A SIMPLE FRAMEWORK FOR PRIORITIZING ROAD SAFETY FUND FOR DIFFERENT GEOGRAPHICAL REGIONS IN BANGLADESH

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ABSTRACT

Priority setting for road safety improvements in different regions is a complicated issue. Developing countries like Bangladesh suffer from the lack of road safety resources and there is an obvious need for the effective utilization of these scarce resources. This paper provides a simple framework for road safety priority setting for different geographical areas in Bangladesh. Data envelopment analysis (DEA) is used to examine the risk efficiency of different regions and identify high risk regions. We found that the relative collision risk of various regions is not directly proportional to number of casualties and transportation accessibilities of those corresponding regions as commonly believed. We therefore recommend that systematic decision making methods like DEA be used to identify high risk regions to maximize return of scarce road safety resource.

1. BACKGROUND

Funding for road safety initiatives is a critical issue because the human and economic consequences of road collisions are devastating. Also, the resources needed to reduce the economic losses resulting from road collisions in developing and transition countries are greater than the total sum they receive from all donor agencies combined. Although it is clear that, road safety investments could relieve pressure on medical facilities and produce significant savings that would be better used on other public services, the funding of road safety projects is still grossly insufficient in many counties, especially in developing countries. Road safety is a major concern for the developing countries which are experiencing rapid growths in their road network and motorization rates. Moreover, general resource scarcity often leads policy-makers in many developing countries to think differently and eventually pay less importance on policy implementation and funding for road safety (PIARC, 2003).

Apart from the insufficiency of road safety resource, there is a considerable amount of inefficiency in allocation of road safety budget among different geographical regions, particularly in developing countries like Bangladesh. From the perspective of decision makers, investment of resources involves the identification and assessment of the safety needs. This approach demands an accurate measurement of the needs for effective budgeting and financing road safety projects. The optimal allocation of resources for safety improvement is therefore a very complex issue with many considerations.

At a macro level, however, one consideration is the division of scarce road safety resources among different geographical regions. To provide evidence based recommendations for the optimal allocation of road safety budget, this paper will develop a framework for identifying the safety needs in different geographical regions in Bangladesh. Priorities can then be set according to the respective safety needs. The next section will describe some of the existing road safety funding scenarios to provide some background information for the readers.

2. ROAD SAFETY FUNDING IN BANGLADESH

According to the official statistics, there were at least 4077 fatalities and 1453 injuries in traffic collisions in 2005. It is estimated that the actual number of casualties could well be over 10000 each year if we take into consideration the underreporting rate and definitional inconsistency (Hoque, 2006). The fatality rate is at least 50 times higher than the rates in Western Europe and North America. More importantly, while the rates are declining in developed countries, fatalities are still on the rise in Bangladesh.

The statistics revealed that Bangladesh has one of the highest fatality rates in road collisions. Despite its importance, road safety projects are being supported only as a minor allocation within the road development projects funded by development agencies such as the World Bank and Asian Development Bank (ADB). Examples of these projects include the Road Rehabilitation and Maintenance Project III (RRMP-III) funded by World Bank and other ADB projects such as the Jamuna Bridge Access Road Project, Southwest Road Network Development Project, and the Road Network Improvement & Maintenance Projects – I & II.

Road projects or schemes funded exclusively by Government of Bangladesh (GOB) do not include any provisions or allocations for road safety work in the project. As a result, road works utilizing the annual road improvement budget (for development works and periodic maintenance works) are executed without any significant spending for safety related road work (Rahman, 2006). The Road and Highways Department is the main highway authority and Table 1 shows a summary of the RHD budget for 2005/6 (ADP, 2005). It is clear that preventive and corrective engineering measures for road safety remains insufficiently addressed in road development and periodic maintenance works, with an allocation of only 0.48% of the development and periodic maintenance budget.

As public demand for road safety increases, its spending priority with Government is expected to increase. As the Government of Bangladesh endorses the safe and dependable transport services as a primary objective (NLTP, 2004), RHD has planned to adopt a policy of using about 2% of the maintenance budget for road safety works (Rahman, 2006). In addition to increasing the budget, the Government has also stress the efficient utilization of the funds as one of the top policy objectives. Nevertheless, there is still no model that can be used to allocate the funding for road safety improvements efficiently. Mostly, funds are allocated on project basis without proper consideration of need of different geographic areas in Bangladesh.

