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A STUDY ON VALUE OF DELAY AT RAILROAD INTERSECTION DUE TO CONGESTION: A CASE STUDY OF DHAKA CITY CORPORATION (DCC) AREA

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ABSTRACT
Traffic congestion is a global issue for which certain communities are inevitably suffering from the constant waste of precious resource of time. It's also a crucial problem in Dhaka, the capital city of Bangladesh. One of the major reasons for this congestion is at grade railroad intersections which causes wastage of time. The main focus of this paper is to determine the value of delay time at major railroad intersections during the crossing of trains. The valuation of delay time is calculated on the basis of average wage rate of vehicle users. The average delay takes place in each major intersections during the working period of the day is 85 minutes and annual value of delay in major railroad intersections of Dhaka city is approximately 0.92 Billion BDT (Bangladeshi Taka-The currency of Bangladesh).

Keywords: Average wage rate; traffic congestion; railroad intersection; value of delay

INTRODUCTION

Congestion is a relative phenomenon which reflects the difference between expectation of users on the roadway system performance and actual road system performance (OECD, 2007). In general, this congestion as well as delay may be fixed in nature and caused due to a traffic signal or rail crossing. On the other hand, it may also be caused due to the interference of other traffic, inadequate capacity of road and poor road condition (Kadiyali, 2003).

However, Dhaka city is facing a huge loss every year due to traffic congestion. From a study of Roads and Highway Department (RHD), the estimated yearly congestion cost for Dhaka city is nearly $3 billion (The Daily Star, 2010). Railway level crossing signals are playing a significant contribution to this congested condition by generating a fixed delay every day.

Railroads play a vital role in the transportation system of Dhaka city by providing access to transportation for industrial or personal uses. Several roads including major arterial roads within the Dhaka City Corporation (DCC) area, intersects with these rail roads. When a rail line is at the same level with road, a variety of problems including congestion, safety incidents, and higher pollution occurs. With the increasing train traffic and vehicle levels, more vehicles are being delayed from their destinations due to the impedance at grade crossings. This wastage of time has an adverse effect on individual's income as well as national income which ultimately results in loss of productivity.

The benefit of saving time could have been received by taking an alternative action. In general, grade separations, such as overpasses and underpasses between rail lines and surface streets, are used to reduce the problems related to grade crossings. The construction of these overpasses and underpasses can effectively eliminate the delays associated with grade crossings. But for a developing country like Bangladesh, grade separations can be very expensive solution and less feasible. Due to these financial constraints, a feasibility study will be required before taking any decisions and value of delay in railroad intersection has to be determined.

OBJECTIVE

The main purpose of this study is to determine the cost of delay time due to congestion at railroad intersections on major arterial roads of DCC area.

ASSUMPTIONS

- Four categories of vehicle: cars, bus, truck and Non- Motorized Vehicle (NMV) are considered.
- Car includes only private car, taxi and Compressed Natural Gas (CNG) driven auto rickshaw.
- It has been assumed that, all the vehicles that are counted in vehicle count survey had been waiting from the beginning of the level crossing signal.
- Any human being below the age of 18 years has been considered to be a child (Young, 2007).

METHODOLOGY

The whole research is based on extensive survey, such as – delay time survey and vehicle count survey. Average wage rate method is mainly used to determine the value of delay. A detailed schematic diagram is given below.

