. A charter carrier can not sell tickets directly to the public, as can a scheduled carrier, but must sell them to a tour operator. The tour operator may then sell to the public, however, in the early years of charter flights, to purchase a ticket the traveller must also join the charter affinity group. Charter carriers provide transportation on demand; whereas, scheduled carriers must operate regardless of the number of seats sold. In addition, the fares of Canadian charters are calculated on a per kilometre or per hour of flight time basis. Conversely, fares of scheduled operators are priced on a per seat basis (Statistics Canada 51-207, 1994).

The focus of this research is to compare the responses of the Canadian and the American domestic air transport industries to deregulation. Specifically, the research will compare the effects of deregulation on industry concentration and airfares. It will also determine what impact Canadian charter carriers have had on the degree of competition and the determination of fares. In doing so, it will utilize the inverse Herfindahl index to measure the degree of competition, the real yield index to measure the response of air fares, and a case study of the Vancouver to Toronto route to explain possible anomalies.

I have used the book "The Evolution of the Airline Industry," by Steven A. Morrison and Clifford Winston (1995) to provide the basis for the American comparison. Because charter carriers do not have a significant presence in the U.S., Morrison and Winston have focused their study on the domestic scheduled market. Alternately, charter carriers have been acknowledged to be influential in Canada. Oum, Stanbury, and Tretheway (1991) have stated that the charter company, Wardair, played an important role in Canadian fare competition. They have also suggested that its exit may have caused fares to rise. However, they have not tested this hypothesis. To the author's knowledge, no Canadian study to date has focused strictly on the domestic scheduled market, nor has one included the charter component. This research, therefore, will expand upon previous work by including charter carriers in the analysis of the changes in the industry concentration and airfares since deregulation. Ultimately, it will determine if deregulation has had the same outcome regarding industry concentration and airfares in Canada as in the U.S..

The layout of the paper will be divided into three sections. To aid in interpreting the empirical results, the first section will discuss the economic forces of air transportation and the economic theory of regulation and deregulation. It will be followed by a section providing evidence of the effects of regulation and deregulation in the U.S. and Canada. The discussion of deregulation in Canada will focus on the many structural and regulatory changes that have affected the industry since deregulation. Specific quantitative results will be discussed in the third section. This section will be the focus of the paper. It will describe the methodology and the data used, as well as the results gained from the research. The third section will be subdivided into the three analyses performed; the inverse Herfindahl index, the real yield index, and the Vancouver to Toronto case study. Finally, the paper will conclude with a summary and a comparison of the Canadian and U.S. industries' response to deregulation.

Given the numerous differences between the Canadian and American domestic markets, it is not surprising that this research suggests that the Canadian and the American industries have responded differently to deregulation. In the U.S., air transport deregulation occurred in 1978. By 1992, competition had increased and real average fares had fallen by 33 percent (Morrison and Winston, 1995). Deregulation

did not begin in Canada until 1984. The evidence presented in this paper indicates that, in contrast to the U.S., by 1995 competition in Canada had fallen to slightly more than two competitors. Moreover, the real average fare had risen by 25 percent.[2] Furthermore, competition and average fares were greatly influenced by Wardair and the charter carriers.

The Vancouver to Toronto case study shows that carriers took advantage of the reduced competition and fare deregulation to change their pricing structure. Canadian carriers are now charging higher fares to passengers with inelastic demands and lower fares to passengers with elastic demands compared to before deregulation. Since Wardair's exit, the new charter carriers have continually increased their market share. Full fare ticket prices ceased to rise once the charter market share reached approximately 20 percent and declined when it reached approximately 30 percent. Furthermore, discount fares stopped their upward trend when the market share reached approximately 30 percent. This evidence implies that there is a threshold level of competition that must be met before charter carriers will affect fares. Therefore, the results of this research confirm that the Canadian and American air transport industries have responded differently to deregulation. Moreover, it suggests that Wardair and the new charter carriers have played a significant role in competition and fare determination in Canada.

Section 1

The Economics of the Air Transport Industry

Although airlines come in many sizes, ranging from large international carriers to small local commuters, the underlying economics of airline cost and demand is common to all carriers. Airline costs fall into two categories, one relating to flight costs and the other to the magnitude of the firm's overall operation. Regarding flight costs, airline cost per seat declines as the size of the aircraft increases, as the stage length increases, and as the load factor increases. The fact that cost per seat declines as the size of the airplane increases is known as economies of aircraft size. The stage length is the distance flown in one flight segment; for example, a nonstop flight between Vancouver and Toronto is one stage length. The load factor is the percentage of seats sold on one flight segment (Oum and Tretheway, 1992).

In relation to the magnitude of a carrier's operation, costs will be lower if economies of scale and scope are present than if they are not. In the air transport

[2]The Morrison and Winston study covers the years 1978 to 1993; whereas, this study covers the years 1984 to 1995.

industry, economies of scale are divided into economies of firm size and economies of traffic density. Economies of firm size refer to the expansion of output by adding points (cities) to a carrier's network. There are approximately constant returns to firm size for carriers as large as the U.S. and Canadian national (trunk) carriers.[3] However, for smaller carriers there may be increasing returns to network size. In contrast, significant economies of traffic density do exist in the industry. That is, the unit cost of service decreases as output is expanded within a carrier's existing network. Furthermore, these economies are more easily exploited by the large trunk carriers (Gillen, Oum, Tretheway, 1990).

Alternately, economies of scope refer to the cost savings due to the shared use of inputs across product lines. Whenever the cost of providing two or more shared services is less than the cost of providing the services separately, the multi product cost function exhibits economies of scope (Panzar and Willig 1981, in Weisman 1990). In the airline industry, economies of scale prompt consolidation and mergers; whereas, economies of scope motivate hub-and-spoke networks (Bailey, Graham, and Kaplan, 1985)

The determinants of consumer demand are the factors that affect an individual's decision to enter the air travel market and, then, how much travel to do (Gillen, Oum, Tretheway, 1990). Airline consumers are not a homogeneous group. Therefore, economists have divided them into two sub groups, the business traveler and the leisure traveler. Studies have shown that the demands of the business traveler are inelastic, being more sensitive to flight frequency and connection times than to price. Conversely, the demands of the leisure traveler are elastic; they are more sensitive to price than to frequency and connections (Morrison and Winston 1986).

In addition, consumer demand is influenced by income. In the Canadian air transport market, the income elasticity of consumer demand is between 1.6 and 2.5. This implies that a 10 percent growth (contraction) in the economy would lead to a 16 to 25 percent rise (fall) in air travel demand. This pro cyclical nature of the industry contributes to its vulnerability to economic downturns (Oum and Gillen, 1993). Knowing these economic factors is important for the interpretation of the two industries' response to deregulation.

---

[3]Trunk carriers are also referred to as national or mainline carriers. They are certified to operate across the entire nation and are generally larger carriers. Some examples of trunk carriers are: Delta Airlines, American Airlines, United Airlines, Air Canada, and Canadian Airlines International.

The Economic Theory of Regulation and Deregulation

In both the U.S. and Canada, the main objectives of air transport regulation were to keep the industry financially stable and to promote air service (Viscusi et. al., 1992). Without regulation, policy makers believed that airlines would engage in destructive competition that would result in financial instability. Destructive competition may occur in industries that experience long, sustained periods of excess capacity and have fixed or sunk costs as a large percentage of total costs. If the market is competitive, many firms, if not the entire industry, may operate at a loss (Kahn, 1971). In the air transport industry, it was feared that financial instability would lower the quality of air service, specifically regarding maintenance, operations, and scheduling (Lazar, 1984).

Conversely, economic theory predicted that regulation would reduce productivity growth by restricting price, entry, and exit. Ultimately, regulation would result in economic inefficiency. The prevention of entry and exit would allow inefficient firms to remain in the industry (Viscusi et. al., 1992). Furthermore, price restrictions would lead to fares being set below marginal cost in some markets. To cover these losses, they would then be set above marginal cost in other markets. This is known as cross-subsidization (Viscusi et. al., 1992). In addition, to reduce losses, firms would decrease the number of flights on their unprofitable routes. Higher fares on profitable routes and fewer flights on unprofitable routes would result. In either case, consumer welfare would suffer (Bailey, Graham, and Kaplan, 1985).

In addition, theory says that because fares were regulated, carriers would find other means of competition, such as service. To gain market share on profitable routes, they would compete by increasing their flight frequency or improving their aircraft type, or both. On these routes, this would cause over capacity and inefficient aircraft usage; service inflation. Subsequently, service inflation would lead to lower than optimal load factors (Bailey et. al., 1985).

Deregulatory theories have been primarily based on the empirical studies of the effects of regulation. Economic theory predicted that regulation would result in a deadweight loss because of the maintenance of inefficient firms, cross-subsidization, and service inflation. Economists, therefore, predicted that deregulation would lead to improved producer efficiency, increased competition, more flight frequency, and lower average fares (Winston, 1993).

The removal of fare restrictions would eliminate the need for cross-subsidization and service inflation. Consequently, carriers could price discriminate, thereby, offering fares appropriate to each consumer's sensitivities. In addition, the removal of entry and exit restrictions would enable airlines to optimize their network structure. Producer efficiency would be improved because carriers could schedule their routes and deploy their fleet based on consumer demand. Flight frequency would

increase to meet the demands of the higher paying, inelastic, consumer. The cost savings from improved efficiency would then be passed on to the consumer as lower average fares. It is in these ways that deregulation would result in improved producer efficiency, more efficient route and aircraft scheduling, and lower average fares (Viscusi et. al., 1992). Most economic analysis agrees that air transport deregulation has improved industry efficiency and consumer welfare in the U.S.. However, the extent to which this has occurred in the Canadian domestic market has not been studied.

The remainder of this paper will examine the U.S. and Canadian domestic air transport industries under the two policy regimes. Morrison and Winston (1995) have done a complete analysis of the U.S. industry. However, such an extensive study is beyond the scope of this paper. Therefore, the discussion of deregulation will focus on the areas relevant to my research, industry concentration and airfares.

Section 2

Regulation in the United States

In 1938, responding to fears of destructive competition, the Civil Aeronautics Board (CAB) regulated entry, exit, and fare pricing of all interstate scheduled carriers in the U.S.. In contrast to Canada, scheduling, equipment type (aircraft), and intrastate carriers were not regulated (Bailey et. al., 1985). Charter carriers also were unregulated, except that they could only sell their product to affinity groups and could not operate regularly scheduled flights (Morrison and Winston, 1995).

During the regulatory years, the U.S. industry operated, as an oligopoly comprised of both national and regional carriers, all privately owned. To ensure carrier profitability, fares were set to yield a 12 percent return (as of 1974), based on standard industry load factors and seating density (Bailey, et. al., 1985). Furthermore, entry regulations generally restricted competition to two or three carriers per route (Viscusi et. al., 1992).

Consistent with economic theory, regulation led to cross-subsidization and service inflation. Cross-subsidization resulted in fares being set below marginal cost in short haul markets and above marginal cost in long haul markets.[4] Airline efficiency and consumer welfare were compromised because fares did not reflect the true cost of operations (Bailey et. al., 1985).

---

[4]In Canada, the long haul domestic market consists of routes of over 800 kilometres (Statistics Canada 51-206, 1995).

Moreover, service inflation caused inefficient use of aircraft. For example, when Alaska Airlines tried to introduce lower fares for flights using DC-4's (a less costly aircraft) than Pan American was charging for the same routes using DC-6's, its request was denied. To remain competitive, Alaska had to upgrade its fleet before the usefulness of the DC-4's had expired (Kahn, 1971). Furthermore, the unregulated intrastate carriers upgraded their fleets long after their regulated competitors, evidence that regulation was indeed distorting airline equipment decisions (Bailey et. al., 1985).

In addition, intrastate carriers in California, Texas, and Florida offered reduced fares, yet prospered. This showed that fare regulation was not needed to ensure airline survivability. Meanwhile, low fares offered by Southwest Airlines (an intrastate carrier) on the Dallas-Houston-San-Antonio route resulted in an expansion of the traffic base. This suggested that lower fares could stimulate an entire new market segment (Morrison and Winston, 1995).

In summary, although regulation had been imposed to correct market inefficiencies, it clearly had resulted in cross-subsidization, service inflation, and reduced consumer utilization. Higher fares and inefficient aircraft usage had increased costs to both the consumer and the producer. Therefore, consistent with economic theory, air transport regulation had resulted in economic inefficiency in the U.S. air transport industry.

Deregulation in the United States

The intrastate carriers' experience had demonstrated that unregulated carriers could offer lower fares, remain profitable, and stimulate new market segments. Furthermore, they could provide a lower priced, more efficient, service than their regulated competitors. This realization, along with industry pressure, culminated in the signing of the Airline Deregulation Act (ADA) on October 8, 1978. With its passage, the authority of the CAB to set fares and award routes was to be phased out over four years (Bailey et. al., 1985).

Following deregulation there was a dramatic influx of new carriers into the market. By 1993, however, many new entrants had merged with larger carriers. The exact number of carriers is not an accurate measure of competition, though, because it gives equal weight to both large and small carriers. Therefore, Morrison and Winston (1995) have used the inverse Herfindahl index to measure the number of

effective competitors.[5] Their results show that, at the national level, the number of effective competitors increased from fewer than nine in 1978 to a peak of more than twelve in 1985. Ultimately, mergers reduced this number to slightly less than eight, where it remained in 1993. After fifteen years of deregulation, competition at the national level had not appeared to change significantly (Morrison and Winston, 1995).