Table 1 RHD Budget on Road Improvements in 2005/6

Category	**Taka (million)**
Development Projects	
Co-funded by development partners	5,917
Funded by GOB	15,334
Periodic Maintenance Projects	
Co-funded by Development Partners	2,325
Funded by GOB	1,061
Road Safety Work	
Co-funded by development partners	118
Funded by GOB	0

As a result, there is disparity in the spatial distribution of road safety initiatives. Often investments in road safety far exceed commensurate investments in other input factors and thereby result in inefficient allocations. The critical question is how to determine the marginal rate of return for inputs or factors of production. This determination also leads to the identification and quantification of slack or surplus of the input factors. Existence and magnitude of slack or surplus determine the need for further investment.

3. PREVIOUS STUDIES

There are several studies regarding the optimal allocation of resources for infrastructure facilities. For examples, the impact of transportation investment on economic development is discussed in Berechman (1994), Buffington (1992) and Perera (1990). There are also regional studies addressing the impact of transportation infrastructure on local and regional economic development. One very relevant study is done by Alam et al

(2004) who examined the role of transportation investments on the regional economic development of Bangladesh. Data Envelopment Analysis (DEA) technique was used to examine the technical efficiency of investments in transportation for each region of the country. Investments in infrastructure in the less-developed regions were found to be more effective because of a higher rate of return. DEA is used to identify investment priorities for specific regions, and their relative impacts are assessed. However, the relationship between regional development and road safety is yet to be established. Additionally, the correlation of transportation development and road safety improvement is also unknown in Bangladesh. A new model to assess the risk efficiency of various regions of Bangladesh is therefore much needed.

A model is developed by Melachrinoudis (2002) for allocating funds to highway safety improvements. Besides the commonly used binary variables that represent discrete interventions at specific points of a highway, continuous variables are introduced to represent the lengths of a highway over which continuous improvements, such as pavement resurfacing or lighting, are implemented. The problem is formulated as a mixed integer knapsack model with linear multiple choice constraints. Some insights into solving the problem are provided and an efficient branch and bound algorithm is proposed. The main assumption used in this study is that discrete improvements are associated with different points of a highway. Therefore, no interaction between two discrete improvements exists. In addition, it is assumed that no interactions between discrete and continuous improvements exist. As traffic collision is a multi factor event, so these assumptions are difficult to satisfy. Also, this model focuses only on road improvement and not overall area-wide road safety program which may comprise engineering, education and enforcement provisions.

In another study, Elvik (2003) examines how setting priorities for road safety strictly according to cost–benefit analysis would affect the provision of road safety in Norway and Sweden. The paper is based on recent analyses of the efficiency of road safety policies in these two countries. It is found that cost-effective road safety policies could prevent between 50 and 60% of the road collision fatalities in both Norway and Sweden, if pursued consistently during a period of 10 years (2002–2011).

For developing countries like Bangladesh, however, evaluation of the cost effectiveness of road safety measures is still has far to go. As an initial step, a simple and yet effective efficiency measure to rate the needs and programs of the different regions in Bangladesh is needed to utilize the scarce resources with higher efficiency.

4. MODEL DEVELOPMENT

DEA is a linear programming-based technique for determining the relative efficiency of decision making units (DMUs), based on the performance of all other DMUs in the data set (Charnes, 1994; Chatzoglou, 1999 and Kauffmann, 2000). Using a linear programming model, the best performing DMUs in the data set are used to define an efficiency frontier, against which all other DMUs are benchmarked. The efficiency score for each DMU is then calculated based on its distance from the efficient frontier. The most efficient DMUs are assigned an efficiency score of “1” or 100%. The method of calculating distance from the frontier depends on the type of DEA model used (e.g., input minimizing, output maximizing, additive, etc). Each inefficient DMU is measured against the portion of the efficient frontier defined by the efficient DMUs with the most similar input/output mix.

