Serbian Journal of Management 4 (2) (2009) 203 - 213

Serbian Journal of Management

www.sjm06.com

EXPLAINING THE SIGNIFICANCE OF TRANSPORTATION LEAD TIME IN INDIAN ROAD LOGISTICS: AN ECONOMETRIC ANALYSIS

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(Received 12 May 2009; accepted 17 September 2009)

Abstract

In this paper the authors used econometric tools and techniques that are conventionally used in the estimation of relationship between and impact of different variables and their application features in the literature of transport economics. The study made an attempt to empirically analyze the impact of the variables like average number of fast moving vehicles per day, average slow moving vehicles per day, drivers rest hours, average number of light/heavy vehicles ratio, number of population habitats on particular routes on the lead time of transportation (travel time from origin to destination) on selected 68 routes in India. The study is divided into three sections. Section 1 describes brief background of the road transport sector in India and reviews the literature on the topic. Section 2 made an attempt to show how the econometric techniques can be applied to estimate the impact of different variables on the lead-time of transportation. Section 3 highlights the results and derives some concrete solutions, which are helpful for policy implications and further research.

Keywords: Transport network, lead-time of transportation, freight, infrastructure, India

1. INTRODUCTION

Good transport network is crucial for sustained economic growth and development of a nation. This vital infrastructure is regarded as an important determinant for the success of a nation's effort in diversifying its production base, expanding trade and linking together resources and markets into an integrated economy (Puri, 2003). It is also necessary for connecting villages with towns, market centres and in bringing together remote and developing regions closer to one another. Transport, therefore,

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forms a key input for production processes and adequate provision of transport infrastructure and services (Morash & Clinton, 1997). Among the various criteria's for measuring road competitiveness, there is an increase in the importance of the non-monetary component, namely transportation time, especially with the development and strengthening of just-in-time (JIT) techniques, which tend to represent a smaller part in the value chain, but allowing the achievement of relevant economies of scale from the supply side (Basta & Morchio, 2008).

1.1. India's Road Logistics

Poor transportation system may lead to slow down of economic growth and also lead to its decay. Also, poor traffic management and transportation results in loss of millions of rupees in vehicle operation and travel time costs (Darbari et al., 2008). Hence, the significance of logistics and supply chain management in any economy is unavoidable. India spends about 13 % of Gross Domestic Product on logistics, which is high compared to its major trading partners like USA (9.5 %), Japan (10.5 %) and Germany (10 %). From the cost component point of view, transportation accounts huge share of about 35 % of the total logistics costs. The reasons for this huge spending on transportation are insufficient infrastructure regulatory obstacles, lesser usage of information technology in logistics, etc (Planning Commission, 2005). The delay on the roads also results in high inventory costs for the industry, thus affecting its competitiveness vis-à-vis international industry operating on JIT inventory principles. These deficiencies causing huge economic losses because of poor connectivity, damaged road networks, slow movement of vehicles, delays at the check posts, etc.

India has one of the largest road networks in the world with over 3.3 million kilometers (km). The road traffic has been growing at a rate of 10 % since 1951. National Highways (NHs) are the main arterial roads; connecting ports, state capitals, industrial centers and neighboring countries. They constitute less than 2 % of the total road network in the country but carry nearly 40 % of the total road traffic. Their growth in quantitative terms has been rather gradual, from 22,255 km in 1951, to 66,590 km in 2007. Out of the total 1,098,489 km of National and State Highways, only 2 % of their length is four-lane, 34 % two-lane and 64 % single-lane. As far as NHs are concerned, only 5 % of their length is four-lane, 80 % two-lane and 15 % continues to be single-lane (National Highway Authority of India (NHAI), 2007).

1.2. Freight Handled by Road Network

Road transport sector has seen higher growth vis-à-vis railways over the years (Planning Commission, 2005). The share of road transport in carrying freight has gone up from mere 13 % in 1950's to more than 65 % in 2007. Freight carried by road registered a growth rate of about 7.5 % in 2006-07 over the previous year. Several factors leading to the relative high growth in road transport are structural. These include more dispersed industrial and business location patterns and increased need for JIT deliveries. Second, the sector is composed of many small private operators in a highly competitive and dynamic environment.