At the route level, competition followed the same path of expansion and contraction until mid 1989. It then changed course and increased through 1990. Since then, it has remained well above its 1979 level, falling only marginally in 1991 because of the liquidation of Eastern Airlines and the economic recession. Furthermore, on routes over 2000 miles, the number of effective competitors has risen 70 percent since deregulation (Morrison and Winston, 1995).

Therefore, consistent with economic theory, the removal of entry regulations did lead to entry and increased competition in the U.S.. Although fewer effective competitors now exist at the national level, Bailey and Liu (1995) have found that this has improved efficiency. Consolidation has allowed the surviving carriers to further expand their networks, thus, to take advantage of economies of stage length and traffic density. These cost savings, they are now able to pass on to their customers as lower fares. Consequently, Bailey and Liu conclude that as market size increases the equilibrium network size increases and the equilibrium number of carriers decreases (Bailey and Liu, 1995).

Economic theory also predicts that the removal of price and entry/exit regulation would improve producer efficiency. What innovations the airlines would develop to do so, though, were unknown. Therefore, the adoption of the hub-and-spoke network system was an unanticipated outcome of deregulation (Viscusi et. al., 1992).

Using a hub-and-spoke system, traffic from I destined for J, is routed through the hub, H. It is then combined with other traffic from H destined for J. By combining traffic, carriers can take advantage of economies of scope. Furthermore, hubbing allows airlines to centralize operations, lower costs, reduce passenger connection times, and increase flight frequency. Consequently, since deregulation, most U.S. airlines have adopted this form of route structure to some extent. Southwest Airlines, the model low cost carrier, has two hubs but relies on a linear route system for its

---

[5] The inverse Herfindahl index measures the number of equal size, effective competitors, in a market. It can be thought of as giving the number of equal-sized competitors that would provide the same degree of competition as observed in the data. A high index value thus indicates that a market is effectively competitive, while a value near one indicates that it is essentially monopolized (Morrison and Winston, 1995).

short-haul routes. Between 1978 and 1981, overall U.S. departures rose 19 percent, implying greater frequency and accessibility of air travel (Bailey et. al., 1985). Therefore, the removal of entry and exit restrictions has allowed for greater flexibility and frequency in route scheduling. Indeed, the benefits to the consumer from improved flight frequency have been estimated at $10.3 billion per year (Morrison and Winston, 1995).

Ideally, increased competition and improved airline efficiency should result in lower fares. Although some price increases have occurred during periods of high demand or for consumers with inelastic demands, real average fares have fallen since deregulation. The standard measure of airfares is yield, the average fare per mile (kilometres in Canada) for trips by paying customers. In the U.S. the real yield initially rose for approximately two years following deregulation. This suggests that the regulatory fare ceiling had been effective and carriers could not instantly adjust their input costs (Smith, 1998). In addition, airlines may have had to incur costs to develop hub-and-spoke networks. Once route restructuring and contract negotiations were complete, airlines were able to offer lower fares and the real yield declined. As a result, in 1993, real yield was two-thirds of its 1978 value. It was also 22 percent less than it would have been had regulation continued (Morrison and Winston, 1995). Using these results, Morrison and Winston (1995) have estimated an annual saving to the traveler of $12.4 billion 1993 dollars.

The U.S. air transport industry is still in a period of transition and settling into equilibrium may involve more structural change. For this reason, Morrison and Winston (1995) have estimated how fares would respond to further fluctuations in the industry structure. Their results show that route competition from either American Airlines (the giant of carriers) or Southwest Airlines (the premier low cost carrier) would lower the fares of all other carriers on the route. The amount of the fare reduction would be greatest if Southwest was a competitor. Given this, it is not surprising that Southwest's presence deters market entry. Furthermore, if Southwest were to exit the industry, fares would potentially increase by 8.5%. In 1990, Southwest had only 5.6% of the market share. The fact that it can have such a strong impact on the industry illustrates that a carrier's identity can be as important as its numbers (Morrison and Winston, 1995). Whether Wardair had a similar influence in Canada will be addressed in the Canadian analysis below.

The evidence cited above implies that regulation had resulted in economic inefficiency in the U.S. air transport industry. Much of this inefficiency has been eliminated by deregulation. Although competition at the national level is similar to its pre deregulation level, at the route level it has increased. Carriers have been allowed to adopt the most appropriate route structure for their markets, which has resulted in increased flight frequency and reduced costs. Consumers have benefited from greater accessibility to air travel and lower average fares. Therefore, consistent with

economic theory, deregulation has resulted in a more efficient American air transport industry.

Regulation in Canada

Unlike the U.S., the Canadian industry has historically been dominated by two national carriers, Air Canada (AC) and CP Air (now CAIL). Initially, the goal of Canadian air transport policy was to develop a reliable air transport network linking all regions of the country. To pursue this goal, the Air Transport Board (ATB) regulated the industry in 1944. Regulation was more widespread than in the U.S. as it included scheduling, capacity, and equipment type along with entry, exit, and pricing. Because the Crown Corporation, AC, was the government's policy tool, it remained unregulated. Nevertheless, AC was forced to service many unprofitable remote communities, use specific aircraft, and ensure a uniform fare structure across the country. This led to cross-subsidization of routes and over- capitalization of equipment for both AC and its competitor, the privately owned CP Air (Gillen, Oum, and Tretheway, 1985).

To guarantee the effectiveness of cross-subsidization, the Regional Carrier Policy (RCP) was enacted in 1966. It limited competition by confining the regional carriers to non-overlapping geographical areas and restricted them to providing feed traffic to the two trunk carriers, AC and CP Air.[6] The RCP also caused producer inefficiency because it did not allow the regional carriers to expand and exploit economies of stage length (Gillen et. al., 1985).

Fare regulation also increased cross-subsidization. To ensure that price competition did not occur, the Air Transport Board (ATB) applied a tapered fare formula to all scheduled carriers. This produced identical first class and economy class fares.[7] As in the U.S., on many routes fares differed greatly from cost, thereby, increasing cross-subsidization. Restricted discount fares were introduced in 1979; however, Wardair was not allowed to offer these fares on its domestic charter flights until 1984 (Oum, Stanbury, and Tretheway, 1991). In spite of the above restrictions, domestic travel, especially discount utilization increased substantially (Statistics Canada, 51-501E, 1993). Therefore, just as low fares had spurred market demand in Texas, so had they stimulated demand in Canada.

During regulation, the Canadian industry experienced limited production growth (because of the RCP), a rigid fare structure, and cross-subsidization. Service

---

[6]The four regional carriers were Pacific Western (PWA) in the west, Eastern Provincial Airlines (EPA) in the Maritimes, Nordair in central Canada, and Quebecair in Quebec.

[7]Business class fares were not established until the 1980's.

inflation, however, was not as apparent as in the U.S.. This suggests that service competition may have been curtailed by Canada's capacity and scheduling regulations. Apart from this difference, evidence confirms that regulation had also led to economic inefficiency in the Canadian air transport industry.

Deregulation in Canada

Unlike the swift deregulatory process in the U.S., in Canada the process was gradual and only applied to the south.[8] It began in 1984 with The New Canada Air Policy and was expanded in 1988 with the National Transportation Act (NTA). The New Canada Air Policy permitted entry into southern charter markets only. Furthermore, it allowed incumbent carriers to exit southern routes if faced with new entry. The policy also called for the privatization of Air Canada and the elimination of the RCP.[9] It allowed unlimited freedom to reduce prices but fare increases remained regulated. In 1985, Wardair was given permission to operate domestic scheduled flights, which it began in 1986 (Oum et. al., 1991).

Further deregulation did not happen until 1988 when the NTA removed all entry and fare regulations in the southern scheduled market. This eliminated the upper bound on fare increases. Exit and fare regulation, nevertheless, continued to apply to northern Canada (Oum et. al., 1991).[10] Therefore, although the privatization of AC may have reduced some need for cross-subsidization, the continued regulation of the north may have offset this benefit.

In 1984, the relaxation of entry and exit restrictions allowed carriers to take advantage of economies of firm size and traffic density. This prompted the mergers between CP Air and the regional carriers that, by 1987, had resulted in the formation of CAIL. Following this, the two national carriers, AC and CAIL, developed alliances with small, local, carriers (Oum et. al., 1991). These alliances enabled them to form feeder networks analogous to the U.S. hub-and-spoke systems. However, because 80 percent of the Canadian population is distributed linearly along the U.S. border (Rowan, 1996), it was unclear whether a hub-and-spoke system would be the most efficient type of operation. Moreover, because service inflation had not been as apparent in Canada as in the U.S., the possible gains from deregulation may not have been as great.

---

[8]A line of demarcation at roughly 50-55 degrees was determined to distinguish between southern and northern Canada (Christopher, 1993).

[9]Air Canada was privatized on April 12, 1988.

[10]Regulation continued to apply to northern Canada for the duration of this analysis.

By 1988, mergers and alliances had resulted in 95.5 percent of the industry being dominated by the two families of carriers, AC and CAIL. Wardair comprised most of the remaining 4.5 percent. In 1989, Wardair was bought by CAIL, thereby, creating a duopoly in the Canadian air transport industry (Oum et. al., 1991).

Furthermore, after the 1991 recession Canada was threatened by the prospect of being served by only one airline. At this time, CAIL had posted huge losses that raised serious doubts about the financial viability of the company. Seeing the opportunity to monopolize the domestic market, AC initiated fare wars with CAIL. This was an unsuccessful attempt to motivate a merger, buy out, or takeover of CAIL but it may have affected fares.

The removal of entry barriers did prompt some carriers to enter the market, however, few were successful until after Wardair's exit. Therefore, as with Southwest Airlines, the presence of Wardair may have deterred entry into the Canadian domestic market. It was not until after the 1991 recession that charter carriers began to regain the market share lost by the exit of Wardair. This growth continued throughout 1995 (Statistics Canada 51-207, 1995). Whether the Canadian industry is now more, or less, competitive and how these changes have affected fares, will be addressed in the analysis to follow.

The remainder of this paper will estimate the changes in the Canadian industry focusing on competition and airfares. The research will see if there have been differences between the Canadian and the American industries, and if so, why. To effectively compare these results with those of Morrison and Winston (1995), the estimation techniques will mirror theirs where possible. Because Canadian data is only available with a two-year lag (Oum et. al., 1991), the years covered will be 1984 to 1995. The rest of the paper will present the analysis and the results.

Section 3

The Analysis and Results

The Inverse Herfindahl Index

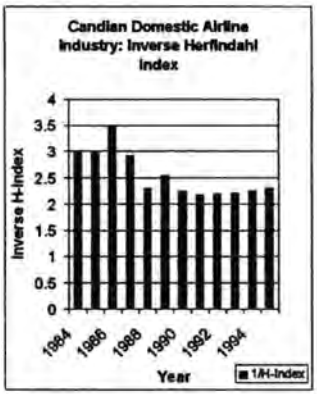
The inverse Herfindahl index measures the number of equal size, effective competitors in an industry. In the U.S. it was constructed at both the national and route level but, due to data limitations, I have only estimated it at the national level. The index was constructed using data from the International Civil Aviation Organization (ICAO) Digest of Statistics, Traffic Series, and Statistics Canada Air Charter Statistics, Series 51-207. These data contain the number of domestic scheduled and non-scheduled passengers on each airline. To avoid duplication between the ICAO non-scheduled and Statistics Canada charter passengers, the

Statistics Canada figures were used only when ICAO data did not exist. The formula for the inverse Herfindahl index is as follows:

$$1/H_t = 1/\Sigma (S_{it})^2$$

where: H_t = the Herfindahl index = $\Sigma (S_{it})^2$
S_{it} = the market share of airline i in year t
S_{it} = # of Pax on airline i in year t / total # of Pax on all airlines in year t
Pax = passengers

Graph # 1 presents the Canadian inverse Herfindahl index from 1984 through 1995. Evidently, there was more competition before full entry regulations were removed in 1988 than after. Unlike the U.S., immediately after the relaxation of entry regulations in 1984, there was no increase in competition. Even during the consolidation process to form CAIL, the index remained close to three. It only increased to 3.47 after Wardair began scheduled operations in 1986. When further entry restrictions were removed in 1988, the index fell 34 percent to 2.30. This corresponds to a 90 percent drop in the number of charter passengers that resulted from Wardair's abandonment of its domestic charter operation (Statistics Canada 51-207, 1995). The fact that competition decreased after Wardair exited the charter market implies that, in the long run, it was not able to retain its market share when directly competing in the scheduled market.



Graph 1, *Source: Author's Calculations*

The charter carrier, Canada 3000, entered the market in 1989. Thus, the 11 percent rise to 2.55 in 1989 may be accounted for by Canada 3000's entrance. Throughout the end of 1989 and 1990 many fledgling charter carriers went bankrupt and, again, the index fell. Since then it has shown a gradual increase of 7 percent, from 2.17 in 1991 to 2.31 in 1995. Meanwhile, domestic charter traffic grew 149 percent. Although charter carriers regained their pre 1985 market share in 1993 (Statistics Canada 51-207, 1995), as of 1995, they had not achieved the same level of competition as had Wardair. Ultimately, competition was reduced to slightly more than two following deregulation. Moreover, these results imply that Wardair significantly influenced competition in Canada.

Today, both the American and the Canadian air transport industries are more concentrated than they were before deregulation. However, expansion did occur in the U.S. immediately following deregulation and competition has increased at the route level. Conversely, except for Wardair's entrance into the scheduled market, competition in Canada has fallen since the removal of entry regulations. Economic theory would predict just the opposite. This suggests that forces other than deregulatory policy may have influenced the level of competition in Canada.