For brevity, the mathematical formulations, as well as detailed description of the different types of DEA models, are not presented here. Instead, the reader is referred to excellent texts (Bowlin, 1999; Thanassoulis, 2001). Currently, several DEA software packages exist to allow managers and researchers to implement DEA models without directly solving a linear program (Herrero, 2002). The analysis in this study used Efficiency Measurement System (EMS) which is available free of charge for academic purpose.

For this preliminary study, twenty different districts (regions) of Bangladesh are selected as the DMUs for the DEA model. Output variable is district-wise total number of road collision fatalities. These data are compiled from police reports into the MAAP5 database by the Accident Research Institute in Dhaka, Bangladesh. The average annual collision data for five years, 2000-2004, are used in this analysis. The total number of death is split into motorized vehicle death (passenger and drivers) and pedestrian death. For the ease of computation and analysis, all data are normalized with respect to maximum value of the corresponding variable.

Table 2 provides the data set used in the analysis here. Data on population and land area are obtained from the national census report (BBS, 2002). Effective land area is estimated as the aggregate of actual land of the region weighted by productivity of the land. GDP is classified by several sectors: primary (agriculture), secondary (manufacturing), and tertiary (service).

Transportation accessibility data is collected from a secondary source (Alam, 2004) that provides varying measures ranging from measurements of the transportation stock in a region to accessibility measures based on random utility models as summarized in (Niemeier, 1997). Length of road network is also an important determinant. For this analysis length of national and regional highways are considered as one single input factor and length of feeder road is considered as another input factor. Data on regional contributions to GDP and road length are also obtained from the national census report (BBS, 2002).

Table 2 Input and Output Variables

Region/District	Population , Millions	Effective Land, sq. km	GDP in Million Taka		
			Agriculture	Industry	Service
Dhaka	17.198	10372	31208	63365	155498
Mymensingh	8.902	15500	38870	10640	70069
Jamalpur	3.335	5670	14609	9453	25560
Tangail	3.254	5362	14771	5739	27181
Faridpur	5.985	10761	24192	9503	57960
Chittagong	8.302	10328	35159	56425	91267
CHT	1.325	13729	39527	3379	19131
Noakhali	5.208	8778	18378	7477	41289
Comilla	9.163	11052	32202	16100	86227
Sylhet	7.9	15767	33861	14123	68991
Rajshahi	7.579	12796	32950	8371	56970
Dinajpur	4.643	10959	21322	6009	35319

Rangpur	9.074	16062	39005	10742	66242
Bogra	3.833	6912	19768	5141	31548
Pabna	4.861	7430	15124	6540	33698
khulna	5.693	13889	34761	14951	56076
Barisal	5.83	12343	25487	8431	57213
Patuakhali	2.282	6625	13573	3796	16539
Jessore	5.494	10963	28547	7205	44956
Khustia	3.28	5597	14366	6198	25102

Table 2 continued

Region/District	Accessibility Index	Feeder road, km	Highway (National and Regional), km	Fatality		
				Total	Motorized Vehicle	Pedestrian
Dhaka	6.801	80	70	507	187	320
Mymensingh	3.332	544	106	159	115	44
Jamalpur	1.347	140	21	22	17	5
Tangail	1.674	242	144	165	136	29
Faridpur	1.756	208	83	79	60	19
Chittagong	1.785	1020	208	249	169	80
CHT	0.165	1094	133	83	74	9
Noakhali	1.292	401	41	35	19	15
Comilla	2.818	734	167	152	121	31
Sylhet	1.56	298	142	158	97	61
Rajshahi	2.259	200	124	87	47	40
Dinajpur	1.271	256	108	58	40	19
Rangpur	2.532	252	71	63	43	20
Bogra	1.303	337	164	70	54	15
Pabna	1.568	256	116	88	54	33
khulna	1.715	246	67	37	21	16
Barisal	1.818	453	100	26	19	7
Patuakhali	0.545	211	68	12	7	4
Jessore	1.725	109	171	90	52	38
Khustia	1.197	135	106	16	5	11

A new term Relative Regional Risk Efficiency (RRRE) is introduced which measures road fatality risk corresponding to various inputs. RRRE are measured as a weighted ratio of output and input elements, and explains the overall level of collision risk with respect to those input factors. Also, lower values of the weights of input variables imply that such variables become binding constraints in the process of optimization. As explained earlier, the marginal rate of return for each specific input factor is provided by the values of the weights. A uniform value of the weight implies a balanced utilization of resources. Regions with high RRRE should be targeted for remedial task because they are the most at risk.