1.3. Literature Review

The efficiency of supply chains used by

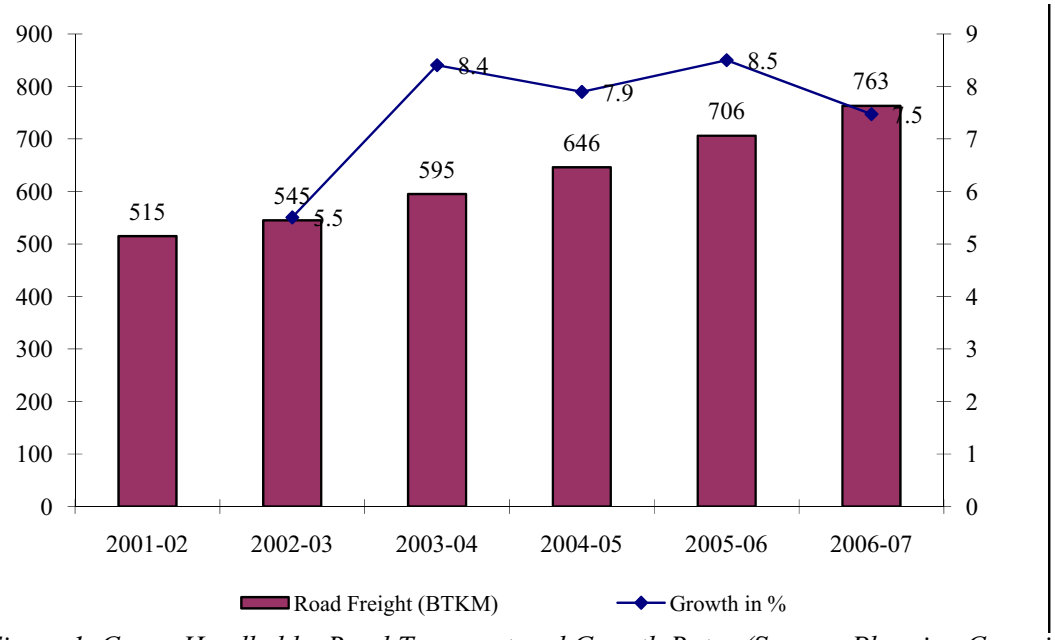

Figure 1. Cargo Handled by Road Transport and Growth Rates (Source: Planning Commission, Government of India)

industry, depend on freight transport services operating reliably whenever and wherever they are require. The research papers that are published in referred journals during last decade (like Transportation Science, Intelligent Transportation Systems, Journal of Geographical Systems, Transportation Journal, International Journal of Logistics: Research and Applications, etc.) shows that travel time is essential for determining the productivity of earthmoving operations and saving in travel time tend to be the dominant benefit of transportation improvements in developed countries. The major findings in the earlier research is that the speed of the vehicles may not be fully available for lesser lead time of transportation from origin to destination due to unavailability of preferred road networks because they are in the process of being repaired, level of congestion, delay departure decisions by the vehicle drivers, variability in road usage capacity, etc. All these factors subject to longer journey time on average.

2. DATA FOR THE STUDY AND METHODOLOGY

Despite the government's efforts on building up of qualitative road infrastructure in the country, the ground reality is that the bottlenecks like slow technological development, slow movement of freight, etc, in road transportation persists. The study involves data from both primary and secondary sources. The issues in this paper are addressed on the basis of cross-road network multiple regressions with lead time of transportation as the dependent variable and the independent variables such as: daily average fast and slow moving vehicles on the routes, rest time by the truck drivers (number of hours), average light to heavy vehicle ratio, number of population habitats on the selected routes. Additionally, a city dummy variable (Developed = 1 and others = 0) also included in the analysis for identifying the impact of their status on lead-time and the pattern of transportation. The variable has

been selected on the basis of the cities in the BOMARU states This dummy variable has been selected on the basis of prevailing cities in the states of Bihar, Orissa, Madhya Pradesh, Rajasthan, and Uttar Pradesh (BOMARU) states and other states in India. Generally, these BOMARU states in India are called as underdeveloped states due to their lower economic growth, healthcare indices and literacy rates. [1].

