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Impact of Telecommunication on Transportation System of Dhaka City

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Abstract

Dhaka city, being one of the most densely populated cities of the world, is suffering tremendous problems especially in transport sector. Also, with the increase in level of urbanization the situation is becoming more acute in the unbearable traffic congestion which takes away around 3.2 million work-hours in a year. Telecommunication is another way of communicating besides physical transportation and now-a-days a large number of travel demands can be satisfied through this advancing technology. In Dhaka, both these modes of communication have experienced tremendous growth over the past few decades and since they can serve the same demands to some extent, it is implied that development in one sector may potentially mitigate the problems of other. In this context, this study investigates the impact of telecommunication on transportation system of Dhaka city. From the impact analysis, it has been found that transportation demand has a positive or complementarity relationship with telecommunication demand and transportation cost. Also, telecommunication demand and supply has positive relationship with transport cost in Dhaka city. Socio-demographic conditions tend to reduce transportation cost and increase telecommunication cost. The implication of the effect of land use change is that non-residential use of land contributes towards the increase of both the supply and demand of telecommunications and travel. It is also suggested by the findings that proper integration transport and telecommunication sector is necessary for this city in order to use telecommunication as a substitute of transport sector to improve the mobility of the city dwellers.

Introduction

For several years of its advancement, telecommunication was considered as a separate entity and its influence on travel behaviour was overlooked. But lately its impact is understood and incorporated in the policies by the city planners. The means of telecommunication ranges from telephones to sophisticated linking of computers for transferring large amount of data throughout the world. Transportation is based on the physical transport of materials and requires numerous modes of travel and facilities, such as roads, bridges, terminals, subways, interchanges, etc. As telecommunication is a less time consuming and easy way of communication, it has profound impact on the lifestyle of the people and has complex interrelationships in the communication system of a city, region or country (Choo, 2004). Generally, transport planners visualize that there is a negative relationship between telecommunication and transportation (Salomon, 1986). But little appears to be known about this relationship in the case of Dhaka city where growth in telecommunication has been profoundly observed during the last five years. Currently there are 12 fixed telephone operators in Bangladesh with 1.03 million subscribers and six mobile phone

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operators are providing service to 103.00 million subscribers (BTRC, 2013a, 2013b). On the other hand, transportation has been one of the major problems of congested cities like Dhaka. A recent study has suggested that this city loses around 3.2 million business hours per day in traffic congestion which amounts to BDT 2 billion or USD 24 million per year (The Daily Star, 2010). This means that in average a working people losses one hour daily. Although the profound impacts of telecommunication on transportation are assumed in different literatures, it is not explicitly considered in the transportation policies of Dhaka city as to whether telecommunication can be utilized in transport sector to relieve travel intensity in high density corridors or it is enhancing both the short and long distance travel demands. By finding this relationship in the context of Dhaka, new policies for transportation can be developed in integration with the policies for telecommunication to utilize their interdependence for a more sustainable transportation system. Therefore, the possibility of managing the travel demand by manipulating telecommunication is a crucial issue, which this study focuses to investigate by finding the relationship, utilizing data from 2001, 2004 and 2007 regarding transportation, telecommunication, land use and socio-demographics of Dhaka city. These three years have been selected due to concomitant availability of data of all the required variables at equal time intervals.

Literature Review

The relationship between telecommunication and transportation is multidimensional and difficult to comprehend. Different researchers identified this relationship in different ways. According to Salomon (1986), Harkness (1977), Mokhtarian (1999, 2000, 2004), Mokhtarian and Salomon (2002) and Nilles (1996), there are potential relationships between telecommunications and travel: substitution (reduction, elimination), complementarity (stimulation, generation), modification (alteration in time, mode, destination, etc., with respect to a trip or communication that would have occurred otherwise), and neutrality (no impact of one on the other, e.g. many e-mail messages have no impact on travel and vice versa).

On the other hand, Gassend (1982) recognized three types of interactions between transportation and telecommunications through applying systems approach. Type I are first order interactions, which are the effects of changes in the service of any of the mode on the relative use of both modes. Substitution and enhancement fall in this category. Type II interactions occur through changes in one system that affects the other. The second type of complementarity (efficiency) is the example of this type. Innovations in either transportation or telecommunications or both can stimulate societal changes which are known as higher order interactions (Type III). Land use changes are an example of this type.