Furthermore, the degree of concentration is also remarkably different in the two countries. The U.S. remains an oligopoly with approximately eight effective competitors; whereas, the Canadian industry is a virtual duopoly. Although Canadian charter carriers have been increasing their market share, they have not yet replaced Wardair. This analysis confirms that there is much less competition in Canada than in the U.S.. In addition, it suggests that Wardair, like Southwest, was an important player in the Canadian domestic industry.

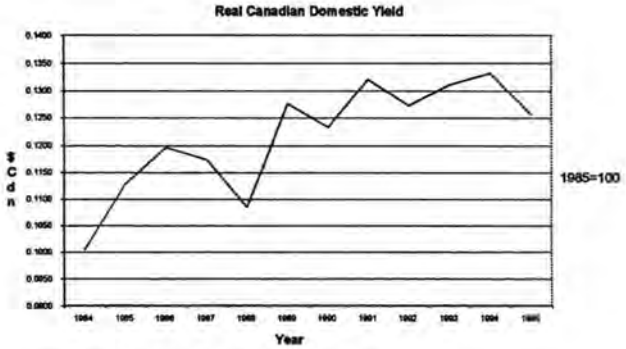
The Canadian Domestic Yield Index

Yield is the standard measure of airline fares. To adjust for inflation, it was constructed in constant 1985 dollars using the CPI. For the index, charter and regional carrier data did not separate passenger revenue into domestic and international components. Consequently, domestic revenue from only Air Canada and CP Air/CAIL was used. As these two families of carriers account for over 95 percent of passenger revenue, this should create an accurate index (Oum et. al., 1991). The revenue data was obtained from Air Canada annual reports, CP Air/CAIL annual reports, and the Standard and Poors Financial Reports. The exact domestic revenue for some years was not available and had to be estimated using information obtained in the annual reports. The data for passenger kilometres was obtained from the ICAO Digest of Statistics, Traffic Series. The CPI until 1989 is given in Oum, Stanbury, and Tretheway, (1991). For the years after 1989 it was calculated using its percentage increase from Statistics Canada "Canada Year Book 1997."

The yield formula is:

Average Nominal Yield = Domestic Pax Revenue / Total Pax Kilometres
Average Real Yield = (Average Nominal Yield / CPI) * 100

Graph # 2 represents the real Canadian domestic yield from 1984 to 1995.



Graph 2, *Source: Author's Calculations*

Surprisingly, it shows that real yield has risen 25 percent since 1984. Between 1984 and 1986, (when CP Air merged with EPA and Nordair), the index rose 20 percent. It only began falling after Wardair entered the scheduled market. It fell another 10 percent after complete fare deregulation was announced in 1988, but rose sharply shortly afterward. This dramatic rise follows the elimination of the upper bound on fares. However, it also corresponds to Wardair's exit from the industry. Since then, the index, on average, has continued a gradual upward path. The subsequent downturns follow Canada 3000's entrance in 1989, the AC/CAIL fare wars in 1991, and the regaining of the charter component's market share in 1993. Further analysis beyond the scope of this research, is needed to separate the effects of deregulation and the exit of Wardair on fares. Nonetheless, these results illustrate the large impact that Wardair and the charter industry had on Canadian domestic fares.

Thus, the response of fares in Canada has been opposite to both the U.S. response and the economic predictions. Whereas American fares are 33 percent lower than before deregulation, Canadian fares are 25 percent higher. Because the U.S. yield is in 1993 American dollars per mile and the Canadian yield is in 1985 Canadian dollars per kilometre, a direct comparison of the two indices would be misleading. The important interpretation is the opposite trends. Nevertheless, to show in which

country fares were higher, I have converted the Canadian 1993 yield to U.S. dollars per mile. This conversion resulted in the real Canadian yield being $00.24 while the American yield was only $00.14. In 1993, therefore, Canadian average fares were 71 percent higher than in the U.S.. This is another piece of strong evidence confirming the different response of the Canadian and American industries to deregulation. I will next examine the Vancouver to Toronto route to see if it gives any explanation for the anomalous behavior of the Canadian air transport industry.

The Vancouver to Toronto Case Study

I have chosen to analyze the Vancouver to Toronto route for several reasons. From the time charter carriers were allowed to compete domestically, this route has consistently carried the most charter passengers. Wardair, Worldways, Nationair, Canada 3000, Air Transat, and Royal Airlines have all been active in this market. In addition, when Wardair was bought and the total charter domestic market share deteriorated, it also fell significantly on the Vancouver to Toronto route. Therefore, it is assumed that the Vancouver to Toronto route will provide the best illustration of how deregulation and changes in the industry composition have affected airfares.[11]

For the analysis I have separated fares into First Class (F), Business Class (J), Economy Class (Y), and Advance Purchase 75 days (AP/75).[12] Passengers traveling on F, J, and Y, full fares are assumed to have inelastic demands, while those on AP/75 discount tickets are assumed to have elastic demands. To incorporate the change in fare utilization, I have also constructed a real weighted average fare (WAF) using the above categories. All fares are Air Canada return fares in 1985 constant dollars.[13] The formula for the weighted average fare is as follows:

$$\text{Air Canada weighted average fare} = (\Sigma_i S_i (AC_i)) / \Sigma_i S_i$$

where: S_i = fraction of passengers in class i
AC_i = average Air Canada fare in class i

This formula is a summation of the product of the fraction of passengers in each fare class and the average fare in that class, divided by the total fraction of paying passengers. Because the data contain the percentage of passengers on airline or travel

---

[11]This study represents a lower bound of discount fare estimation. It is assumed that discount fares may be higher on routes without charter competition.

[12]The Advance Purchase 75 day fare is an average of the most dominant advance purchase fares filed by Air Canada.

[13]Tax is not included in these fares.

agent discounts, the WAF had to be weighted to exclude these passengers.[14] The results of the real F, J, Y, and the WAF are presented in graph # 3. Those of the WAF and the real AP/75 fare are in graph # 4. For ease of comparison, both graphs contain the percentage of charter passengers carried on the route (read off the right Y-axis). This calculation is as follows.

> Charter Passengers as a percentage of Total Passengers =
> # of charter passengers on the Vancouver/Toronto city pair /
> (# of charter passengers + # of scheduled passengers on the
> Vancouver/Toronto city pair)

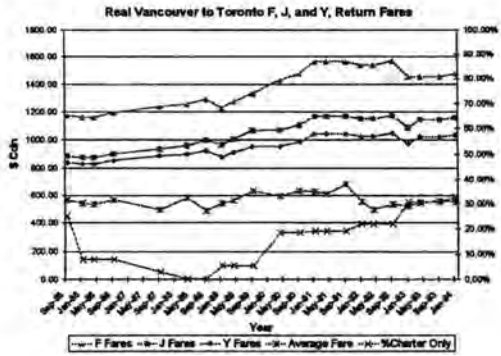
The airfare data was compiled from: (1) the Official Airline Guide (OAG), North American Edition, (2) Statistics Canada, Air Passenger Origin and Destination, 51-204, (3) Statistics Canada, Domestic Scheduled Operations, 51-206, and (4) Statistics Canada, Air Charter Statistics, 51-207. The OAG issues were available for January, April, and September; although not all issues were available for every year. As none of these months is in a peak or a low demand period, these fares will be least affected by seasonal changes in demand. In addition, the OAG changed their method of reporting fares after 1984. Therefore, the case study covers the years 1985 to 1995. Because charter carriers are not required to file fares, the data set contains only scheduled airfares. Therefore, it was assumed that the lowest scheduled fare was the one closest to, and most influenced by, the charter carriers. This was the AP/75 fare.

Consistently AC and CP Air/CAIL filed matching F, J, and Y fares. However, they differed in the number of advance purchase (AP) fares that were offered. Therefore, in constructing the AP/75 fare I have used the average of the most dominant advance purchase fares. In addition, after 1991, discount fares filed by CP Air/CAIL were lower than AC's. Presumably, this was because the company was in financial trouble and was using lower fares to lure customers. Because financial instability may have influenced CP Air/CAIL's pricing policy, AC's fares were used in the analysis.

In calculating the WAF, the fraction of passengers in each fare class was only available after 1988. Consequently, for 1984 - 1987 I have assumed the 1988 values and I have not focused on these years in the discussion of the WAF. In addition, the exact percentage in each class on the route was not given. I used the percentage in each fare class departing Vancouver for a domestic long-haul flight as a close approximation.

---

[14]Passengers on airline or travel agent discounts would be airline or travel agent employees.



Graph 3, *Source: Author's Calculations*

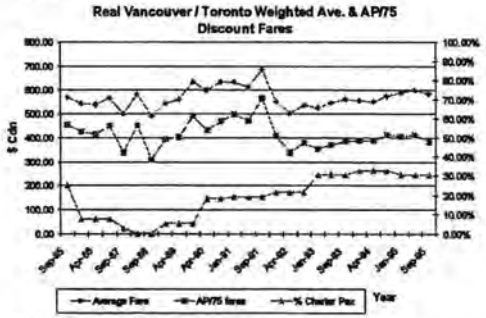
As graph # 3 illustrates, fares in all three full fare classes, F, J, and Y, had begun to rise before 1988. This corresponds to the formation of CAIL. After a brief decline at the end of 1988, they rose significantly until January 1991. The decline follows both the signing of the NTA in 1988 and an increase in the charter market share from 0.2% in 1988 to 5.54% in 1989.[15] In spite of this decline, between September 1985 and January 1991, there was a total increase in fares to inelastic passengers. F fares rose 33%, J fares rose 32%, and Y fares rose 24%. However, after Wardair's exit and it became apparent that the new charter carriers were competing primarily in the discount market, the fare increase was more dramatic. In the two years from January 1989 until January 1991, F fares rose 28%, J fares rose 21%, and Y fares rose 19%. Therefore, it can be inferred that AC took advantage of the lack of competition in the full fare market to increase fares to its passengers who were less price sensitive. These fares remained stable until January 1993, when they fell sharply. This fall coincides with a dramatic increase in the charter market share (predominately Canada 3000) rising from 22% in 1992 to 31% in 1993. In addition, it corresponds to the charter carriers finally regaining their pre 1985 market share. Therefore, although charter carriers were not directly competing in the full fare

[15]It should be noted that the increase in this increase in the charter market share on the Vancouver to Toronto route contrasts the decline in the total charter market share presented in the yield analysis. This implies that the Vancouver to Toronto route was one of the first that new charter carriers entered.

market, their increased market share obviously induced a response from AC. Even so, in the ten years of the analysis, J fares had risen 36% and Y fares had increased 28%.[16]

In contrast to the marked increase in F, J, and Y class fares, on average, the WAF has not increased since deregulation. This is in spite of the many structural and regulatory changes that affected the industry. Although the WAF reached a high of $684.00 in September of 1991, by the end of 1995 it was only $16.09 higher than it had been in 1985. This result implies that the increased utilization of discount fares may have offset the higher prices on full fare tickets.

To further analyze the response of the WAF, I have presented it along with the real AP/75 fare and the charter market share in graph # 4. From this graph, it is apparent that the WAF and the AP/75 fares moved in parallel. This fact indicates that discount fares were the major force behind the movement of the WAF. It also confirms that the increased use of discount fares by leisure passengers had offset the fare increase to the business travelers. However, greater discount utilization was not enough to cause a decline in the WAF.



Graph 4, *Source: Author's Calculations*

Furthermore, both fares responded to changes in industry concentration and deregulation. This is illustrated by the following observations: (1) the decrease in September, 1987 after Wardair had entered the Vancouver to Toronto scheduled market, (2) the rise in April, 1988 when the charter market share dropped significantly, (3) the decrease in September 1988 after deregulation, (4) the rise until September 1989 when there was limited competition from the charter carriers, (5) the fall in April, 1990 when the charter market share again increased, and (6) the rise until September, 1991 before charters had gained a strong market presence. Therefore, it

[16]First class fares were discontinued after January 1994.

is evident that both disscount fares and the WAF responded strongly to changes in the charter component.[17] These fares, though, have been much less volatile since 1993 when the charters gained 31 percent of the market share.

What cannot be explained by the charter carriers or deregulation, however, is the dramatic decrease in both the WAF and the AP/75 between September 1991 and April 1992. It can be inferred, then, that the price wars between Air Canada and CAIL were the cause of this decline. Furthermore, after the fare wars, increased competition from the charters ensured that discount fares would remain low.

Recall from graph # 3 that a 22 percent charter market share only stabilized the F, J, and Y fares. It was not until the market share reached 31 percent that these fares declined. In addition, graph # 4 shows that 31 percent caused the WAF and the AP/75 fares to stabilize. These results suggest that there is a threshold level of competition that must be met before fares will be significantly affected. Approximately 20 percent market share will limit the increase on full fares, whereas, approximately 30 will reduce them and stabilize discount fares.

The other interesting observation in graph # 4 is the change in the spread between the WAF and the AP/75. In 1985 the price difference was approximately $115., whereas, it had increased to approximately $200. by 1995. This comparison shows that travelers on AP/75 fares were paying approximately $85. less than the average ticket in 1995 than they were in 1985.

The evidence from the Vancouver to Toronto case study shows that first class, business class, and economy class fares have risen since deregulation. This suggests that Air Canada took advantage of the removal of the upper bound on fares and Wardair's exit to raise fares to passengers with inelastic demands. Although fare deregulation may not have benefited these passengers, they have gained because of increased competition from the charter component. Both the weighted average fare and the AP/ 75 fare moved in unison, implying that the higher percentage of passengers flying on discount tickets had greatly affected the weighted average fare. In addition, the spread between the WAF and the AP/75 has increased since 1985. This implies that leisure travellers have gained from deregulation and the increased presence of the charter carriers. Therefore, as economic theory would predict, deregulation had resulted in price discrimination in the Vancouver to Toronto market.