The lead-time of transportation data and rest time by the truck drivers were obtained from the press and media sources, transport companies, truck owners associations and truck drivers who frequently travel on these routes. The data on daily average fast and slow moving vehicles, average light to heavy vehicle ratio and number of population habitats were collected from the National Highway Authority of India (NHAI) website. The identified routes and National Highways (NH) are given in Annexure 1. The following assumptions have been made for the analysis:

- ***Assumption 1***: The variables like daily average fast moving vehicles on the

Table 1. Summary of Research Papers on Travel Time in Referred Journals

References	Key Findings
Hackney et al., 2007	Found that the impacts of the structural variables show that they must be taken into account in order to understand variation in local speeds. While the macroscopic speed/space relationships yielded are statistically significant.
Heydecker & Addison, 2005	Considered an equilibrium model of the joint choice of departure time and route through a congested road network. Clarified the distinct roles of the origin-destination time-specific cost functions, and identified the close interrelationship between them.
Fowkes et al., 2004	Investigated the difference between just-in-time (JIT) and non-JIT movements. The paper strongly suggests that delays would be valued relatively highly in the case of JIT flows.
Ettema et al., 2004	The paper applied a CHAID-based classification algorithm to describe how travellers classify trips made under various conditions (departure time and presence of traffic information) into mental classes with comparable expectations in terms of travel time.
Fleischmann et al., 2004	Presents a general framework for the implementation of time-varying travel times in various vehicle-routing algorithms
Marzouk & Moselhi, 2004	Presented a two-step fuzzy clustering method for estimating haulers' travel time and found that lesser travel time is essential for determining the productivity of earthmoving operations.
Sherali et al., 2003	Proposed a dynamic programming based solution method for the time-dependent, label-constrained shortest path problem. Also suggest that it would be beneficial to explore alternative heuristic curtailment techniques that exploit any available information on potential bottlenecks, or high-speed corridors, or effective transport modes that might exist within the network region.
Choi & Chung, 2002	Focuses on the development of an information fusion algorithm based on a voting technique, fuzzy regression, and Bayesian pooling technique for estimating dynamic link travel time in congested urban road networks. Findings showed that the fused link travel time is superior to the pure arithmetic mean method and, hence, more worthwhile, accurate, and reliable in producing a more realistic link travel time.
Stephen et al., 1997	Demonstrated evidence of growth of travel in Europe at both the EU level and in seven individual countries over the last ten years through a range of travel indicators. Identified several travel reduction measures and assessed their potential effect on travel behaviour.
Morash & Ozment, 1996	Statistically and significantly proved that time-based transportation strategies are important sources of competitive advantage and value.

1) BIMARU was coined by the Indian demographer Ashish Bose (later Orissa has also been added in the list (BOMARU) due to its lower economic growth, health care indices and literacy rates).

route, rest time by truck drivers and number of population habitats on the route have positive relationship with the lead time of transportation on the routes.

– ***Assumption 2***: The variables like daily average slow moving vehicles on the route and the average light to heavy vehicle ratio have negative relationship with the lead time of transportation on the routes.

Before proceeding to the regression analysis, simple correlation techniques were used to understand the relationship between the variables and results are presented in Table 2.

It has been observed that rest hours by vehicle drivers and number of population habitats are positively and significantly correlated with the lead-time of transportation. It is important to note here that these two independent variables are also correlated positively and significantly, which states that the variables are moving in the same direction and may create a problem of multicollinearity. So, to avoid the problem population habitats variable have been dropped in the regression analysis to improve the robustness of the model. The model proved to be 'best', this has been tested by test of robustness. Following tests have been satisfied by the model for robustness, such as, Multicollinearity, Autocorrelation, Residuals following normality, P-P plot also following linearity.