5. RESULT AND ANALYSIS

The following sections illustrate results obtained in the study. The first analysis is for the Relative Regional Risk Efficiency (RRRE) of the number of fatalities, followed by analyses with separate vehicle occupants and pedestrian fatalities. The results are shown in Figure 1. Among the 20 regions considered in the analysis, four regions were found to operate at the highest RRRE level. These four regions are presumed to have highest collision risk. But even among these 4 regions, an imbalance exists in the roles of input factors. In the case of Dhaka, length of feeder road is an important factor with relatively higher value for its weight. Most of the crashes occurred in city streets of Dhaka and a large share involves pedestrian collisions. Thus, an increase in feeder road increases the fatalities for Dhaka region. Chittagong Hill Tracts (CHT), on the other hand, suffers for the lack of accessibility. With an increase in the accessibility of the transport network, there is an increased chance of traffic fatalities. As most part of the CHT and some part of Chittagong is mountainous, there is a greater need for road safety improvements with the growing transport infrastructure. It is also observed from Figure 1 that the estimated efficiencies of the separate motor vehicle and pedestrian fatalities are higher than the same measures of the aggregate model, which is due to better correlation among input and output factors because of the incorporation of a wider spectrum of outputs corresponding to different types of collision.

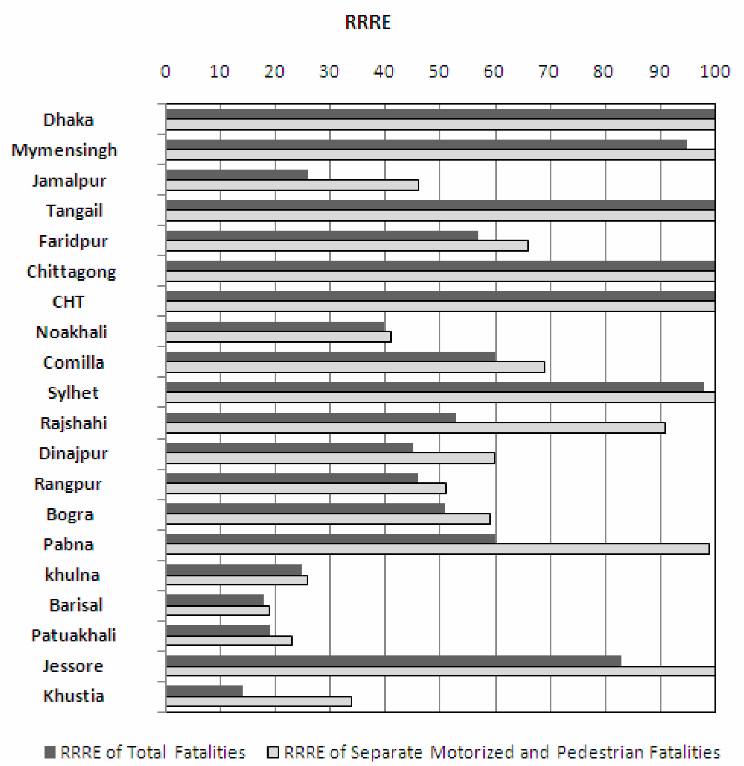

Figure 1 RRRE of Total Fatalities and Separate Motorized and Pedestrian Fatalities.

Figures 2 & 3 represent the comparison of the RRRE values from the aggregate fatality model with respect to Relative Accessibility (Normalized Accessibility) and Relative Fatalities (Normalized Accessibility). Both Figures reveal that there is no significant correlation between relative efficiency and accessibility or fatality number. These results indicate that resource allocation based on fatality number or accessibility alone is often misleading and can lead to inefficiency in the utilization of scarce road safety resources.