---

[17] Canada 3000 gained a significant presence in the market in 1990. Moreover, it almost doubled its travellers between 1992 and 1993. Air Transat entered in 1988 but it was not until 1991 that it gained a significant percentage of the domestic charter market share. In addition, Royal Airlines entered in 1993 and had immediate success. (Statistics Canada 51-207, 1995).

Summary and Conclusion

In summary, the response of the Canadian air transport industry to deregulation has not emulated that of the U.S.. Although regulation in both countries was inefficient, the reaction of the two industries to deregulation has been remarkably different. After deregulation in the U.S., there was an immediate expansion of effective competitors. Conversely, in Canada there was not. The only expansion came after Wardair entered the scheduled market. Since Wardair's exit, the Canadian industry has remained extremely concentrated. Although Canadian charter carriers have been increasing their market share, their presence has not increased the number of effective competitors. Consequently, the U.S. now has approximately eight effective competitors, whereas Canada has only two.

In addition, the Canadian yield index has not emulated that of the United States. Whereas the U.S. yield index has fallen, the Canadian yield index has risen. Furthermore, in 1993, Canadians were paying, on average, 70 percent more for airline tickets than their American neighbors. Therefore, deregulation in Canada has not resulted in increased competition and reduced fares as economic theory would predict. At least any increased competition has not been reflected in these facts.

The yield index also responded strongly to the entry and exit of charter carriers. It can be inferred from this result that charter carriers play an important role in fare determination in Canada. Moreover, the evidence suggests that the influence Wardair had may be similar to that of Southwest Airlines in the United States. Wardair's presence in the Canadian market increased competition and lowered fares. It also may have deterred entry. This is analogous to Morrison and Winston's (1995) finding about Southwest Airlines.

The results of the Vancouver to Toronto case study have a variety of implications regarding airfares. The response of the first class, business class, and economy class fares indicates that since deregulation began in 1984, Air Canada has discriminated in its pricing policy. After the fare ceiling was removed in 1988, it took advantage of the lack of competition to further increase its fares for the inelastic passengers. However, after 1993, increased competition from the charter carriers caused Air Canada to reduce First, Business, and Economy class fares. Moreover, this increased competition ensured that Air Canda maintained its lower advance purchase fares. Therefore, as economic theory would predict, deregulation has facilitated price discrimination on the Vancouver to Toronto route. Thus, it can be inferred that before deregulation discount fare passengers may have been subsidizing full fare passengers.

In addition, although cross-subsidization was reduced after deregulation, it has not been completely eliminated. This is possibly due to the continued regulation of the Canadian north. The weighted average fare is clearly influenced by advance

purchase fares. However, discount utilization has not been sufficient to cause the weighted average fare to fall. Possibly one explanation for the difference in the Canadian and American yields is much greater discount utilization in the U.S.. Furthermore, the dramatic fall in the weighted average fare and the advance purchase fare during the fare wars implies that market factors have a strong influence on fares in Canada.

Clearly, the United States and the Canadian air transport industry have responded differently to deregulation. The U.S. industry has conformed to the economic predictions of increased competition and lower airfares. In contrast, the Canadian industry has conformed only in relation to price discrimination. Its response regarding competition and lower average airfares has conflicted with economic theory.

The results of this study are incomplete at best. Nevertheless, they provide a clear indication that further research is needed. For a thorough understanding of the factors determining the anomalous response of the Canadian industry to deregulation, a complete regression analysis is warranted. Meanwhile, Canadian consumers can only hope that the current open-skies agreement with the United States will increase competition in Canada and lower airfares.

Bibliography

Bailey, Elizabeth E., David R. Graham and Daniel P. Kaplan. *Deregulating the Airlines*. Cambridge, Massachusetts: The MIT Press, 1985: 11-37, 73-89.

Bailey, Elizabeth, and Dong Liu. "Airline Consolidation and Consumer Welfare." *Eastern Economic Review* Vol. 21, No. 4, Fall 1995: 463-475.

Gillen, David W., Tae H. Oum and Michael W. Tretheway. *Airline Cost and Performance: Implications for Public and Industry Policies*. Vancouver, B. C.: The Centre for Transportation Studies, The University of British Columbia, 1985: 3-37, 139-144.

Gillen, David W., Oum T. H. and Tretheway M. W. "Airline Cost Structure and Policy Implicatons." *Journal of Transport Economics and Policy* 24 (1), January 1990: 9-34.

Gillen, David W., Oum T. H. and Tretheway M.W. "Privatization of Air Canada: Why it is Necessary in a Deregulated Enviromnent." *Canadian Public Policy* 15 (3), September 1989: 285-299.

International Civil Aviation Organization, "Traffic Commercial Air Carriers," Digest of Statistics No. 445, 1984-1995.

Kahn, Alfred E. *The Economics of Regulation: Principles and Institutions*. Vol. 2, Toronto, Ont.:John Wiley & Sons, 1971: 172-176, 209-220.

Lazar, Fred. *Deregulation of the Canadian Airline Industry: a Charade*. Toronto: Key Porter, 1984: 25-30.

Official Airline Guide, North American Edition, 1984-1995.

Oum, Tae H., Stanbury W. T. and Tretheway M. W. "Airline Deregulation in Canada and Its Economic Effects." in *Airline Economics and Policy: Selected papers of Tae Hoon Oum*. Eds. T.H. Oum. Seoul: The Korea Research Foundation For the 21st Century, 1995: 157-195.

Oum, Tae H., and D.W. Gillen. "The Structure of Intercity Travel Demands in Canada: Theory, Tests and Empirical Results," *Transportation Research*, 1993: 175-191.

Oum, Tae H., and Michael W. Tretheway. *Airline Economics: Foundations for Strategy and Policy*. Vancouver, B.C.: The Centre for Transportation Studies, The University of British Columbia, 1992: 1-29.

Oum, Tae H., Zang A. and Zang Y., "Airline Network Rivalry" *The Canadian Journal of Economics*, V. 28, No.4, November 1995.

Mark, Greg. American Express travel agent. Interview by author, November 1997.

Morrison, Stephen A.and Clifford Winston. *The Economic Effects of Airline Deregulation*. Washington, D.C.: The Brookings Institute, 1986: 5-7, 40-43.

Morrison, Stephen A. and Clifford Winston. *The Evolution of the Airline Industry*. Washington, D. C.: The Brookings Institute, 1995: 1-163.

Rowan, Geoffry. "Canadian Airlines Faces a tougher haul this time." *The Globe and Mail*, December 2, 1996: B1, B9.

Smith, Jeffrey. electronic mail correspondence, November 1997.

Viscusi W. Kip, Vernon J. M. and Harrington J.P. *Economics of Regulation and Antitrust*. Lexington, Ma. D. C. Health, 1992: 344-355

Weisman, Ethan. *Trade in Services and Imperfect Competition Application to International Aviation*. The Netherlands, Kluwer Academic Publishers, 1990: 31-35.

Winston, Clifford. "Economic Deregulation: Days of Reckoning for Microeconomists." *Journal of Economic Literature* (31) September 1993: 1263-1269.

Canada. Statistics Canada. *Air Carrier Operations in Canada*. cat. no. 51-002,1994.

Canada. Statistics Canada. *Air Charter Statistics*. cat. no. 51-207, 1988-1995.

Canada. Statistics Canada. *Aviation in Canada*. cat. no. 51-501E, 1986, 1993.

Canada. Statistics Canada. *Canadian Civil Aviation*. cat. no. 51-206, 1988-1995.

Canada. Statistics Canada. *Air Passenger Origin and Destination*. cat. no. 51-204, 1984-1995.

Canada. Statistics Canada. *Canada Year Book 1997*.

An Examination of the Current Barriers to Effective Waste Reduction in the Airline Industry: A Case Study of Toronto's Lester B. Pearson International Airport

Introduction

Today's airports form the backbone of the world's global transportation network. The movement of airline waste from one continent to another increases the complexity of the already intricate system of waste management. Interestingly enough, even though waste management and waste reduction continue to receive increased attention in the media, little thought has been given to airport policies concerning waste separation, recycling, transportation and disposal.[1] Reducing waste is not only favourable to the environment, but it can also produce considerable financial savings.

The Toronto Lester B. Pearson International Airport (LBPIA) is the fourth largest entry point into North America, and therefore provides a good representation of some of the typical obstacles that large international airports often find themselves up against with respect to waste management. Currently host to sixty-two different airlines, three catering services, nine ground handling services and over twenty-two million passengers a year, this airport is almost a community in itself. Yet, with all of the traffic that passes through the airport's three terminals (which includes an average of 60,000 people daily)*, its waste management program has remained literally unchanged since the airport's inception. Unfortunately this appears to be a common trend among airports, and one that needs further consideration.

Given increasing pressures to take a more sustainable approach to management, it is worthwhile to consider the current waste management system within the airline industry by using the LBPIA as a case example. To do so, it is necessary to consider the present regulatory structure for waste management and waste reduction at a municipal, provincial and federal level, as it pertains to the Pearson Airport.

An analysis of the current barriers to environmental reform in this industry reveals that some of the difficulties lie in the lack of appropriate legislation at the provincial level, while others stem from the existing organizational framework of airports in general. More specifically, these hurdles include highly decentralized airport waste removal systems as well as terminals that were built without the consideration of a design that would facilitate the movement of waste and recyclable material. Many of these barriers could be alleviated through standardized waste collection methods,

increased communication amongst Canadian airports and the encouragement and reward of outstanding private sector initiatives in the area of waste management. In this way, the enormous volume of waste that currently passes through an airport could be substantially reduced.

The Current Picture

The General Regulatory Structure of Waste Management in Canada

The key planners and enforcers of waste collection, transportation, disposal, reduction and recycling are primarily found at the **provincial** and **municipal** levels. However, as with any environmental policy, the federally legislated ***Canadian Environmental Protection Act*** (CEPA, 1988) has final say in any decision made that will affect the environment. The purpose of the CEPA is to establish a set of regulations that will cover all aspects of toxic chemicals affecting air, water and land, from cradle to grave.[2]

At the provincial level, the **Ministry of Environment and Energy** is responsible for pollution control, such as waste, and administers approximately seven different Acts, including the *Waste Management Act*.[3] The main regulation for waste management in Ontario is **Regulation 347** (The General Waste Management Regulation). This regulation was established under the *Environmental Protection Act* to set prescribed standards for the province of Ontario with regards to location, maintenance and operation of both waste disposal sites and waste management systems.[4] A series of waste reduction regulations was established by the NDP government in 1994 to monitor the level of waste produced amongst the Industrial, Commercial and Institutional (IC&I) sectors. **Regulations 102-105** (also known the **"3Rs Series"**) includes standards for businesses to conduct waste audits, produce waste reduction workplans, organize source separation for recyclable items and conduct packaging audits.[5]

With the election of the Harris government in 1995, several changes have occurred with respect to Ontario's waste management regulatory structure. These changes have been as a result of the Conservatives' promise to reduce unnecessary bureaucracy and duplication of administrative processes through its "Red Tape Review Process". The main changes include a substantial reduction in the budget for the Ministry of the Environment and a general movement away from prescriptive regulation. Part of the Conservatives' plan was to revoke Waste Reduction Regulations 102-105. Yet after much public protest to this change in policy, the Conservatives decided at the end of 1997 to keep the "3R's" environmental legislation that was originally implemented by their predecessors in March of 1994[6].

The municipal government's involvement in waste management entails a two-tiered system that controls and operates local waste. The **lower tier**, such as a town or city, is responsible for the collection of waste, while the **upper tier**,

such as a township or region, is responsible for its disposal.[7] It is likely that increased power will continue to be given to the upper-tier municipalities over the next decade.[8] While municipalities must still conform to the standards set by the provincial government, they also have the freedom to create stricter bylaws to reinforce provincial legislation. Despite the fact that municipalities have been given this increased responsibility, the Ontario government has made substantial reductions in the money it grants to municipalities to deal with these concerns. Funding for programs, such as recycling, has been all but eliminated by the Harris government. This has increased the economic burden placed on local communities.

The Regulatory Structure of the Airline Industry

International airports in Canada fall under a complex combination of international, federal, provincial and municipal legislation. Although the majority of control has traditionally been at the federal level, municipalities have been granted increased power in recent years. Developing a full understanding of the regulatory structure of airports in Canada is imperative to knowing **where** the power comes from and **who** has the authority to has the power to change the current system.

At the international level, there are two main bodies that deal with airport and airline regulations: the International Air Transportation Association (**IATA**) which promotes common industry-wide safety and security standards and the International Civil Aviation Organization (**ICAO**) which is a specialized agency of the United Nations.[9] At the national level, the Ministry of Transportation Canada (**MOT**) is responsible for overseeing the safety and security of both passengers and crew on-board an aircraft. Together, these three agencies play an integral role in environmental decision-making. Anything that affects the operation of an airport or airline must always be carefully considered in this industry since safety and security are top priorities.

In 1994 the decision was made to transfer the operation and management of twenty-six of Canada's largest airports from Transport Canada to community-based airport authorities. Since December 2, 1996, Pearson Airport has been under the management of the Greater Toronto Airport Authority (GTAA). It is hoped that this shift to a community-based airport authority will allow airport management to be more responsive to the needs and visions of the regional community.[10] The GTAA is a privately run non-profit organization that is now responsible for the airport's three terminals as well as for the general administration and operation of the airport itself. As such, it is still obliged to follow the standards and regulations that are set by MOT.

