A Comparative Approach to Bio-Product and Traditional Product Value Chains

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Abstract

What makes a successful bio-product is a generating significant interest in many parts of the Canadian economy. In the broadest sense, a bio-product is based on renewable biological resources that can be used to produce fuels, chemicals, plastics and other industrial products. Many bio-products initiatives and private/public investments have run into trouble because of problems with value chain development and sustainability.

For any value chains to operate effectively, business leaders and policymakers need to understand where the value is created and how the created value can be captured. From a policy perspective, it is important to understand the factors that can contribute to success and failure of bio-product value chains.

Why do bio-product value chains fail? This paper introduces an approach that focuses on the basics of production and consumption in a value chain. When a value chain is distilled to its essence, production and consumption are based on three activities:

- Acquisition (A)
- Transformation (T)
- Distribution (D)

This analysis shows that it is feasible to analyze bio-products in terms of their values within the chain. As bio-products leave the laboratory and enter the market economy an increasingly important consideration will be their economic viability. The ATD model provides a methodology for that assessment.

Introduction

Porter popularized the value chain concept in 1985 with the publication of the "Competitive Advantage: Creating and Sustaining Superior Performance."[2] Porter's perspective is that value is the amount the consumer of the firm's output is willing to pay for that output. The value chain consists of the activities the firm undertakes to create value, plus its margin. Porter suggested there are two broad types of value creating activities: primary and support. Primary activities involve processes such as inbound and outbound logistics, operations, marketing, and service. Support activities that assist the primary activities include human resources, technology, and procurement. Using Porter's approach, the processes of the firm can be analyzed so it can better strategically position itself either as a cost leader or a product differentiator. In either case, it attempts to maximize its margin.

Norman and Ramirez[3] suggest that Porter's "assembly" line perspective of value chains may be limited. Porter's model, according to Norman and Ramirez, boils down to every company finding its specific place within the industrial value chains, adding value and then passing this added value downstream to the next member of the value chain. According to Norman and Ramirez, new markets, greater competition and technological change is providing firms with more options in terms of creating value. In particular, there is a greater need to co-produce value with suppliers, customers, and other business partners.

In a similar vein, Hobbs, Cooney and Fulton, take the value chain concept from the specific organization and expand it to an industry. According to the authors, a value chain is a "strategic network between a number of independent business organizations within a supply chain"[4]. They suggest that value chain members share the goal of satisfying customers, while sharing the risks and rewards of the chain. This definition implies a much higher level of co-operation amongst the chain members than would either of the previous views.

Consistent amongst the views is the focus on the needs of the customer. Simply, value chains are demand driven with a pull through the system as opposed to a push. All three perspectives suggest that value chains are multi-participant entities, with a degree of communication if not co-operation amongst the members. The latter authors suggest a high level of interaction with a trend toward joint decision-making.

Bio-products range from current industry technologies, such as multiple use of the outputs of forestry, to the creation of new biological entities (genetic modifications to plants and animals) to reusing waste products. At the basic level, the key objective is to replace traditional hydrocarbon-based products with carbohydrate-based bio-products. This will result in a more sustainable economy and improved economic security as reliance on foreign sourced hydrocarbons decrease. A typical example in this case is using bio-diesel as a replacement for regular diesel fuel.

All bio-products do not strictly fit this description. Some existing bio-products use bio-materials in a different manner, competing with other bio-products. An example in this case is strawboard competing with wood-based fibreboards.

Policy activity in Canada and the United States has been directed toward increasing the use of bio-products over the medium and long term. This growth, however, may or may not occur dependent on whether in the value chain from bio-products adoption is superior to the value chain from status quo from the perspective of the demander of the product. That perspective may not only include the price (or cost) but also the intrinsic value of other factors, such as being sustainable.

A Comparative Methodology

Increased use of bio-products has important implications for value chains. For existing consumers of hydrocarbon-based products, it means the development of new partnerships. For example, a refiner that produces diesel fuel may not only have a relationship and chain with an oil company but also an oilseed crusher. It may also result in the formation of entirely new value chains. An example is the value chain that was created when strawboard was developed.