In reality, the relationship between transportation and telecommunication is complex, because they include constantly changing behaviour of individuals and organizations. The studies related to the relationship between telecommunication and travel is conceptual, suggestive, and provisional lacking any empirical analysis. Moreover, telecommunications and travel are not considered within a comprehensive framework, integrating other factors such as the economy, land use, and socio-demographics. There is little empirical evidence on the application of complicated telecommunications technologies and their effects on transportation especially for South Asian countries.

Methodology and Data

At first, a conceptual model has been developed to depict the relationships between all the eight latent variables of telecommunication, transportation, land use and socio-demographics. The expected relationships have been derived from an understanding of the existing conditions and literatures including similar studies. The conceptual model would act as a baseline with which the study findings would be compared. This model has been constituted with variables that indicate travel demand, travel supply, telecommunication demand, telecommunication supply, travel cost, telecommunication cost, land use and socio-demographics. The hypothesized relationships among the variables have been either negative or positive or both (bi-directional). The developed conceptual model is illustrated in Figure 1.

The impact of telecommunication on the transportation system of Dhaka city has been explored from different specified models, from different perspectives using different variables. The causal relationships have been investigated using structural equation modeling (SEM) in conjunction with path diagrams. SEM is a modeling technique that can be used to make a relationship between a large number of endogenous and exogenous variables, as well as between latent (unobserved) and observed variable. Models constructed using this technique represent unidirectional effects of one variable on another. Each direct effect is shown using arrows in a path diagram (Golob, 2001). SEM has two major distinctions in variables – observed and latent variables. Observed variables are the collected values which is the data. Latent variables are hypothetical constructs or factors which are used to represent a continuum which cannot be observed directly. According to Golob (2001), SEM is advantageous compared to any linear-in-parameter statistical method because it includes the following capabilities: 1) treatment of both endogenous and exogenous variable, 2) latent variable with multiple indicators, 3) separation of measurement errors from specification error, 4) testing the model overall rather than coefficients individually, 5) modeling of mediating variables, 6) modeling of error term relationship, 7) testing of coefficient across multiple groups in a sample, 8) modeling of dynamic phenomena such as habit and inertia, 9) accounting for missing data, and 10) handling of non-normal data.

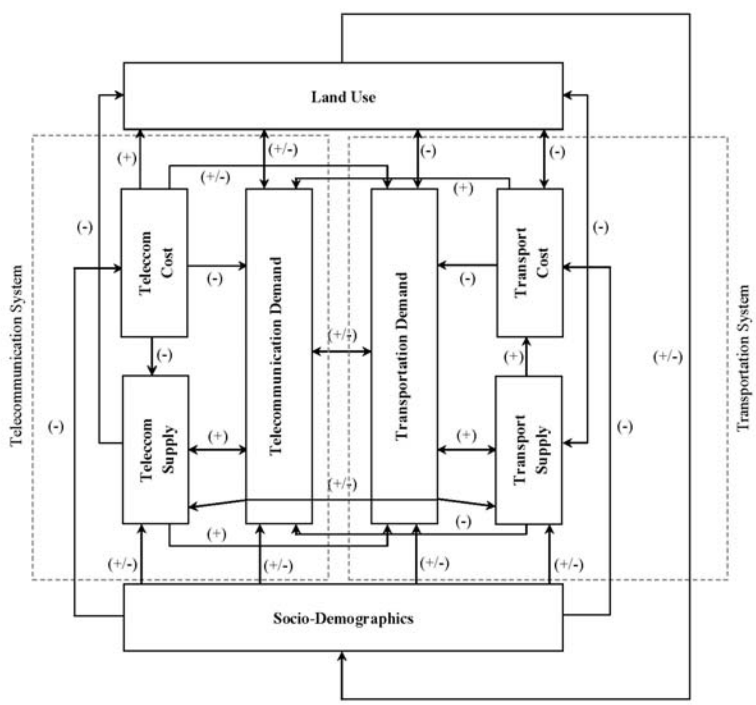


Figure 1: Conceptual Model of Telecommunication and Transportation
Source: Prepared by author based on literature.