Looking specifically at the operational structure of Pearson Airport's waste collection system (**Figure 1**), it can be said that it is highly decentralized in nature. Each tenant of the airport (such as food concessions, retail stores and

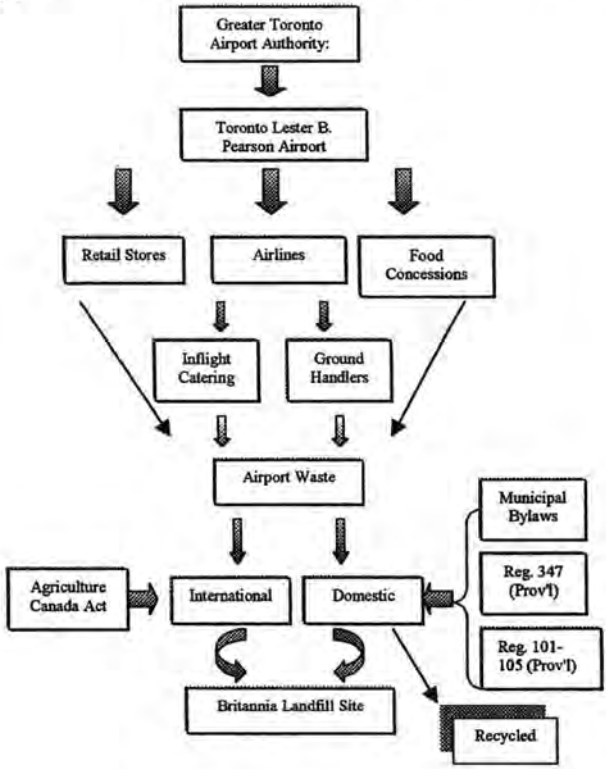
airlines) is individually responsible for the disposal of its waste. Generally, when an airplane touches down in Toronto, the waste generated from the inflight service is taken off by either a Ground Handling Service, or by the airline's Catering Service. In fact, once this garbage is removed, the airline is no longer responsible for the collection, transportation or disposal of this waste. Any flights that originate from a foreign destination (including within North America) are subject to the regulations set out by the ***Animal Health Act*** of Agriculture Canada.[11] Any international waste must be treated and disposed of separately from domestic waste and ***cannot***, at present, be recycled.[12] The LBPIA is the only airport in Canada that has approval to dispose of their waste in a landfill site. As a general rule, all international waste originating from an airline's inflight service must be incinerated.

The Britannia Landfill Site, located just west of the airport, is the location for the international waste at Pearson Airport. Certain conditions must be met at this facility for the disposal of the international waste. For example, the waste must be placed a certain distance from any watershed or waterline, it must be buried daily and a fence must be installed around the landfill to keep wildlife out.[13] Under the direction of the Region of Peel, the Britannia Landfill charges an eighty dollar tipping fee for one tonne of either domestic or international waste. Peel Region has decided not to deal with any recyclable waste that is collected by private haulers, and thus, IC&Is are obliged to take any recyclable material to private recycling facilities.[14]

Presently, airlines and airports are under no obligation to develop or enforce plans for waste reduction and have, generally in Canada, made little progress in this area. Although some airlines are beginning to develop environmental management teams, waste reduction programs are most often organized by the inflight personnel that deal directly with the garbage on-board the aircraft. Some airports, such as the Toronto LBPIA, have initiated small recycling programs in the terminal buildings, such as placing recycling receptacles near cafeterias and retail outlets. This program was organized by the **Environmental Management Team** of the GTAA. At present, the general handling of waste at the airport is highly decentralized in the sense that the retail stores, cafeterias, airlines, ground handling services and catering services all operate on separate waste management systems which are collected and disposed of by private haulers.

As previously mentioned, the waste management system has remained relatively stagnant at LBPIA over the past twenty years, although some attempts have been made at modernizing the present system. This next section will focus on some of the obstacles that are impeding companies to take more effective action. These barriers will be examined from a provincial level as well as from an industry-specific point of view.

Figure 1: Waste Management at Toronto's Lester B. Pearson International Airport



Limitations to the Current Structure

Airports usually enjoy a considerable amount of freedom and independence with respect to planning and management of the airport itself. There is no set standard for solid waste management in this commercial sector, even though other environmental concerns have been regulated for many years. Traditionally, the focus of these concerns has been on noise pollution since it is

an issue that is easily "visible" to the public.[15] Waste, on the other hand, is an issue that is often put aside, due to its complexity.

Understanding the organizational framework of an industry provides us with clues as to where the weaknesses lie in the present system. In the case of the airline industry in Ontario, some of these weaknesses are a result of the provincial government's current regulatory stance, while others involve the logistical design of the airport itself. The identification of these barriers helps us to find a starting point for improving the current level of environmental initiative.

General Limitations in Ontario

Throughout history, the provincial government in Ontario has been unable, or unwilling, to instigate and enforce appropriate legislation in the area of waste management.[16] Furthermore, the government has taken a predominantly *re*active approach in developing waste management regulations by focusing on treatment *alternatives*, when it should be concentrating on waste *reduction* plans. The latter of these approaches often proves costly to both the government and the private sector and is generally far less effective than taking preventative measures.[17] Similarly, Macdonald points out in his book *The Politics of Pollution* that providing incentives "either by economic means of disposal pricing or through legislation and regulation carries a political price that elected representatives in Ontario, and in other Canadian provinces, have been unwilling to pay".[18]

With respect to environmental issues, the policies of the provincial government have undergone many changes over the past three years. As previously mentioned, the early 1990s brought with it strong regulatory policies under the leadership of Bob Rae. However, since 1995, when Ontario Conservative leader Mike Harris came into power, we have been witness to a regulatory system that is rapidly weakening. More responsibility is being given to the private sector because of cutbacks that are occurring in the province's previous environmental initiatives. This restructuring of the MOE through the Conservative's "Red Tape Review Process" is not only making it difficult for the province to develop a clear set of standards for industry to follow, it is also creating uncertainty in the private sector. Any insecurity in the business world generally leads to conservative action, which, in this case, is resulting in reduced levels of investment in 3R's technology.[19] Mark Winfield, Director of Research at the Canadian Institute for Environmental Law and Policy, feels that the current approach to environmental legislation in Ontario has not remained static for long enough, and has not generally been enforced. This, he believes, is creating no incentive for the private sector to act, or *re*act, in this area.[20]

Most importantly, however, are the substantial reductions in funding that continue to be made by the Harris government. The almost one hundred

million dollars that have been cut from the MOE's operating expenditures budget in the past two years have greatly affected waste management, as well as many other environmental programs, in Ontario. The effects from these cuts are also being felt strongly at the municipal level, as municipalities find themselves being removed of any funding for recycling programs. Although the trend over the past five years has been to create a more decentralized waste management system (by giving the municipalities greater control) local communities now find themselves with no support from the provincial government to initiate or enforce policies.

Despite these reductions in budget, tipping fees for IC&Is remain surprisingly stable, and generally low. Considering the laws of supply and demand, the current tipping fees are creating no incentive for businesses to develop any means of reducing their volume of garbage. Furthermore, fees to take materials to private recycling facilities are often hefty and very much dependent on the market's "going rate" for the various materials.

The barriers to waste management that have been mentioned up to this point provide only part of the story. There is an additional obstacle course, in the form of indirect legislation, through which both airlines and airports must pass.

Limitations in the Airline Industry

Some of the major barriers to improving the current waste management system in the airline industry come from non-environmental legislation implemented by Federal departments such as the Agriculture Canada and the Ministry of Transportation. For example, as mentioned in the previous section, the *Animal Health Act* has been established, in part, to control the any animal or food related products that travel in or out of Canada. The restrictions that are currently in place for the proper disposal of any international waste makes it difficult for airlines to reduce current levels of inflight waste. As the LBPIA is the fourth largest entry point into North America, Toronto has more than fifty per cent of its flights coming and going from international destinations. Current Agriculture Canada regulations effectively eliminate the possibility of recycling any waste from these flights.

The lack of clarity, or lack of knowledge, of the regulation's existence has resulted in a few particular airlines "illegally" recycling their waste! Interviews with two Canadian airlines (who will remain nameless) revealed that although they both had recycling programs in place, they did not restrict source separation only to domestic flights. Avi Gil, Chief of Aeropolitical, Regional and Environmental Affairs at the Airports Council International in Geneva feels that, in general, national legislation regarding the transboundary transport of waste may not be neither clear, nor sufficient.[21] Needless to say, whether it is as a result of naiveté or direct violation of legislation, several major airlines have

waste recovery programs that include the recycling of material from both domestic and international flights.

Another major obstacle is the issue of safety. As *The Environmental Management at Pearson Airport* report states, "protecting the environment is a high priority at LBPIA, second only to safety." The difficulty here is that the priority of safety issues often clashes with environmental activities. For example, the Ministry of Transportation has created strict regulations with respect to where garbage can be placed on an aircraft, making it difficult for an airline to store any separated waste that cabin crew may have collected during the flight. Both Air Canada and Canadian Airlines' Environmental Managers agreed that this was, indeed, a difficult obstacle to overcome in the quest for inflight recycling.[22] High safety standards, however, are an essential part of the air transportation system and cannot be overlooked or compromised.

One of the most common critiques of the current operational structure of waste management at airports is that it is too decentralized. Although the trend in Ontario over the past five years has been towards decentralizing waste management systems, it has not proven to be an effective alternative for airports. Each component of an airport currently runs its own waste management system, leaving little room for standardization, or uniformity, of collection and disposal methods. In a waste audit study done for Los Angeles International Airport, the largest complication found was that there was no centralized control of waste stream information. By using the theory of economies of scale, airport waste management systems could generally increase their efficiency by working together on a collective basis.

Decentralized waste systems are a problem not only at individual airports, but also amongst the industry as a whole. Many airlines are having difficulty finding an effective recycling program that will work at every major airport in Canada. Travel between provinces brings with it the different standards and regulations of each location. At some airports, for example, there is currently no option to recycle inflight waste since the terminal does not have a system in place. Other airports only have facilities to collect certain items. This lack of uniformity causes logistical nightmares for the environmental departments of airlines who are working to develop effective waste reduction programs for their inflight service.

One of the major concerns about the future of waste management at airports is the emphasis that the Harris government is placing on industry-managed solutions to environmental problems. Even if airports and airlines were willing to develop waste reduction programs, the intricacies of the current system do not allow for efficient waste management. The lack of motivation, or of incentives, from the provincial government is not easing the situation, and many sectors of the airport do not have the capital resources to initiate their own programs. This is presenting an economic barrier to further development in this area.

An additional deterrent is the way in which airlines pay for the production of waste. Generally, the catering or ground handling service charges each individual airline a set rate that is calculated by the number of passengers that were on-board the flight. Most tenants of the airport's terminal pay for their waste through individually contracted haulers.[23] Under this system, however, if one company develops a waste reduction program for their inflight service, they are not going to reap the full benefits of the initiative. Secondly, if an airport-wide recycling program were to be implemented, this would create billing nightmares for the airport authority.[24] Stemming from this, is the issue of accountability. The garbage from the current waste management system passes through several different hands before it finally is disposed of in the landfill. It is therefore questionable who is really responsible for the waste that is created. This "passing the buck" syndrome needs to be examined more closely so that the level of subjective or objective accountability can be increased to motivate the bodies responsible to take action.

Should the airport be accountable for the waste a foreign airline leaves in Toronto? Should the airline be accountable for its own waste even though it is the catering and ground handling services that collect and dispose of it? By deciding who is (are) responsible for the waste, we can also determine who has an obligation to make plans to reduce it. This is an issue that has, thus far, not clearly been addressed at airports in Canada. Although the complexities of accountability are beyond the scope of this paper, it remains nonetheless an important issue in environmental policy.

Putting environmental regulations aside for a few moments, there are several matters of logistics that are adding an extra few hurdles to the waste management challenge. The first is the issue of security. Consider the Lester B. Pearson International Airport in Toronto. Due to the high volume of traffic that passes through Pearson International, security is always a major concern. Therefore any changes to the current waste management system at the airport must be approved by and communicated to the airport's security division. Secondly, the present design of the terminals, namely of Terminals 1 and 2 at LBPIA is also a concern. These buildings were designed far before waste management was a major concern, and thus they did not take into consideration a design that would facilitate the movement of waste and recyclable material throughout the building(s).[25] Space restrictions within the airport's terminal are an integral part of this problem. It is difficult to find somewhere to store materials until they can be taken away to a MRF (Materials Recovery Facility).[26] Perhaps a lesson can be learned from Canada's American counterpart who is now scrambling to retrofit obsolete airport waste management systems as more and more environmental legislation takes effect.[27]

Finally, there are specific constraints that apply to designing an effective waste reduction plan on the aircraft itself. These barriers are based on comments from airlines that have already implemented waste reduction

initiatives either successfully or unsuccessfully. Airline representatives cite similar problems that were resulting in a set back of their efforts towards waste reduction. Number one in the list was the lack of consistently available time for the flight attendants to collect and sort recyclable items on board. In second place, was the problem of storage both on-board the aircraft and on the ground once the plane reached its destination. The financial benefits from recycling are considerably lessened because of the need for the waste to be frequently removed from on-site due to the lack of adequate storage space.[28] Other problems that were mentioned include the unreliability of markets (depending on the aircraft's final destination), the lack of co-ordination between the ground and air operational efforts[29] as well as difficulties in obtaining the proper permits for the local recycling operator to have airport security clearance.[30] Gil Peters, manager of food services at Northwest Airlines (USA) stated that their largest obstacle to recycling was working their way around the city's waste flow ordinance that guarantees airport waste for the local incinerator.[31]

Finally, the attitudes of airline passengers towards waste reduction initiatives is one aspect that cannot be overlooked. In a conference paper directed at British Airways, Hugh Somerville stated that:

> The obvious dilemma for airlines in this area is the conflict between the provision of the high quality service that the customer expects and the creation of apparently unnecessary waste. The 'average' traveller is not yet prepared to do without in order to conserve materials.[32]

Unfortunately, this statement has a lot of truth to it. For the most part, a passenger's expectation of the service he/she should receive on-board an aircraft outweighs his/her attitudes towards waste reduction programs. Passengers may be keen on recycling and waste reduction until they discover that in order to have source separating bins on-board, there is no longer room for an extra meal cart. Without the support of the public to push airlines and airports into action on this issue, environmental supporters are fighting an uphill battle.