A key policy matter consideration is the factors that can contribute to success and failure of bio-product value chains. While bio-products may be considered superior from a technical or environmental standpoint this superiority is not as guarantee of their adoption in the marketplace. Examples of bio-products that have shown promise but have not gained wide acceptance in the market are strawboard as replacement for wood fibre board and methane production from manure.

Why do such chains fail? An approach to gain a better understanding is to consider the basics of production and consumption in a value chain.

When distilled to its essence for each value chain partner production and consumption is based on three activities:

- Acquisition (A)
- Transformation (T)
- Distribution (D)

Acquisition is the process of finding and acquiring the necessary consumable. For a feedlot it ranges from feeder cattle, to feed such as distiller grains and other grains, to veterinary supplies. For a petroleum producer it would be finding or buying oil and gas pools. For a consumer it is finding and purchasing a motor vehicle.

Transformation is the process of using inputs. For the feedlot operator it is using the inputs of feeder cattle, feed and veterinary supplies to produce finished cattle. For a petroleum producer it is drilling and removing the oil and gas, refining and making it ready for shipment to the consumer. For the consumer it is using the motor vehicle for transportation.

Distribution is the process of passing the transformed product onto the next or final user. For the feedlot operator this would include selling and transporting the finished to the market. For the petroleum producer it would be transporting gas through pipelines to industrial and residential users, or providing diesel fuel at a service station. For the consumer it would be selling the vehicle when they are finished with it.

For a carbohydrate based bio-product to replace a hydrocarbon-based product on a pure economic basis regardless of position in the value chain the following equation (the simple ATD model) must hold:

$$\mathrm{Cost}_c\ (A) + \mathrm{Cost}_c\ (T) + \mathrm{Cost}_c\ (D) \leq \mathrm{Cost}_h\ (A) + \mathrm{Cost}_h\ (T) + \mathrm{Cost}_h\ (D)$$

Carbohydrate Hydrocarbon

If a subsidy is applied to the chains as well as a value for sustainability the pure economic value equation would change with values ascribed to both. In this case for a hydrocarbon-based product to be replaced, the following equation (the extended ATD model) must be satisfied:

$$\mathrm{Cost}_c(A)+\mathrm{Cost}_c(T)+\mathrm{Cost}_c\ (D)-\mathrm{Value}_c(S)-\mathrm{Value}_c(R)\leq$$

Carbohydrate

$$\mathrm{Cost}_h\ (A) +\mathrm{Cost}_h\ (T)+\mathrm{Cost}_h(D)-\mathrm{Value}_h(R)-\mathrm{Value}_h(S).$$

Hydrocarbon

Where: Value (S) is the amount of the subsidy, and
Value (R) is the value of sustainability.

Subsidies are greater for a carbohydrate value chains than hydrocarbon chains. This means that

$$\mathrm{Value}_c(S) > \mathrm{Value}_h\ (S).$$

Therefore the equation can be simplified as follows:

$$\mathrm{Cost}_c(A)+\mathrm{Cost}_c(T)+ \mathrm{Cost}_c\ (D)-\mathrm{Value}(S)-\mathrm{Value}_c(R)\leq$$

Carbohydrate

$$\mathrm{Cost}_h\ (A) +\mathrm{Cost}_h\ (T)+\mathrm{Cost}_h(D)-\mathrm{Value}_h(R).$$

Hydrocarbon

Where Values(S) is the net subsidy to the carbohydrate chain.

It is assumed that carbohydrate value chains are more sustainable than hydrocarbon based chains. Therefore

$$\mathrm{Value}_c(R) > \mathrm{Value}_h\ (R)$$

The equation can be further simplified as follows:

$$\mathrm{Cost}_c(A)+\mathrm{Cost}_c(T)+\mathrm{Cost}_c(D)-\mathrm{Value}(S)-\mathrm{Value}_c(R)\leq$$

Carbohydrate

$$\mathrm{Cost}_h(A)+\mathrm{Cost}_h(T)+\mathrm{Cost}_h(D).$$

Hydrocarbon

> Where Values(R) is the net sustainability benefit to the carbohydrate chain

This model can be applied to any bioproduct value chain, purely domestic, domestic and international or purely international. An application of the model is discussed in the following section.