Data on 16 variables have been collected for the previously stated eight latent variables. Both primary (questionnaire survey) and secondary sources have been explored for collecting the data available for past three years, i.e., 2001, 2004 and 2007 (Table 1).

Mode of telecommunication in Bangladesh can be divided into fixed phone and mobile phone. Fixed phones are those with wired connection and are attached to specific home or work addresses. Mobile phones are much popular and widely available because of its wireless service which is not fixed to any location. Other telecommunication options have not been selected as they are not accessible to all sections of the community and e-commerce is yet not much popular in this country due to lack of IT infrastructure and high cost (Bhowmik, 2012). Data has been collected from three income groups – low, middle and high income groups, through a road user survey in 2011. The income groups have been identified through their respective income ranges based on the context of Bangladesh. As indicated in the Strategic Transport Plan for Dhaka, monthly household income range for low income group has been considered as less than BDT 12,500, for middle income as between BDT 12,500 to Tk. 55,000, and above BDT 55,000 for high income group (GoB, 2005). Since Dhaka has a population of 14.65 million, the sample size for the study has been determined as 384 at 95% confidence level and confidence interval of 5 (Index Mundi, 2011). This sample number has been equally distributed among three income groups.

Table 1: List of Variables and their Data Sources

Latent variable	Observed variable	Source
Transportation Demand	Number of trip per year per person	Questionnaire survey
	Miles travelled per Person per	Questionnaire survey
	Passenger carried by each type of vehicle	Sharmeen, Sadat & Zaman (2010)
Transportation Supply	Total number of different types of vehicles	Bangladesh Road Transport Authority (BRTA)
	Capacity of these vehicles	BBS (2009)
Telecommunication Demand	Number of calls by fixed phone per year	Questionnaire survey
	Number of calls by mobile phone per year	Questionnaire survey
Telecommunication Supply	Number of fixed phone subscribers	Bangladesh Telecommunications Company Limited (BTCL)
	Number of mobile phone subscribers	GrameenPhone Limited
Transportation Cost	Fuel cost (per litre)	Bangladesh Petroleum Corporation
	Total travel cost	Derived from fuel cost
Telecommunication Cost	Fixed phone call cost	Bangladesh Telecommunications Company Limited (BTCL)
	Mobile phone call cost	GrameenPhone Limited

Land use	Change in land use pattern	GoB (2004), Kashem (2008) and RAJUK (2010)
Socio-demographic Condition	Average household size	BBS (1998)
	Income	Questionnaire survey

Source : Author.

The collected data reveals that trip frequency, miles travelled and number of vehicles have been on the rise across all income groups as the years advanced. While the demand and supply of mobile phones have increased, the same for fixed phone have decreased considerably. This is supported by the fact that mobile call rate had been reduced by 50% between 2001 and 2007 while fixed phone call rate had been more or less steady during that period. Although the overall telecommunication cost has reduced, transportation cost has increased considerably due to about six fold rise in fuel cost. During these years, rapid urbanization has taken over more land in commercial use. It is observed that the share of non-residential land use has increased by 29% from 2001 to 2007. Simultaneously, household size has decreased with increased household income.

All the values of each have been normalized by converting them into standard scores or z-scores. A total of five models including a composite model have been developed to identify the causal relationships between telecommunication and transportation. Composite scores have been produced by summing up the z-scores of the constituent variables for each observation under each latent variable. The values thus obtained have been converted to z-score through subtracting the mean (which is 0.00) and dividing by the standard deviation of the combined distribution. Development of structural equation models using these composite variables as observed variables is the second step of the modeling process. It can capture the effect of each latent variable or the combined effect of its observed variables.