In conclusion, there are many obstacles and barriers to effective waste management in the airline industry such as ineffective legislation, logistical complexities of airports and lack of corporate financial support. Many positive outcomes have also been achieved through the promotion of waste reduction. As the old cliché goes, "every little step counts". The next move, however, must be to work towards ways to eliminate or plan around the existing boundaries.

Stepping over the Barriers

There are a number of ways to lessen the impact of these barriers on the current system. These include devising standards or regulations appropriate to airlines and airports, encouraging and rewarding private sector initiative and improving alliances and communication between certain groups in the airline industry.

In February of 1997, a conference held at Queen's University on the *Canada-Wide Accord on Environmental Harmonization* unveiled several common themes of environmental policy. Among them was the notion that any plan that is created, whether it is regulatory or voluntary, must be *flexible and adaptable* so that it does not smother the creativity of finding a workable solution to the problem at hand.[33] Furthermore, the "pros" and "cons" of voluntary initiatives versus legislative action must be carefully considered with respect to the individual situation. For example, sometimes the "carrot" works better than the "stick", and vice versa.[34] Thirdly, the role of the public, and of special interest groups, in any given situation is a key issue that needs to be taken into account before proceeding with a prescribed action.[35]

It is not easy to decide the appropriate level of government involvement as well the respective roles of the public and private sector. There is currently much debate over the effectiveness of traditional regulatory measures versus voluntary pollution prevention initiatives by the private sector. Since the dismantling of the regulatory structure in Ontario in recent years, the province has joined many other Canadian provinces in a movement towards increased pressure on the private sector to undertake voluntary environmental initiatives. The current focus of the provincial government on industry-managed solutions is not sufficient to resolve the problems at hand.

If the provincial government, however, decides to concentrate on private sector initiatives, certain ingredients must be readily available in order for them to be effective. These include incentives to reduce costs, external pressures from public interest groups as well as the desire by industry to avoid or delay regulatory action. The mere *threat* of regulation is often enough to drive any industry into environmental management activities.[36] A certain level of government interaction is always necessary, even if the role of the government is simply to offer incentives and assistance in helping businesses increase their current level of voluntary pollution prevention measures. More specifically, government intervention such as tax incentives, grants and educating IC&Is to evaluate their present waste management system, will provide an excellent stepping stone to improved environmental improvements such as waste reduction.

But as the Canadian Institute for Environmental Law and Policy's report "Putting the Environment into Green Industries" points out, one of the best incentives governments can provide to IC&Is is a regulatory system that does not remain static, and one that is enforced. The major problem with this method is that, as the Harris government discovered, regulation requires costly administrative structures in order to ensure compliance. This is a price most governments are not willing to pay.

A solution that can often be used in tandem with more direct forms of regulation is the use of economic instruments to internalize the cost and benefits of reducing waste.[37] This "polluter pays" strategy would complement the

Ontario Government's focus on industry-managed solutions by using market forces to influence IC&I behaviour. Effluent charges in the form of increased tipping fees would institute the laws of supply and demand to influence the use of waste reduction programs in the private sector. This type of system has experienced a considerable amount of success at the municipal level of solid waste management in both Western Europe and in the United States.[38]

The general trend of waste management in Ontario, and in Canada, is towards giving municipalities increased control over waste management and waste reduction programs. This, however, may not be an effective solution for waste management programs at airports. The general consensus amongst the current literature on airport waste is that the present system must become more centralized.[39] This movement towards centralization must come from two levels. First of all, there must be a centralized authority at each airport that standardizes the system used to reduce and recover in-house waste. This includes increasing cooperation amongst the airport authority, airlines, catering services, retail stores and ground handling services. Some of the advantages of centralization of services at airports include:

- better contract prices for waste collection
- increased ability to enforce compliance to standards/regulations
- possibility of maximizing recovery of recyclable material through standardization of collection and transportation methods.
- financial savings from avoided waste disposal costs[40]

The second level of centralization must occur between the airport authorities across Canada. Cooperation in this area will help to combat some of the present difficulties airlines are experiencing with waste reduction programs that are not standardized across-the-board. The recent transfer of operational and management power from Transport Canada to the Canadian Airport Authorities represents an excellent opportunity to create alliances amongst Canada's twenty-six largest airports.

For the case of the Lester B. Pearson International Airport, a plausible solution might be for the Greater Toronto Airport Authority to take more control over the current waste management system. Although its Environmental Management Team has organized some recycling efforts in parts of the three terminals, a more comprehensive system is necessary. As Dawn P. Jacalone points out in her article "Incorporating Recycling into Airports: Opportunities and Complexities," it is necessary to gain the support of a general airport authority. Individual efforts by airlines will not maximize the results that an airport could expect to achieve for their waste management program.[41]

Furthermore, the planned building of a new terminal to replace Terminal One and Two provides the airport with a perfect opportunity to integrate the necessary changes to the current waste management system. It is a

well-known fact that progressive waste management and recovery systems can be implemented far more efficiently and effectively if they are preconceived in the design, rather than forced on the existing structures.[42] The following provides a summary of specific recommendations that could help to improve the current waste management system both at Pearson Airport as well as at Canadian airports in general. These industry-specific solutions are based on the ideas that were discussed earlier on in this section:

- centralize the waste management system to be controlled by one body within an individual airport.
- develop a communication system amongst the various governmental departments responsible for airport regulations (i.e. Ministry of Transport, Agriculture Canada, Ministry of Environment and Energy, etc.) to straighten out any intradepartmental conflicts regarding regulations/standards.
- encourage the airline industry's private sector to initiate waste reduction programs by providing incentives such as government grants, education tools, tax savings and effluent charges (i.e. increased tipping fees).
- improve alliances between certain groups in the airline industry, such as airport management, catering services, airlines, ground handling services and retail outlets.
- develop a set of uniform standards/regulations in Canada for airport waste reduction that are monitored and enforced by a central agency (i.e. as part of the group of Canadian Airport Authorities). These regulations should be both *stringent* and *certain*.
- revise the present system of having a "collective" method of charging airlines for their waste in order to form incentives for them to create more comprehensive reduction programs (i.e. each airline should be charged according to the *individual* waste they produce).

It is clear that the current regulatory structure for waste management in Ontario is not sufficient to motivate the airline industry (or IC&Is in general) to take action with respect to the present waste management crisis that is rapidly developing. As discussed above, the solutions for overcoming the obstacles that lay in their path must not only come from industry-managed solutions, but more importantly from a regulatory system which provides both the metaphorical "stick" and "carrot" through standards and regulations that take into account the industry-specific barriers to waste reduction.

Conclusion

Since the election of the aggressive Conservative party into the provincial government in 1995, the slant of Ontario's environmental policy has been towards voluntary initiatives and industry-managed solutions. Similarly, the

control of the municipalities over the issue of solid waste management has increased considerably over the past four years due to changes in the *Municipal Act*.

Some critics of the present regulatory structure feel the funding cuts that have occurred (as a result of Harris' "Common Sense Revolution") are unacceptable. Although the private sector should play an important role in resolving the waste management problems, many feel that letting IC&Is carry out this role through voluntary initiative alone will not be sufficient to combat the problems at hand. A careful balance must be found between government and private sector involvement. Government participation is necessary to push businesses to take on environmental management programs. Industry, however, also needs to be involved in order to tailor a program that fits both their specific needs and limitations they may have.

Within the airline industry itself, there are several factors that are making it difficult for this sector to effectively establish waste reduction programs. Logistical problems of airports that were designed before waste reduction was an issue as well as safety and security issues regulated by the federal Ministry of Transportation limit somewhat the actions that can be taken. Amongst the most difficult barriers to overcome is the fact that waste originating from an international flight (including transboundary US destinations) cannot, at present, be recycled. Reconsideration of some of the current airport legislation might help to increase the current options for waste management programs.

The present system of the collection, transportation and disposal of airport waste is also too decentralized to be effective. As waste passes through many different hands before it is disposed, it is difficult to determine who is ultimately responsible. The lack of standardization between Canadian airports results in a logistical nightmare for airlines trying to establish a workable program and is something that needs to be improved.

The extraneous factors of the airline industry make it a unique case for the waste management sector to resolve. Conducting waste audits and implementing education programs will create increased awareness of the waste problems the airline industry is experiencing. This will provide an excellent stepping stone for pursuing an area that, to date, has been given little attention.

---

[1] Suzanne C. McClean, "World's airport operators face a variety of critical environmental issues", *ICAO Journal*, Jan.-Feb., 1995. p. 6.

• Based figures taken from the yearly rate of passengers and divided by 365 days. Source: Lester B. Pearson International Airport Yearbook and Directory, 1996. p. 8.

[2] David Estrin and John Swaigen, *Environment on Trial*, (Toronto: Edmond Montgomery Publications & CIELAP, 1993), p. 480.

[3] *Ibid.* pp. 33-35.

[4] *Ibid.* p. 773.

[5] Based on a summary of the Ontario Ministry of Environment and Energy 3Rs Series, 1994.

[6] Tim Webb, Personal Communication , Ministry of Environment and Energy, March 3, 1997.

[3] *Ibid.* pp. 33-35.
[4] *Ibid.* p. 773.
[5] Based on a summary of the Ontario Ministry of Environment and Energy 3Rs Series, 1994.
[6] Tim Webb, Personal Communication , Ministry of Environment and Energy, March 3, 1997.
[7] Doug Macdonald, *The Politics of Pollution: Why Canadians are failing their environment,* [note 8], p. 206.
[8] Estrin and Swaigen, *Environment on Trial,* [note 3], p. 773.
[9] www3.itu.ch/MISSIONS/US/bb/iata.html and www.icao.int/.
[10] Transport Canada Airports, *Lester B. Pearson International Airport: 1996 Annual Review*, p. 1.
[11] Personal Communication, Brian Skul, Ministry of Agriculture, Guelph, July, 1997.
[12] *Ibid.*
[13] Personal Communication, Malcolm Metcalfe, Canadian Airlines Environmental Management Team, March, 1997.
[14] Personal Communication, Region of Peel "Wasteline", August, 1997.
[15] Hugh Somerville , "The Airline Industry's Perspective", in *Transportation, the Environment and Sustainable Development* (for British Airways, Heathrow International Airport, UK:, Chapman & Hall, 1993) p. 161.
[16] For examples of this point see Mark Winfield's "*Putting the Environment into Green Industrial Strategies*" and Doug Macdonald's *The Politics of Pollution* (p. 202-216).
[17] Kirsten Oldenburg and Joel D. Hirschhorn, "A New Strategy to Avoid Pollution", *Environment*, Vol. 29, No. 2. p. 18.
[18] Doug Macdonald, *The Politics of Pollution: Why Canadians are failing their environment,* [note 8], p. 203.
[19] Mark S. Winfield and Jan Rabantek, *Putting the Environment in Green Industrial Strategies*, (Toronto:CIELAP, 1995), p. 3
[20] *Ibid.* p. 3.
[21] Avi Gil, "World's Airports concerned about handling of several crucial environmental problems", *ICAO Journal*, Jan/Feb. 1994. p. 10-12.
[22] Personal Communication with Malcolm Metcalfe of Canadian Airlines and Don Maclean of Air Canada, Feb. 1996.
[23] Dawn P. Jacalone, "Incorporating Recycling into Airports," [note p.18], 48-50.
[24] *Ibid.* p. 52.
[25] Personal Communication with Randy McGill of the GTAA's Environment Management Team, July, 1997.
[26] Dawn P. Jacalone, "Incorporating Recycling into Airports", [note 18] p. 52.
[27] *Ibid.* p.47.
[28] Jeanne Trombly, "Airline Recycling Takes Off", *Resource Recycling,* Feb. 1991, p. 62
[29] Prall Culviner, Recycling Takes Off! *Waste Age*, March 1993, p. 71
[30] Trombly, [note 36], p. 62.

GLOBALIZATION: BRITISH AIRWAYS' VISION AND PROSPECTS

Phoebe Ho
Department of Civil Engineering
University of British Columbia

1.0 INTRODUCTION

British Airways (BA) is the largest international passenger carrier in the world, as well as one of the most profitable. Ever since its privatization in 1987, BA has been very aggressive in acquiring new or existing airlines in Europe and pursuing strategic alliance with other international carriers to extend its market network. It is currently negotiating an alliance with American Airlines, the world's second largest airline in terms of revenue and passengers carried, and the mega-alliance is bound to bring significant impacts to the airline industry on a global basis.

This paper will investigate the topic of airline globalization from the perspective of BA: its existing global network, its corporate goals and business strategy, the threats it brings to its major competitors, its effect on the European airline market with the full force of the EU liberation, as well as the ripple effect on the global market as a whole.

2.0 BACKGROUND

2.1 Airline Industry in a Global Market

Air transport has long been recognized as one of the most rapidly changing industries in the world. Its intimate connection to the global economic and political climates further makes the airline business one of interest and fascination. The US deregulation of its airline market in the mid 1970's and the subsequent privatization of international airlines in the 1980's have redefined the nature of competition in the civil aviation industry. January 1993 saw the introduction of open skies within Europe when a single market in aviation formed part of the range of economic activities in the European Union

Starting in April 1997, the intra-EU airline markets are completely liberated where member countries are free to operate in each other's domestic markets.