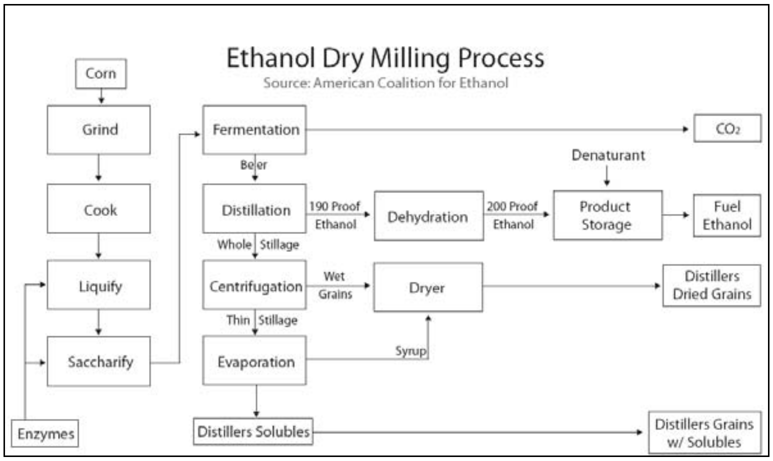
As appropriate to the acquisition, transformation and distribution process, there will potentially be differences between a bio-product value chain and the competitor chain. For example, acquisition costs related to logistics would be different for a bio-product value chain, compared to the existing chain. Similarly, quality control costs may be different as they relate to the transformation process.

In order for a carbohydrate chain to be superior to a hydrocarbon based chain or vice versa it need not be superior for each cost component, but must be superior overall. Any combination of factors may result it being either superior or inferior.

The Case of the Ethanol versus Gasoline Value Chain

Figure 1 outlines the production or transformation process of corn based ethanol using the dry milling process. This process is similar to wheat based ethanol production, which is more common in Western Canada. Corn based ethanol is more prevalent in Eastern Canada and in the United States.

Figure 1 Ethanol Dry Milling Process[5]



To compare the costs of an ethanol value chain with a gasoline value chain requires determining the acquisition, transformation and distribution costs for ethanol as well as gasoline. For the purpose of this case study the costs of ethanol production are based on averages from several sources for a 120 million litre facility.

Ideally in both cases costs would be evaluated from the first member of the chain to the final consumer. In the case of ethanol this would start at the production of seeds, fertilizer, electricity, natural gas, etc. and proceed through to the use of the ethanol as well as the other products by the final consumers. However, costs can vary dramatically at the farm unit, depending on the weather and the skill of the operator. Distribution cost from the ethanol plant can also vary depending on location and the type of transportation available. For this particular case study, the ATD model will be applied to a generalized ethanol production facility. The purpose of the case study is not to perform the evaluation, rather demonstrate how the method is used.

For the purposes of the case study, a generic ethanol production facility will be used. (S&T)[2] Consultants Inc. and Edna Lam Consulting[6] developed a model for such an ethanol plant in 2005. That summary was applied to the ATD model for comparative purposes.

The Simple ATD Model

Acquisition costs

Acquisition costs for this particular ethanol plant would include the purchase and delivery of grain feedstock to the plant door. Estimated annual expenses are shown in Table 1.

Table 1

Acquisition Costs	**Annual Expenses**	**$ / Litre**
Feedstocks	$44,000,000	0.36
Total	**$44,000,000**	**0.36**

In this case acquisition costs equal $44,000,000 or 36 cents per litre of ethanol produced.

Transformation costs

Transformation costs result in the conversion of inputs into the products of the plant, such as ethanol, carbon dioxide, distillers' grains, and other outputs. As shown in Table 2 the costs associated transformation include energy costs, supplies for production, labour, repairs and maintenance, general and administration expenses, interest costs an property, capital and income taxes.