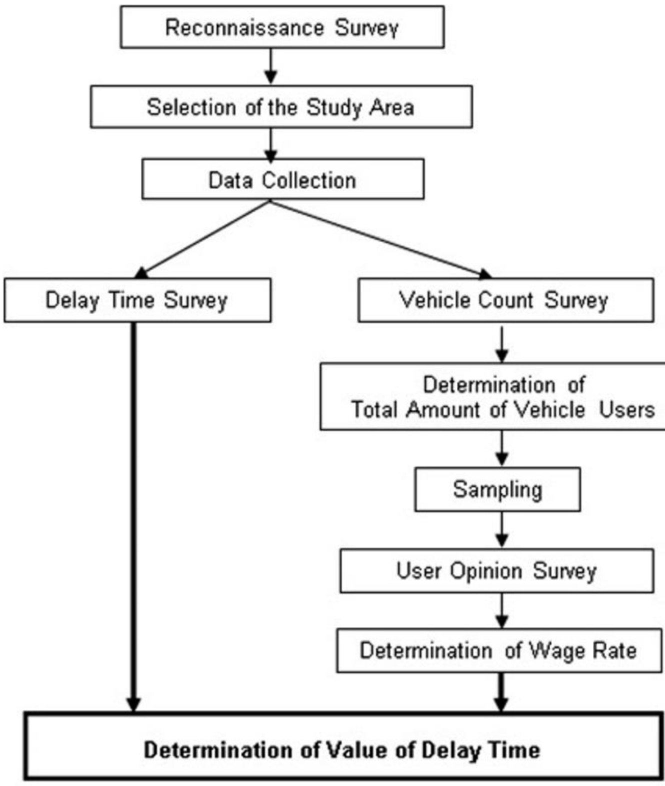

Fig. 1: Methodology

Selection of Study Area

A development plan for Dhaka metropolitan area, titled as Dhaka Metropolitan Development Plan (DMDP) was accumulated by capital development authority of Bangladesh. It covers 1528 sq. km of land including the area of DCC. There are fifty railroad intersections in the DMDP area and among them forty are in the DCC area. Some of them are intersecting the roads which have high volume of traffic flow. Among these rail crossings across the DCC area, twenty-eight are authorized by Bangladesh Railway and twelve are unauthorized (Shuboktagin, 2011). Moreover, nine authorized rail crossing gates are in the same grade with the major arterial roads and are divided into two categories. Six intersections have accessibility both for motorized and non-motorized vehicles whereas only three intersections are only for motorized vehicles. All of these nine intersections have been considered as the study area for this research.

DETERMINATION OF VALUE OF DELAY

A detail reconnaissance survey was conducted to assess the present condition of the study area which has provided a guideline for necessary surveys required for this research. Other surveys named vehicle count survey, delay time survey and user opinion survey have also been conducted.

According to Road Master Plan 2009, the motorized vehicles are classified into three categories such as car, bus and truck (Roads and Highway Department, 2009). In this research, the vehicle count survey has been conducted for these three categories of motorized vehicles and non-motorized vehicles. Also a delay time survey was conducted. Delay time and vehicle count survey were conducted on a working day for each intersection. For a specific day (7:00am – 7:00pm), every moment when a train passes through the intersection point, time counting has started and vehicles were counted during that time.

From vehicle count survey it has been seen that, the volume of vehicles is high in Malibag, Senakunja and Khilgaon area. The lowest volume is at Saidabad.

Table 1: Composition of Vehicles at Different Intersections

Intersection	**Car**			**Bus**	**Truck**	**NMV**	**Total**
	Passenger car	**CNG Auto**	**Taxi**				
Saidabad	67	456	10	698	17	763	2011
Khilgaon	739	1610	103	211	35	13201	15899
Malibag	6714	2782	463	2092	504	18516	31071
Maghbazar	2887	1543	103	458	100	257	5348
FDC	2234	1227	201	94	97	487	4340
Mahakhali	4998	3414	305	1738	2	0	10457
Banani	2282	1205	201	112	5	348	4153
Senakunja	13161	3686	1214	2597	844	231	21733
Kuril	5754	1936	564	3854	495	0	12603

Source: Field Survey (2011)

Amount of vehicles have been converted to amount of users by multiplying with respective occupancy rate of vehicles. According to Road User Cost Annual Report (2010) of Bangladesh, the occupancy rate of car, bus and NMV are respectively 3, 36.4 and 2. The calculated amount of car, bus and NMV users are respectively 179577, 431486 and 67606. So, total population passing through these intersections using different types of vehicles (except truck) in a day is 678669.

After that, sample size of total population has been determined by using 95% confidence level and confidence interval of 5. The formula for sample size is-

$$Sample\ Size = \frac{P \times (1 - P) \times Z^2}{C^2}$$

Where, Z = Z value (e.g. 1.96 for 95% confidence level); P = Percentage picking a choice; C= Confidence interval

The total sample size for questionnaire survey is 384. Likewise, the sample sizes of car user, bus user and NMV user have also been determined and they are respectively 102, 245 and 39. After that, the ratio of car in each intersection has been determined. The obtained sample size for car has been distributed to these intersections according to this ratio. Same procedure has been followed for bus and NMV. Questionnaire survey was conducted by picking each type of vehicle users randomly at each intersection according to stratified sample size. The questions were asked about the age of vehicle user, their purposes for trip, individual income or household income and working hour. From the questionnaire survey, various types of information about 382 vehicle users were found. It has been found that, about 66.5% of vehicle users were wage earners and 41.2% of the trips were non-working trip. Working trips were mostly made by buses and cars. On the other hand, most of the non-working trips were made by NMVs.