In response to the open market environment in the airline industry, airlines have engaged extensively in global alliances and partnerships. As of June 1996, more than 389 alliances have been formed between 171 international carriers[1]. Industry experts have observed that "*alliances among airlines are not a passing phenomenon but rather a permanent fixture of the industry*"[2]. It is the industry's prediction that a limited number of major global alliance networks will likely be formed in the near future and that these global alliances will be competing for the majority of the world's air transport traffic. By the year 2000, the six principal markets - the Pacific region, North America, Europe, and the markets between them - will account for almost 80 percent of global demand for scheduled services. Any successful international airline will have to secure a strong presence in each of these markets to be a truly global airline.

2.2 British Airways: Corporate Overview

February 1998 celebrates BA's 11 years of privatization and its legendary success in turning the ailing carrier into one of the most far-reaching and profitable in the world. As of March 31, 1997, British Airways, with its alliance carriers, has a global network coverage of 474 destinations in 103 countries. Its fleet of 249 aircrafts had carried a total of 38 million passengers and 721,000 tonnes of cargo in the year 1996-97, generating an operating revenue of £8,359 million (US$13.7 billion) and an operating profit of £673 million (US$1.1 billion). Approaching the new millennium, the company's declared mission is "*to be the undisputed leader in world travel*" and the corporate focus will be on "*international routes and building global alliances which enables BA to stretch its brand into travel-related areas*"[3].

3.0 BRITISH AIRWAYS' GLOBAL NETWORK

Beginning in the early 1980's, BA has adopted a global corporate strategy in terms of marketing and operations in order to provide integrated airline services to consumers world-wide. BA's existing global network consists of airlines involving equity investments, franchise agreements and code-sharing agreements. Up until recently, BA's globalization strategy has been focused on

---

[1] Airline Business, June 1996.
[2] Oum, T.H., Park, J.H., Airline Alliances: Current Status, Policy Issues and Future Directions, *Journal of Air Transport Management*, March 1998, pp.1.
[3] British Airways Reports & Accounts, 1996-97.

making investments in its partner carriers, as investments tend to permit a stronger strategic link in alliance formation. However, equity alliances can become fragile when the strategic goals and policies diverge between the partner carriers. This is especially true in unidirectional investments when the investor airline over-exercise their controlling power over the junior carrier or when the junior carrier attempts to regain its autonomy after coming out of its financial crisis. Recognizing this potential shortcoming of equity alliances, BA's revised strategy lies in building alliances based on broad commercial and equitable gain-sharing arrangements. Towards this end, BA's single most notable development in recent years was its intended alliance with American Airlines and their subsequent efforts to gain ratification and approval from the British Government, the United States Government and the Commission of the European Union (EU). Furthermore, BA is actively strengthening and expanding its relationship with its equity investment, franchise and code-sharing partner airlines. These alliances are described in more detail in the following sections while the proposed BA-AA alliance and its potential impacts will be explored in Section 4.

3.1 Equity Investments

BA places significant emphasis on equity investments in its alliance partners as alliances involving equity exchange tend to form more stable and longer-term relationships. The two planks in BA's equity partnership include the alliance with Quantas, giving BA a presence in the Asia/Pacific region, and its investments in TAT European Airlines (Air Liberte) and Deutsche BA which help strengthen the airline's dominance in continental Europe.

TAT European Airlines and Air Liberte

In 1992, BA purchased a 49.9 percent stake in the French TAT European Airlines when Air France was forced by the EU Commission to sell its 35 percent share in the airline as a result of its recent acquisitions of UTA and Air Inter. In August 1996, BA purchased the remaining 50.1 percent of the share capital of TAT European Airlines which was then fully consolidated as a quasi-subsidiary of the BA Group. In January 1997, BA acquired effective control of Air Liberte based at Orly Airport, Paris, operating mainly scheduled services within French overseas territories. The control of TAT and Air Liberte has allowed BA to develop its presence in continental Europe. It has also enabled BA to compete directly with Air France, the long-struggling government-owned airline, in its own market. Together, the two airlines code-share with BA a total of 33 destinations, 26 of which in France and 7 in Africa, the Indian Ocean and the Caribbean. With the full force of EU liberalization, BA will be in a good position to compete with all other European carriers.

Deutsche BA

In March 1992, BA acquired a 49 percent share of the German Delta Air and renamed it Deutsche BA. Right after its acquisition, Deutsche BA immediately set about challenging its main internal competitor, Luthanza, by simultaneously exploiting the dual advantages of being part of the international BA partnership and of being a true German airline. Since its first commercial jet flight in June 1992, the airline has grown rapidly and has secured a 34 percent share of the German market. Today, Deutsche BA operates more than 900 scheduled and charter flights a week to 23 destinations in 8 European countries. Its jet fleet is mainly concentrated in the new Munich Airport, with Berlin as the other major hub operation. The route structure is separate yet complementary to BA's own network, using the Gatwick Airport as a feeder for the BA flights. The Deutsche BA partnership, and the similar setting with TAT/Air Liberte, gives BA a European hub-and-spoke arrangement with flights from Germany and France feeding into its trans-Atlantic network in London.

Quantas Airways

The acquisition of 25 percent of Quantas' shares has enabled BA to expand its route network to the Southeast Asia and Pacific regions. In the BA-Quantas alliance, BA sees itself benefiting from efficiencies gained through joint frequent-flyer programs, bulk purchasing of fuel and aircraft machinery, and overall aircraft purchases. Benefits will also arise from shared maintenance facilities, higher aircraft utilization and combined staff training. In addition, extensive code-sharing will enable the two carriers to improve flight scheduling, coordination and service quality, leading to higher market shares in the Asian/Pacific market. In addition to their combined 4 flights/day service connecting the UK and Australia, BA code-shares with Quantas to 13 destinations in the Asia/Pacific region. Starting in early 1997, BA and Quantas operate as one airline in Singapore and Bangkok with the Singapore flights providing connections to 8 other destinations in the region.

Air Mauritius

BA currently holds a 12.8 percent share of Air Mauritius, the regional carrier of the former British colony and now the popular tourist island in the Indian Ocean. Besides its home market in Mauritius, Air Mauritius provides connections between London and a number of destinations in North Africa via the London Gatwick hub.

Recent developments in BA's equity investments include the withdrawal of United Airlines in the early 1990's when United decided to expand their own operations in trans-Atlantic routes, and the departure of US Airways due to the potential BA-AA partnership. Despite its existing 24.6 percent equity holding

in the US Airways Group, Inc. (formerly USAir Group, Inc.), the far more extensive market reach of American Airlines made the prospect of this new alliance a matter of long-term strategic importance to BA.

3.2 Franchise Agreements

According to Robert Ayling, BA's Chief Executive, the most economic path to growth and one of BA's favourite strategies is franchising. BA has forged franchise agreements with a number of regional airlines in its effort of empire building. Ever since its formation two years ago, BA's franchise business has gone from a turnover of zero to more than $76.5 million, with the major revenues from franchise fees. As of today, BA has a total of eight franchise airlines which carry approximately 5 million passengers annually on 150,000 flights. BA estimates that 10 percent of these flights are fed into its system.

The benefits of franchising to BA's long-term strategies can be identified in three major areas. Firstly, franchisees provide significant feeder traffic into BA's long-haul flights; secondly, franchise airlines create a sense of presence in those parts of the world where BA cannot reach with its own force; and thirdly, franchising saves BA money in capital investments. An example of the success of BA's franchising business can be found in the operations of Manx and Loganair in Scotland. For years, BA's scottish "highland and islands" operations lost millions of dollars because the loads it generated were not enough to offset BA's high fixed-cost structure. With the involvement of Manx and Loganair, which have assumed nearly all of BA's Scottish routes, losses in Scotland have diminished considerably. As most franchise partners acquire their own aircrafts, franchising has also played a role in BA's deferment of a $1 billion order for 60 regional aircrafts to replace its ageing Boeing-737's. Another advantage of franchising for BA is that there is no union limitations on the size of aircrafts owned by franchisees, allowing them to operate the most cost-effective aircrafts to feed BA's hubs. Franchising, despite its short history, has no doubt helped BA achieve its dominant position in the UK.

3.3 Code-Sharing Agreements

In addition to the equity investments and franchise arrangements, BA has a number of code-sharing agreements with its alliance carriers on specific routes. In early 1997, BA has expanded its code-sharing agreement with Canadian Airlines International (CAI) on its Europe-Canada routes. BA now code-shares with CAI on more than 800 flights each week between 14 cities in Canada and 7 in the UK and Europe. Code-sharing with America West Airlines has also enabled BA to reach 12 major destinations in the US and a further 65 destinations via America West's domestic network.

3.4 Route and Hub Planning

BA's operations is traditionally based in the London Heathrow Airport with a market share of 39% of all air transport movements in and out of the airport[4]. London Heathrow is the world's leading airport with a total annual traffic of $44.3 millions in international passengers handled. In addition to the principal base at Heathrow, BA has placed much focus in recent years at the Gatwick Airport to relieve the congested Heathrow operations. Together with the partner airlines, BA now operate up to 116 destinations from Gatwick - more than from Heathrow. Since April 1997, new services have been launched to link Gatwick with Glasglow, Barcelona, Lisbon, Warsaw and Krakow. Flights to St Petersburg and Pisa have been transferred from Heathrow, together with a new four times weekly service to Riga in Latvia. Latin American services from Heathrow have also been transferred to Gatwick. With the combined strengths of Heathrow and Gatwick as the gateways to the rest of Western Europe, BA has built a successful hub network despite its severely constrained geographic location.

4.0 BA-AA ALLIANCE

On June 11, 1996, British Airways announced its plan to form a world-wide alliance with American Airlines (AA), the world's second largest airline in terms of Revenue-Tonne-Kilometre carried. The mega-alliance represents the most ambitious globalization strategy in the history of BA and is bound to bring significant impacts to the international air travel industry. The alliance is also faced with unprecedented political and regulatory complications as it is perceived as the catalyst for the long-pursued goal of replacing the Bermuda 2 bilateral agreement with a liberal UK-US Open Skies. This section discusses the proposed alliance, the potential benefits to the two partner carriers, the political and regulatory implications, and the major competitors in the globalized air transport market.

4.1 The Proposed Alliance

The proposed BA-AA alliance is an extensive code-sharing agreement to provide customers of both airlines the benefits of dealing with a single carrier. A vast choice of routings and schedules will be offered over one of the world's largest airline networks. The alliance will enable both carriers to achieve operating and marketing efficiencies leading to lower unit costs. The potential benefits of the alliance, for both passenger and cargo traffic, extend to more than 36,000 city pairs, comprising a 61 percent market share in the UK-US market, a

[4] Market share information from British Airways website at http://www.british-airways.com.

28 percent market share in the Europe-US market and an 18 percent of all world scheduled revenue-passenger-kilometre.

As concluded by a study by Roberts, Roach & Associates, Inc.[5], full implementation of the BA-AA alliance will generate the following benefits:

Service and Frequencies:
- an 86% increase in weakly flights between London and the US;
- first non-stop London service for six US cities and , eventually for as many as six more;
- new London carriers for 12 US cities that already have some non-stop London service;
- 29 US cities with new or additional service to London Heathrow;

Traffic:
- 9.4 million new passengers annually between London and the US consisting of:
  - 4.5 million local passengers between US cities and London;
  - 4.3 million passengers between US cities and other points in Europe;
- 600,000 passengers between US cities and points beyond London in Africa, the Middle East and Southeast Asia.

4.2 UK-US Open Skies

One important aspect of the proposed alliance relates to its linkage with the Open Skies agreement between the UK and the US. As required by the US Department of Transportation (DOT), the replacement of the existing restrictive Bermuda 2 bilateral agreement with Open Skies is a pre-requisite to the approval of the alliance. With the proposed Open Skies, the UK/US carriers will be given complete market access, as well as route, schedule, capacity and pricing freedoms. On the one hand, Open Skies will promote competition in the Trans-Atlantic market as it will open the flood-gate to dramatic increases in service by every one of the alliance's existing competitors and by any other new carriers. It will also permit access to the London Heathrow by any US carriers denied Heathrow access by Bermuda 2. Over time, this will result in the shift of much of the existing US-London Gatwick service to Heathrow. On the other hand, major airline competitors such as United, Northwest, Continental and Lufthanza have expressed their concerns over the BA-AA alliance on antitrust grounds. These competitors have alleged that, even with the Open Skies treaty, other airlines will not obtain enough landing and take-off rights at the London

[5] *Economic Benefits of US-UK Open Skies*, AMR Corp. Communications News Release, Nov 12, 1996.

airports. Their primary concern is that the BA-AA alliance will be so strong that it will drive out competition from all other airlines. Both the BA-AA alliance and the UK-US Open Skies are now pending approval from the authorities of the EU and USDOT. An objective principal of the approval is to ensure that a maximum degree of competition will be promoted among all carriers and alliances.

4.3 Heathrow Airport Access

The issue of airport slots and facilities at London, primarily at London Heathrow, plays a dominant role in the discussions of the UK-US Open Skies and the BA-AA alliance. Full implementation of the AA-BA alliance and Open Skies will, by fifth year, see 463 additional London-US weekly nonstop round-trip flights. London Heathrow will see 525 additional round-trips, of which:

- 403 will be new London-US services; and
- 122 will be substitutes for existing Gatwick flights.