Table 2

Transformation Costs	**Annual Expenses**	**$ / Litre**
Processing supplies	$4,000,000	0.033
Natural gas	$8,000,000	0.068
Electrical	$2,000,000	0.017
Denaturant	$700,000	0.006
Water	$200,000	0.002
Repairs & maintenance	$700,000	0.006
Salaries & wages	$2,000,000	0.017
General & Administration	$2,000,000	0.017
Amortization	$3,000,000	0.025
Interest Expenses	$2,000,000	0.017
Non Excise Taxes	$5,000,000	0.042
Total	**$29,600,000**	**0.25**

Transformation costs equal $29,600,000 or 25 cents per litre of ethanol produced.

Distribution Costs

Distribution involves passing the ethanol, carbon dioxide, distillers grains and other outputs to the next users. It also includes the removal of waste material, which in the case of ethanol is waste water. The distribution of ethanol must be by truck, rail or special purpose pipelines as ethanol absorbs impurities. For this example, the distiller grains have been dried, but freight costs are borne by the purchaser. Selling expenses, such as establishing and running an order desk are included in the calculations. Ethanol plants selling other outputs, such as carbon dioxide might have additional expenses. A retail margin and taxes have been applied to equalize costs with gasoline. Table 3 shows these costs.

Table 3

Distribution Costs	**Annual Expenses**	**$/Litre**
Waste management	$200,000	0.002
Marketing expenses	$300,000	0.003
Freight Expenses – ethanol	$600,000	0.005
Retail margin[7]	$4,000,000	0.035
Federal Excise tax	$12,000,000	0.10
Provincial taxes	$18,000,000	0.15
GST	$5,000,000	0.042
Total	**$40,100,000**	**0.33**

Distribution costs would equal $40,100,000 or about 33 cents per litre of ethanol produced.

The combined costs of acquisition, transformation and distribution results in the production cost of ethanol and the other outputs from the plant of $113,700,000 or $0.94/litre.

Gasoline information was also compiled using 2005 data. In 2005 the average rack price in Montreal, Toronto and Vancouver was $.55 per litre[8] with a retail price before taxes of $.58 per litre[9] . The average retail price was $.89[10] per litre, consisting of the $.58 per litre retail price, GST of $.06 per litre and provincial and federal taxes of $.25 per litre.

According to the Canada Department of Finance[11] in 2005 the retail price for gasoline consisted of the following:

Crude: 49.5%
Refiner: 14.5%
Retailer: 3.5%
Provincial taxes: 16.5%
Federal excise tax: 10.0%
GST: 6.5%

Using these percentages and the average \$.89 per litres cost can be broken down as follows:

Acquisition Costs:	\$.44/litre	(.89x.495)
Transformation Costs:	\$.13/litre	(.89x.145)
Distribution Costs:	\$.32/litre	(.89x(.035+.165+.10+.065))

Applying the simple ATD model,

$$\underbrace{\mathrm{Cost}_c(A)+\mathrm{Cost}_c(T)+\mathrm{Cost}_c(D)}_{\text{Carbohydrate}} \leq \underbrace{\mathrm{Cost}_h(A)+\mathrm{Cost}_h(T)+\mathrm{Cost}_h(D)-}_{\text{Hydrocarbon}}$$

$$\begin{aligned} \$.36+\$.25+\$.33 &> \$.44+\$.13+\$.32 \\ \$.94 &> \$.89 \end{aligned}$$

suggests that the ethanol value chain was inferior to the gasoline value chain in 2005. Without subsidies or a valuation for sustainability the ethanol chain would eventually fail.

It is interesting to note where the differences occur. The hydrocarbon chain has an advantage in terms of transformation, while the carbohydrate chain has an advantage related to acquisition. The two chains are similar on the distribution component, simply since the bulk of costs are taxes.

It is the value of the subsidies and related sustainability that enhance the potential of the ethanol based value chain.

The Extended ATD Model

Subsidies

Ethanol value chains are heavily subsidized relative to hydrocarbon based chains. In the United States, recent policy has jump started the ethanol industry. Driven by national security interests as much as environmental interests United States policy consists of production and blending mandates, tax elimination (or tax expenditures) and grants. Current federal tax relief for production of ethanol for blending is $.54 per gallon.[12] The current national mandate known as the Renewable Fuel Standard is 7.5 billion gallons of production of ethanol and biodiesel fuel by 2012[13]. The bulk of this production is expected to come from the rapidly expanding ethanol industry. Tax support is provided to small ethanol producers of $.10 per gallon[14], whereby excise taxes are eliminated. Infrastructure, such as refuelling stations, qualify for a 30% tax credit up to $30,000[15]. Grants are available to support research and fund rural bio-fuel plants. On top of these federal incentives, local jurisdictions provide additional incentives. For example in Minnesota has an ethanol mandate, tax relief for production, as well as grants[16].