Model Specification, Identification and Fit

Using path diagrams based on the conceptualized model, the five structural equation models have been specified by changing each observed variable under specific latent variables to develop a converging model. Variables which are constant or render the model under-identified have been excluded. For example, Total Travel Cost has been selected as a variable of Travel Cost instead of Fuel Cost. The reason behind this is while using Average Fuel Cost there has been less variation in data than Total Travel Cost. This is because, Average Fuel Cost is same for all travelers but their travel distance varies from person to person. As a result, Total Travel Cost may provide better relationship with other variables than Average Fuel Cost. Moreover, Total Travel Cost truly reflects a person’s mode choice, distance travelled and fuel cost. The model using composite variables included all the observed variables. Identification refers to whether a structural equation model can be mathematically calculated or not. If the model was found to be under-identified, then its specification was changed by restricting some parameters or removal of variables from the path diagram. The models have been justified using chi-square value, degrees of freedom, probability value (p-value) and Root Mean Square Error of Approximation (RMSEA). This process has been completed using LISREL, a specialized program for conducting SEM, and the resultant five identified models are:

- Mobile Telecommunication and Trip Frequency;
- Mobile Telecommunication and Distance Travelled;
- Fixed Telecommunication and Trip Frequency;
- Fixed Telecommunication and Distance Travelled;
- Composite model

Findings and Discussion

The major findings derived from the models are summarized in Table 2. Relationships that do not confirm the conceptualized model are highlighted. Figure 2 represents the relationships between all the composite variables.

Table 2: Major Findings

Relationship	Concept	Findings	Influencing Variable
Telecom Demand – Transport Demand	+/-	+	Number of Mobile Calls, Trip Frequency
Telecom Demand – Telecom Supply	+	+	Number of Mobile Calls, Number of Mobile Phone Subscribers
Transport Demand – Transport Supply	+	+	Trip Frequency
Telecom Demand – Telecom Cost	-	-	Number of Mobile Calls, Mobile Phone Cost
Transport Demand – Transport Cost	-	+	Miles Travelled
Telecom Demand – Transport Cost	+	+	Number of Mobile Calls
Transport Demand – Telecom Cost	+/-	-	Trip Frequency
Telecom Demand – Transport Supply	-	+	Number of Mobile Calls
Transport Demand – Telecom Supply	+	+	Trip Frequency
Telecom Supply – Transport Supply	+/-	+	Number of Fixed and Mobile Phone Subscribers

Telecom Cost – Telecom Supply	-	-	Mobile Phone Cost, Number of Mobile Phone Subscribers
Transport Cost – Transport Supply	+	+	....

Source: From conceptual model and calibrated model

Relationship Between Telecommunication and Transportation

Telecommunication and Transportation Demand and Supply

It has been observed that Telecommunication Demand has positive but very weak relationship with Transportation Demand and Supply with correlation coefficients of 0.19 and 0.15 respectively (Figure 2). If only the mobile telecommunication is considered as the only way to communicate, there is a strong positive relationship with transportation demand and supply. Moreover, telecommunication supply also has moderately strong positive relationship with transport demand (r^2=0.31) and supply (r^2=0.54).

Transport Cost and Transport Demand

Transport cost has positive relationship with travel demand (r^2=0.52), which does not comply with the conceptual model where it has been expected that transport cost only has negative relationship with travel demand. This is because, with the increase in transport cost (as consequences of lack of alternative fuel), people's daily activities are not reduced rather increased to meet the increased mobility. This evidence has been confirmed by all the five models, including the composite model (Figure 2).