According to a recent Boeing study, Heathrow Airport, as of today, has not yet reached its operational capacity, although it is congested and is projected to be at capacity by the year 2010. In addition, the airport has been undergoing procedural improvements creating additional slots, particularly during the daily peak hours. Based on the opinion of the study by Roberts, Roach & Associates, with the removal of the Bermuda 2 restrictions, airport slots currently used for services of lesser economic value can be re-deployed for additional higher-value trans-Atlantic operations. It is the alliance proponents' argument that, with a slot-trading market mechanism in effect as in the US today, all of these 525 additional flights could be accommodated without regulatory intervention.

4.4 Major Competitors

Considering the size of the proposed BA-AA alliance, 3 major competitors in the international air travel market are identified: the Star Alliance, the Northwest-KLM alliance and the Delta-Swissair-Sabena-Austrian alliance. These alliances are described in the following sections while their comparative measures are summarized in Exhibit 1.

Star Alliance

The Star Alliance originates from the code-sharing agreement between Luthanza and United Airlines in October 1993. In May 1997, the alliance was expanded to include world-renowned airlines from different continents: SAS, Air Canada, Thai International Airlines and Varig. The six carriers each have their own extensive domestic and international route networks and together they claim to create "the Airline Network for Earth". In the Europe-US market, Star Alliance offers a potential service of 55,000 city pairs, as compared to the 36,000 city

pairs served by the BA-AA alliance. It will also dominate 51 percent of the Germany-US market, 16 percent of all world scheduled revenue-passenger-kilometre, and 63 percent of the departure slots at the Frankfurt Airport.

Northwest-KLM

Northwest and KLM are each strong carriers in their home market, Northwest being the fourth largest carriers in the US after United, American and Delta, and KLM also being the fourth largest carriers in Europe after BA, Luthanza and Air France. The two carriers combined
offers a potential service 37,000 city pairs in the Europe-US market, occupying a 64 percent market share in the Netherlands-US market, 6 percent in all world scheduled revenue-passenger-kilometre, and 52 percent of airport slots at Amsterdam.

Delta-Swissair-Sabena-Austrian

The Delta-Swissair-Sabena-Austrian alliance represents significant dominance in both Europe and US markets. The combined network of the carriers offers a potential 34,000 city pairs in the Europe-US market, controls 61 percent of the Belgium-US non-stop market, 74 percent of the Switzerland-US non-stop market, 100 percent of the Austria-US non-stops, and 11 percent of all world scheduled revenue-passenger-kilometre. The alliance also operates 64 percent of the flights at Zurich's Kloten Airport.

5.0 FUTURE PROSPECTS

5.1 Geographic Coverage

Upon examination of its existing global network, BA, together with Deutsche BA, TAT/Air Liberte and the various franchise carriers, is certainly the leading, if not the dominant, airline in Europe. As confirmed by the recent cost-competitive studies by Oum and Yu[6], BA has out-performed all other European carriers in terms of input prices and cost-competitiveness. However, with the full force of the EU liberalization and the ever-expanding Europe-US bilateral packs[7], competition is only going to become more intense in the years to come. In terms of efficiency and global network coverage, Luthanza, with its Star Alliance partners, will be the BA's most intensive competitor. The threats posed by Air France should also not be overlooked. The government-owned

[6] Oum, T.H., Yu, C., *Winning Airlines: Productivity and Cost Competitiveness of the World's Airlines*, 1998.

[7] Bilateral packs have been signed between the US and the European countries such as the Netherlands, Belgium, Luxemburg, Austria, Denmark, Finland, Sweden, Norway and Germany.

carrier, backed up by its "free" injections of financial resources, has recently signed a bilateral air agreement with the US allowing almost complete deregulation over the next five years[8]. In conjunction with the bilateral agreement, Air France has proposed alliances with Continental and Delta Airlines. BA's proposed alliance with American Airlines is no doubt a counter-strategy to compete with its European neighbours in this regard.

On the Asia/Pacific front, the strong alliance with Quantas has given BA the presence in this blooming economic region. The predicted annual traffic growth in the Asia/Pacific region between 1997 and 2006 is about 7 percent, compared to 5.2 percent for Europe and 4.2 percent for North America[9]. To increase the market share in this potentially lucrative market, BA's best strategy lies in further alliances with other Asian carriers. Strategic alliances will be more efficient than any other means in the Asia-Pacific region for two reasons: firstly, market dominance in the region by a foreign carrier is unlikely due to the various political and geographic constraints; secondly, the low input prices in Asia is insurmountable by the European carriers. The recent announcement by Cathay Pacific and Japan Airlines in joining the BA-AA alliance will serve to be an excellent opportunity for BA in this endeavour.

In North America, market penetration has been attempted by means of code-sharing agreements with America West and Canadian Airlines. However, in light of the strengths of the US carriers[10], BA will probably need to adopt a more aggressive approach to gain meaningful market shares on the Europe-US routes. Without an advanced alliance arrangement with a senior US partner, BA can simply not afford the opportunity to compete for the US local traffic behind the international gateways. This "behind-the-gateways" market provides significant feed traffic as it represents nearly 50% of all US-UK passengers travelling to or from US cities. The proposed alliance with the giant American Airlines will be an important move to gain access to this critical feed traffic in the US.

5.2 Future of the BA-AA Alliance

As evident from the above geographic analysis of BA's global position, the pivot point in the company's development prospects rests on the proposed alliance with American Airlines. The BA-AA alliance is definitely an intelligent move for both airlines to equip themselves for the globalized air transport market. However, it is not without its hurdles. The extent of regulatory scrutiny

---

[8] Europe Information Service, European Report, April 10, 1998.
[9] Boeing Study, 1997.
[10] In 1995, United, American and Delta Airlines continued to occupy the top 3 positions in IATA airlines in terms of revenue-tonne-km flown.

is unprecedented: the alliance proposal has been submitted to the USDOT and US Justice Department for nearly 2 years and approval is still not forthcoming. The regulators' concerns are primarily associated with the anti-competition effects of the alliance on the airline industry, particularly on the lucrative Europe-US routes. Currently, trans-Atlantic routes represent 20% of BA's passengers and 15% of American's passengers. The UK-US market is particular important as it accounts for over one-third of all Europe-US traffic, double the next biggest market between Germany and the US. Competitors have called the alliance "merger from hell" as it will have monopoly or near-monopoly positions on some of the highest-traffic routes between the UK and US[11].

BA's determination in the AA alliance is evident in its continual attempts to amend the original alliance proposals. In July 1997, BA and AA announced their intention to include Aerolineas Argentinas and Iberia Airlines in their alliance to expand their market in Latin American and in Spain. However, the proposal with Iberia Airlines was withdrawn two months later in an attempt to speed up the regulation process. In January 1998, BA and AA further proposed to delay implementing their proposed alliance on North Atlantic routes to win EU approval. The excursion would be temporary until rival companies have obtained slots on the highly coveted routes. The European EU Commission has demanded that the two airlines give up about 350 weekly landing and take-off slots at London's Heathrow Airport to avoid creating or strengthening a dominant position on the UK-US routes. BA has so far resisted relinquishing more than 168 slots, insisting that it should be up to the competitive market to govern its buy and sell.

The development of the proposed BA-AA alliance will unfold in the next short while. Given the green light to proceed, it would mean a new chapter in BA's globalization history in face of the immediate market advantage as well as the long-term intense competition with its other competitors. To provide further insights into the globalization prospects of BA, the following explores the advantages of the BA-AA alliance from both the demand and supply sides.

Demand-side Advantages

The demand for air travel is a function of the global political and economic well-being. Technology development, increasing globalization of the world

[11] BA and AA would control 100 percent of UK-US seats in Philadelphia, Charlotte, Pittsburgh, Dallas, Phoenix, Seattle, Baltimore, Raleigh, Tampa and San Juan, and more than 69 percent of the seats in Boston, Chicago, Miami and New York.

economy, and increase in personal disposable income are among the factors which have increased demand for air travel world-wide. These factors are often beyond the control of airline management. Nonetheless, carriers with significant market power have the ability to set prices above cost to generate high yields for the existing traffic demand. In a liberalized or deregulated market environment, market power is usually derived from the use of innovative pricing techniques[12], information technology (ie. Computer Reservation Systems), market information and extensive marketing. Both BA and AA are leaders in these areas and their alliance will undoubtedly generate superior market power, especially in their home markets of Europe and North America. However, in light of the extensive geographic coverage of the Star Alliance, the BA-AA alliance will have to do some "catching up" in forging alliances with carriers from other continents. This will satisfy the customers' general preference of flying with one airline network and create further marketing advantages in the highly competitive environment.

Supply-side Advantages

From the supply side, airlines' main lever to simulate traffic growth is to reduce fares while enhancing quality of service at the same time. Fare reduction means the ability to cut cost and reduce revenue yields without compromising the financial viability of the company. In this regard, BA and AA, with their expertise in revenue management and yield controls, will be at advantage over its alliance competitors. The two carriers also have superior performance in input prices and efficiencies as compared to their local competitors. As shown in Exhibit 2, the airline cost structures are summarized according to the average shares of labour, fuel, capital, and materials, as a portion of total airline costs. Both European and North American carriers have significantly higher labour costs compared to the Asian carriers while the Asian carriers generally pay more for materials purchased. As global sourcing becomes increasing popular and feasible by technology developments, synergies can be created in alliance operations so that input prices and efficiencies can be further improved. In fact, BA and AA are both pioneers in this area when they moved their labour-intensive and back office functions to lower-cost countries (usually developing countries) in the early 1980s[13]. Despite the well-known phenomenon of *constant returns to network size* (Caves, Christensen, Tretheway, 1984) in the airline industry, global sourcing may provide a means to cost reduction to fully

[12] The time-based dynamic pricing technique introduced by American Airlines is an example of pricing innovation for yield management.

[13] BA had moved its accounting operations to Bombay, India, while AA had moved its revenue accounting operations to the Caribbean and its data management services to Barbados and the Dominican Republic.

exploit the airline *economies of traffic density*. Effective global sourcing will require close collaboration of the partner airlines so that strategic linkages can be made in addition to the broad marketing arrangements. The BA-AA alliance could very well excel the Star Alliance from this perspective. Star Alliance was formed based on the recognition that each airline will retain its individual identity so as to serve its local market better. This member autonomy may occur at the expense of strategic linkages, and compromise the potential cost savings associated with close collaboration at both the strategic and the operations levels.

6.0 CONCLUSION

In light of the various deregulation and privatization strategies in air transportation in recent decades, globalization of the industry is both forthcoming and inevitable. British Airways, with its long history in forming global alliances, has managed to be an industry leader in international travel. With its alliance partners and franchise carriers, BA has a global network reaching 474 destinations in 103 countries, representing a market share of 53 percent in domestic UK, 11 percent in Europe, 13 percent in the North Atlantic and 18 percent in the Europe-Asia/Australasia routes.

The recent formation of mega alliances involving BA's major competitors (Star Alliance, Northwest-KLM, Delta-Swissair-Sabena-Austrian, etc.) has made the international air transport industry more competitive than ever. To stay on top of the industry, it is in the best interest of BA to ensure that the carrier secures a significant stake and plays an influential part in the future development of world air transport. To this end, BA has proposed an extensive alliance with American Airlines, the second largest IATA airline in terms of revenue and passengers carried. This mega-alliance represents the most ambitious globalization strategy in the history of BA and will serve to be the landmark in BA's future growth and expansion. Full implementation of the BA-AA alliance will generate significant benefits to both partners in terms of service improvements, revenue increases and, most importantly, market dominance. Given the alliance's complex political and regulatory linkages, approval is still pending with the EU and US authorities. If approval is granted, it will be a turning point for both BA and the international airline industry as a whole. For BA, it will be the beginning of a new chapter in its history in face of the immediate market advantage as well as the long-term intense competition with its other competitors. For the industry, it will confirm that the way forward is to form global alliances as a means of network expansion.

To provide further insights into BA's globalization prospects, the advantages of the proposed BA-AA alliance were explored from both the demand and supply perspectives. On the demand side, the BA-AA combination, with the dominant market power in their home markets, will pose significant threats to the Star Alliance. However, further alliance with carriers from other continents will be required to challenge the Star Alliance's extensive geographic coverage. On the supply side, BA and AA, being the industry leaders in revenue management, input prices and productivity efficiencies, will be at advantage over their alliance competitors. Finally, global sourcing will provide a means to further cost savings through close alliance collaboration at both the strategic and operations level. From the experience of its alliance competitors as well as its own globalization history, lessons should be learnt by BA to strike a balance between the demand-side factors such as marketing agreements and the supply-side factors in reducing bottom-line costs.

Exhibit 1: Comparative Measures of Global Alliances

Alliance	Europe-US City Pairs	Selected Market Share	% World RPK	Airport Slots
BA-AA	36,000	61% UK-US	18%	39% Heathrow
Star Alliance	55,000	51% Germany-US	16%	63% Frankfurt
Northwest-KLM	37,000	64% Netherlands-US	6%	52% Amsterdam
Delta-Swissair-Sabena-Austrian	34,000	61% Belgium-US 74% Switzerland-US 100% Amsterdam-US	11%	64% Zurich

Exhibit 2: Airline Cost Structures

Input	North America	Europe	Asia
Labour	32.5%	32.5%	20.0%
Fuel	11.2%	9.2%	12.6%
Capital	17.1%	13.1%	15.3%
Materials	39.2%	45.2%	52.1%

Source: Oum, T.H., Yu, C., Winning Airlines: *Productivity and Cost Competitiveness of the World's Airlines*, 1998



Designed and printed by Printing Services
University of Saskatchewan • CUPE 1975