Afterward, each type of vehicle users has been categorized into several types on the basis of wage earning, age, trip purpose. Following chart represents various categories of user-

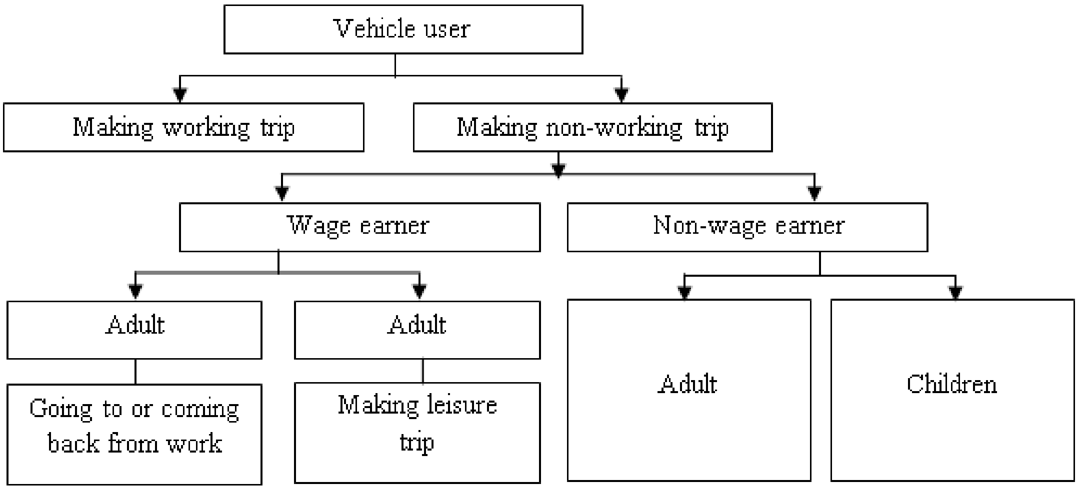

Fig. 2: Categories of Vehicle User

Finally, five categories have been arrived and average income per minute has been derived for each of the categories.

Wage earner user making working trip (F1)

Hourly income of this type of user was adjusted by multiplying by 1.33 to reflect additional employee related costs. This would include paid holidays, employment taxes, other compulsory contributions (e.g. employer pension contributions) and an allowance for overhead required to keep someone employed (Gwilliam 1997). So, the equations to determine the average income of this type of user are-

$$Average\ Hourly\ Income = \frac{\sum\left(\frac{\text{Monthly Income} \times 1.33}{\text{Working Hour}}\right)}{\text{Total Number of F1}}$$

$$Average\ Income\ per\ Minute = \frac{\text{Average Hourly Income}}{60}$$

Non-wage earner and adult user making non-working Trip (F2):

The income of this type of vehicle users has been taken as 30% of per head monthly household income (Gwilliam 1997). Hence the equations are-

$$Average\ Monthly\ Income = \frac{\sum\left(\frac{\text{Monthly Household Income} \times 0.3}{\text{Household Number}}\right)}{Total\ Number\ of\ F2}$$

$$Average\ Income\ per\ Minute = \frac{\text{Average Monthly Income}}{30 \times 24 \times 60}$$

Non-wage earner children user making non-working trip (F3):

Income of a children non-wage earner has been determined by considering it as 15% of total household income (Gwilliam 1997) and the obtained equations for this type of user are-

$$Average\ Monthly\ Income = \frac{\sum(\text{Monthly Household Income} \times 0.15)}{Total\ Number\ of\ F3}$$

$$Average\ Income\ per\ Minute\ =\frac{\text{Average Monthly Income}}{30\times 24\times 60}$$

Wage earner user, making non-working Trip for going to or coming back from work (F4)
Value of time saved of wage earner while making journey to the home or office in non-working hour has been assumed as 25% of hourly income (Kadiyali 2003). Additional employee related cost also was considered.