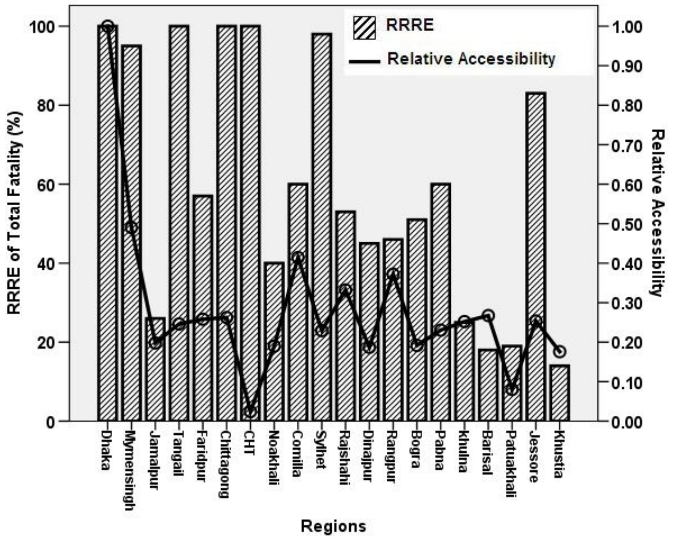

Figure 2 RRRE of Total Fatality and Relative Accessibility of Various Regions of Bangladesh.

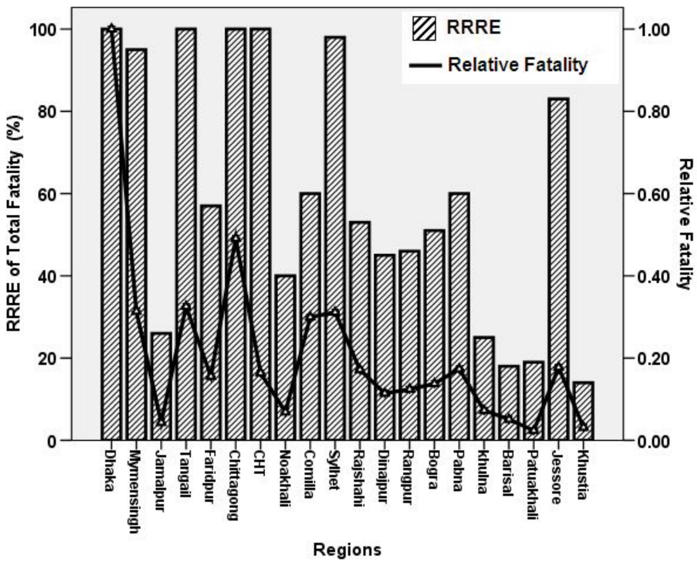

Figure 3 RRRE of Total Fatality and Relative Fatality of Various Regions of Bangladesh.

6. CONCLUSION

In response to the absence of any resource allocation model for prioritizing road safety projects among the different regions of Bangladesh, this paper attempts to provide a very basic framework using commonly available geographic and economic variables. The approach develops a DEA model that estimates the role of these factors on collision fatalities in the various regions in Bangladesh. Considering average annual fatalities as the output, and transport accessibility, effective land area, population, road length and sector specific GDP as inputs in the analysis, the relative regional risk efficiency (RRRE) is estimated as the weighted ratio between output and input.

For the total fatality model, four regions are found to be operating with the highest RRRE. It is also found that there is no correlation between RRRE and relative fatality which implies that regional safety priority cannot be set based on extent of fatality only. The model with vehicular and pedestrian fatality as output, however, identifies seven regions with the highest RRRE. Both models reveal that transport accessibility and industrial growth are important determinants of the RRRE values. Length of the road (highways and feeder roads) is also important in some districts.

Further investigation, however, is required to confirm the results found in this exploratory study. A more comprehensive model should include the impact of education, health facilities, emergency response, existing road safety initiatives, population, and age distribution to provide a better insight into the impacts of various input factors on collision risk. Performing a similar analysis on time series data will also facilitate the development of a new planning tool for planners and decision makers as well as the identification of dynamic factors in the interaction between economic, social, transportation development and road safety.

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