Transport Cost and Telecommunication Demand, Supply and Cost

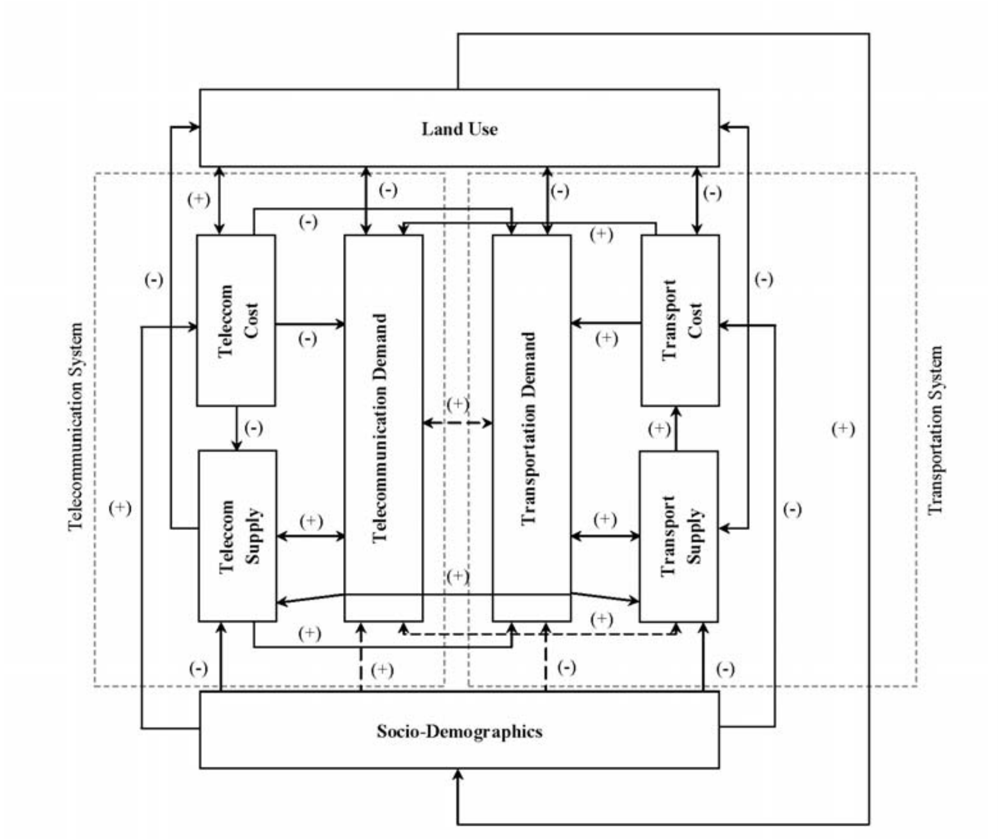
Both Telecommunication Demand and Supply have positive relationship with the Transport Cost with correlation coefficients of 0.33 and 0.88, respectively (Figure 2). Increase in Telecommunication Demand and Supply raise the demand for travel in a short period of time due to increase in working efficiency and mobility. The impact of mobile communication is prominent, but only in the case of demand variable. Transport and Telecommunication Costs shows a strong negative relationship (r^2=-0.76), the major contributor of rise in travel cost is the fuel cost which is rising worldwide.

Telecommunication Cost and Telecommunication Demand and Supply

As expected in the conceptual model, Telecommunication Demand decreases with the increase in Telecommunication Cost, represented by the r^2 value of -0.28 (Figure 2). Most of the share of this relationship is captured by the mobile telecommunication sector, since its prevalence has limited the use of fixed phone. With the significant decrease in Mobile Call Rate compared to Fixed Phone Call Rate, people have found it more convenient to use its service for their differentiated needs. As the demand decreases with the increase in cost, the supply reduces over time which is explained by a correlation value of -0.92 (Figure 2).

Telecommunication Cost and Transportation Demand and Supply

The correlation coefficients, r^2=-0.29 and -0.54, have suggested that with the increase in Telecommunication Cost, both Demand and Supply of Transportation, respectively, will decrease because of the complementarity relationships obtained (Figure 2). Unlike previous relationships, both mobile and fixed phones have strong relationships with the Transportation Supply. But in case of Demand variable of Transportation, the relationship is only moderately strong with the Trip Frequency, whilst with the Miles Travelled per Person per Year, it is very weak.



Note: (+), (-) = overall positive and negative causal relationships.
Solid line represents strong causal relationship ($r^2 \geq$0.25). Dashed line represents weak causal relationship ($r^2 <$0.25).

Figure 2: Causal Relationship Showing Impact of Telecommunication on Transportation
Source: Prepared by author based on calibrated model

Effect of Socio-Demographics on Transportation and Telecommunication

Socio-Demographics, indicating Average Household Size, negatively affect Transportation Demand, Supply and Cost with correlation coefficients of -0.21, -0.37 and -0.61 (Figure 2). This suggests that with urbanization, more land is devoted for non-residential use and both male and female members of the family are now working. All these have resulted in reduced household size and increased travelling tendency in terms of both high trip frequencies and longer distance travelling (trip frequency is more affected than distance travelled). Thereby, demand is increasing for travelling, which raises cost in the short term and supply in the longer term.