$$Average\ Hourly\ Income\ =\frac{\sum\left(\frac{\text{Monthly Income}\times 1.33\times 0.25}{\text{Working Hour}}\right)}{Total\ Number\ of\ F4}$$

$$Average\ Income\ per\ Minute\ =\frac{\text{Average Hourly Income}}{60}$$

Wage earner user, making non-working trip for leisure purposes (F5)
Value of time saved of wage earner while making journey for leisure purposes has been assumed as 25% of hourly income (Kadiyali 2003).

$$Average\ Hourly\ Income\ =\frac{\sum\left(\frac{\text{Monthly Income}\times 1.33\times 0.25}{\text{Working Hour}}\right)}{Total\ Number\ of\ F5}$$

$$Average\ Income\ per\ Minute\ =\frac{\text{Average Hourly Income}}{60}$$

After that, weighted average of all categories was calculated. Sample size of each user pattern has been considered as a weight factor. Weighted average income of car user, bus user and NMV user are respectively 2.23, 1.01 and 0.68 BDT per minute.

Table 2: Weighted Average Income

User pattern	Sample size			Average income (BDT/min)			Weighted average income (BDT/min)		
	Car	Bus	NMV	Car	Bus	NMV	Car	Bus	NMV
F1	59	93	12	3.61	2.23	2.07	2.23	1.01	0.68
F2	12	27	7	1.41	0.40	0.50			
F3	1	51	3	0.65	0.55	0.01			
F4	20	63	13	0.13	0.04	0.04			
F5	14	14	9	0.22	0.10	0.09			
Total	106	248	44						

From the delay time survey, it has been observed that, the extent of delay depends on this frequency of signals. As the frequency increases, the length of total delay also increases. Table 2 shows that, frequency of level crossing signal is the highest in FDC Rail Gate and it causes 64.63 minutes of delay. In contrast, the length of delay at the Saidabad intersection is only 45.5 minutes in a day, as the number of train passing through this intersection is lowest. Width of the road is another factor that influences the length of delay. If the width of the road, intersected by the rail track increases then the length of delay will also increase. For example, at Senakunja, the length of delay is 128.22 minutes, but the number of level crossing signal is not the highest. Finally, value of delay has been determined every time a train has approached in each intersection. Value of delay time for truck has been calculated separately using the standards from "Project Appraisal Framework, Road Sector Manual, 2005". Value of delay per truck is 2.77 BDT per minute (Planning Commission, 2005). Following equations have been used for the calculation.

$$VOT = VOT\,(bus) + VOT(car) + VOT(NMV) + VOT(truck)$$

$$VOT(bus) = Delay \times Number\ of\ bus \times Occupancy\ Rate\ of\ bus \times weighted\ average\ income\ of\ bus\ user$$

$$VOT(car) = Delay \times Number\ of\ car \times Occupancy\ Rate\ of\ car \times weighted\ average\ income\ of\ car\ user$$

$$VOT(NMV) = Delay \times Number\ of\ NMV \times Occupancy\ Rate\ of\ NMV \times weighted\ average\ income\ of\ NMV\ user$$

$$VOT(truck) = Delay \times Number\ of\ truck \times Value\ of\ delay\ per\ truck$$

Where, VOT= Value of Delay Time

Intersection wise calculation of delay time is given below:

Table 3: Value of Delay at Different Intersections

Intersection	No of approach	Total delay (min)	VOT (BDT) - Daily	VOT (BDT) – Annual
Saidabad	14	45.5	102385	37370525
Khilgaon	32	124.45	191324	69833260
Malibag	34	77.38	392327	143199355
Maghbazar	36	63.33	85068	31049820
FDC	37	64.63	62443	22791695
Mahakhali	33	60.1	220880	80621200
Banani	37	90.72	71822	26215030
Senakunja	35	128.22	875777	319658605
Kuril	36	96.97	540658	197340170
Total	280	705.8	2542684	928079660

Source: Field Survey (2011)

CONCLUSION

The output of this research reflects the adverse effect of congestion at railroad intersections. From this case study of Dhaka, it is seen that daily average loss of time is 84 minutes and its annual monetary worth value is approximately 0.92 billion BDT which is very alarming.

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