Canada similarly has a mixed federal provincial approach to supporting ethanol production. The federal government provides relief from the excise tax of $.10 per litre[17] with a mandate of 5% Renewable Fuels Standard by 2010[18]. The federal government also provides project grants under the Ethanol Expansion Program. Manitoba provides tax relief on alcohol production of $.25 per litre for ethanol. In addition it has a mandate of 10% ethanol in 85% of gasoline[19].

Assuming the elimination of taxes is the subsidy, results in an average Value (S) of $.265 per litre (.10+.165).

Sustainability Benefits

Studies in the United States have shown that ethanol made from corn on a per gallon basis results in a 15% to 26% reduction in greenhouse gas emissions[20]. The Chicago Climate exchange[21] provides prices for carbon reductions. In 2005, the price per tonne of CO_2 reductions the price was about $US 2.00 to $US3.00 or about $Cdn 2.50 to $Cdn 3.75.

Assuming that each litre of gasoline results in 2.3 kg of CO_2 [22] a 25% reduction would result in GHG savings of 575 grams of CO_2. Given a metric tonne is 1,000,000 grams the value of the carbon reduction based on traded carbon prices is minimal.

The value of sustainability, Value(R), is therefore equal to 0.

Using the extended ATD model,

$$\underset{\text{Carbohydrate}}{Cost_c(A)+Cost_c(T)+Cost_c(D)-Value(S)-Value(R)} \leq$$
$$\underset{\text{Hydrocarbon}}{Cost_h(A)+Cost_h(T)+Cost_h(D)-Value_h(S).}$$

the ethanol value chain is superior to the hydrocarbon value chain as shown in the following value structure:

$$36+\$.25+\$.33-\$.265-\$0 < \$.44+\$.13+\$.32$$
$$\$.675 < \$.89$$

Comparing the value chains it is evident the subsidy is the fundamental reason that the ethanol chain is superior.

Conclusions and Policy Considerations

The forgoing analysis shows that it is feasible to analyze bio-products in terms of their values chains. As bio-products leave the laboratory and enter the market economy an increasingly important consideration will be their economic viability. The ATD model provides a methodology for that assessment.

In this case the model was applied to the ethanol and gasoline value chains. Based on data from 2005, it shows that the ethanol value chain is not viable without a subsidy, in this case in the form of tax relief. In this case the tax expenditures for ethanol occur in the D component of the chain, but potential subsidies could have occurred at either the A or T component. The model could similarly be applied to bio-diesel, flax fibre or other bio-products.

Particularly important in establishing the sector is determining the right level of subsidy to the sector. A further policy consideration is the effect of the growing supply from the ethanol sector. With mandates in place, currently the alcohol that is produced has a ready market. This need not be the situation in the future. Oversupply could occur, given the trade barriers that have been erected to support local production in Canada (and the United States). While current pricing for ethanol does not bear a relationship to its energy equivalency, policymakers need to bear in mind that the energy content of ethanol is 66%[23] of gasoline. It takes 1.52 litres of ethanol to produce the same amount of energy as gasoline, thus on an energy equivalent using the model above, the relative price of ethanol is $1.02 (1.52x.675) per litre. On this basis the ethanol value chain is at a disadvantage compared to the gasoline value chain, suggesting further subsidies would be necessary.

Endnotes

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[1] Allister Hickson is a Professional Associate with the University of Manitoba Transport Institute. Allen Tyrchniewicz is the President of Allen Tyrchniewicz Consulting.

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[10] Source: Canadian Automobile Association. www.caa.ca/mini%20sites/gasprice/breakdown.html. Retrieved November 26. 2006. Excludes the transit tax in Vancouver and provincial sales tax in Quebec.

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