Socio-Demographics has weak and positive relationship with Telecommunication Demand ($\mathbf{r^2}$=0.08) but strong and negative relationship with Telecommunication Supply ($\mathbf{r^2}$=-0.70) (Figure 2). The weak relationship is mainly attributable to the fixed phone variable of Telecommunication Demand whose impact has clearly been replaced by mobile phones, demand of which has strong negative correlation with Average Household Size. Socio-demographics have strong and positive influence on the Telecommunication Cost with a $\mathbf{r^2}$ value of 0.68 (Figure 2).

Effect of Land Use on Transportation and Telecommunication

A decrease in Residential to Non-Residential Land Use Ratio has corresponded to increased Travel Demand and Supply, expressing negative relationships by the correlation coefficients of -0.30 and -0.54. Trip Frequency is more influenced than Miles Travelled per Person per Year. Commercialization means more business activity and hence increasing demand for travel, which in turn raises supply to meet the demand. Due to this increase in demand, Transportation Cost also increases which is also partially caused due to increase in the fuel cost. This has been represented by the model with a r^2 value of -0.78 (Figure 2).

The relationships between Land Use and Telecommunication Demand and Supply have been similar to that of Transportation (r^2=-0.29 and -0.94 respectively). As increase in commercial and other non-residential activities increases mobility, it also increases the need for telecommunicating to collect information, thereby increasing supply to meet the demand (Figure 2). The demand has been largely influenced through the variable of mobile telecommunication whereas supply has been equally influenced through both mobile and fixed phone variables. The relationship between Land Use and Telecommunication Cost is very strong, which is confirmed by a correlation coefficient very close to 1.00 (Figure 2). This strong relationship has been accounted for both by the fixed and mobile phone cost variables (r^2=0.96 and 0.99 respectively). Due to reduction in residential land use and concurrent high demand for mobile telecommunication, there has been a fall in the use of fixed phones. Hence more mobile telecommunication service providers have come into competition and the cost is reduced consequently.

Conclusion

The main aim of this research is to assess the impact of telecommunication on the transportation system of Dhaka Metropolitan Area. Complementarity relationship between telecommunication and travel has been found from this study which represents that the growth of telecommunication enhances people's travel need that creates extra pressure on Dhaka's transportation system. Land use and socio-demographic factors also contribute a lot for the augmentation of this impact. For Dhaka city, to eliminate this transport problem, it is necessary to integrate transport and telecommunication sector in order to use telecommunication as a substitute of transportation. This substitution may reduce traffic congestion and associated loss of time, pollution, energy and petroleum consumption and road accidents. In this study, it has been also found that with the increased telecommunication demand, telecommunication cost is decreasing because it is a cost effective way to increase telecommunication supply with the increased demand. While at the same time, transport cost is increasing due to the scarcity of non-renewable fuel source and due to the lack of alternative fuel source. So to increase transport supply to meet the increased transport demand is not in any way a cost effective measure. A number of fruitful results have been found in many studies discerning the effective impact of telecommunication on transportation. There are strong evidences that telework (telecommuting, teleconferencing, teleshopping, distance learning, etc.) can effectively reduce travelling if telecommunication can be appropriately integrated with the functioning of a city. According to a survey of 400 U.S. teleworkers, telework reduces vehicle travel by 30 miles per telecommute day (Nilles, 1996). Another survey conducted by Connected Nation found that broadband internet use can reduce average driving of 67 miles per month (CN, 2008). Moreover, telework has been more attractive to travelers who commute longer distances. Therefore, regarding this fact, vehicle miles travelled tend to be highly reduced which corresponds to a reduction of 15% vehicles miles (for commuters travelling more than average distances) due to a 10% reduction of trips (VTPI, 2012).

Considering these well established facts, policy makers can consider the following possible mitigation measures for Dhaka city to address the problems created by increased travel demand:

- Widening the network of teleshopping in terms of both area and items;
- Balancing the rampant commercialization regionally to limit the rising demand for both communication systems;
- Proper mixing of land uses in the light of Detail Area Plan (DAP);
- Providing reselling opportunities of telecommunication services for increased household accessibility and decreased cost;
- Ensuring high speed data transmissibility to facilitate audio-visual communication required for conferences with the foreign companies.

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