3. RESULTS OF THE STUDY

For constructing multiple regression equation the explanatory variables are estimated with the Ordinary Least Squares

Table 2: Correlation Matrix

		Lead Time	AFMVPD	ASMVPD	Rest Hours	ALHVR	Population Habitats	Dummy
AFMVPD	Pearson Correlation	-.265*						
	Sig. (2-tailed)	0.029						
ASMVPD	Pearson Correlation	0.172	-0.156					
	Sig. (2-tailed)	0.16	0.204					
RH	Pearson Correlation	.894**	-0.194	0.07				
	Sig. (2-tailed)	0	0.113	0.568				
LHVR	Pearson Correlation	-0.233	.487**	-0.029	-0.091			
	Sig. (2-tailed)	0.056	0	0.815	0.458			
Population Habitats	Pearson Correlation	.840**	-0.105	0.084	.899**	0.005		
	Sig. (2-tailed)	0	0.394	0.495	0	0.968		
Dummy Variable	Pearson Correlation	-0.135	.386**	-.295*	0.048	.340**	-0.039	
	Sig. (2-tailed)	0.274	0.001	0.015	0.698	0.005	0.754	
	N	68	68	68	68	68	68	68

AFMVPD – average fast moving vehicles per day, ASMVPD – average slow moving vehicles per day, RH – rest hours by drivers (number of hours), ALHVR – average light to heavy vehicles ratio

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Table 3. Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.920[a]	0.846	0.834	11.949	1.711

a. Predictors: (Constant), Rest_hrs, Dummy_Variable, Avg_slow_movg_vehicle_per_day, average_light_heavy_vechile_ratio, Avg_fast_movg_vehicle_per_day
b. Dependent Variable: Lead_time

Table 4. Regression Coefficients (and t-ratios) based on Data for 68 Routes Dependent Variable: Lead Time of Transportation (in Number of Hours)

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	T	Sig.	Tolerance	VIF
1	(Constant)	27.033	5.723		4.724	0		
	AFMVPD	0.025	0.058	0.026	0.424	0.673	0.676	1.48
	ASMVPD	0.366	0.264	0.073	1.39	0.17	0.894	1.119
	ALHVR	-9.701	4.744	-0.12	-2.045	0.045	0.726	1.377
	Dummy Variable (developed =1)	-7.426	3.44	-0.125	-2.159	0.035	0.741	1.349
	Rest hours	3.982	0.23	0.889	17.282	0	0.938	1.067

(OLS) method. The regression model is constructed on the basis of the resulted obtained from SPSS data analysis software. The model summary and the regression results are presented in Table 3 and Table 4.

The adjusted R^2 obtained in the analysis is 83.4 %, indicates that the model as a whole accounts for 83.4 % variation in the dependent variable explained by the independent variables, which is a good resemblance and the effect of independent variables are being explained more. The independent variables that are significant are Rest hours, Average Light/Heavy Vehicles Ratio, which have more impact on the lead-time. The impact of average light/heavy vehicle ratio is -9.701 %t, which implies, one unit change in the variable can reduce the lead-time of transportation by 9 hours. The impact of the rest hours by the vehicle drivers is 3.982 %, again which asserts that one-hour increase in the variable will increase the lead-time to 3.98 hours and vice-versa. The implications for the dummy variable shows that even though the coefficient is negative, logically it implies that development is needed in terms of expansion of highways from 2 Lanes to 4 Lanes and bypass routes, which eventually decline the transportation time from the point of origin to destination.

There is no autocorrelation in the independent variables, which is represented by Durbin-Watson test, and multicollinearity can be tested by looking at tolerance or VIF factor, which represents that econometric model, is a good model.

Graphs in the Figure 2, tells us about the

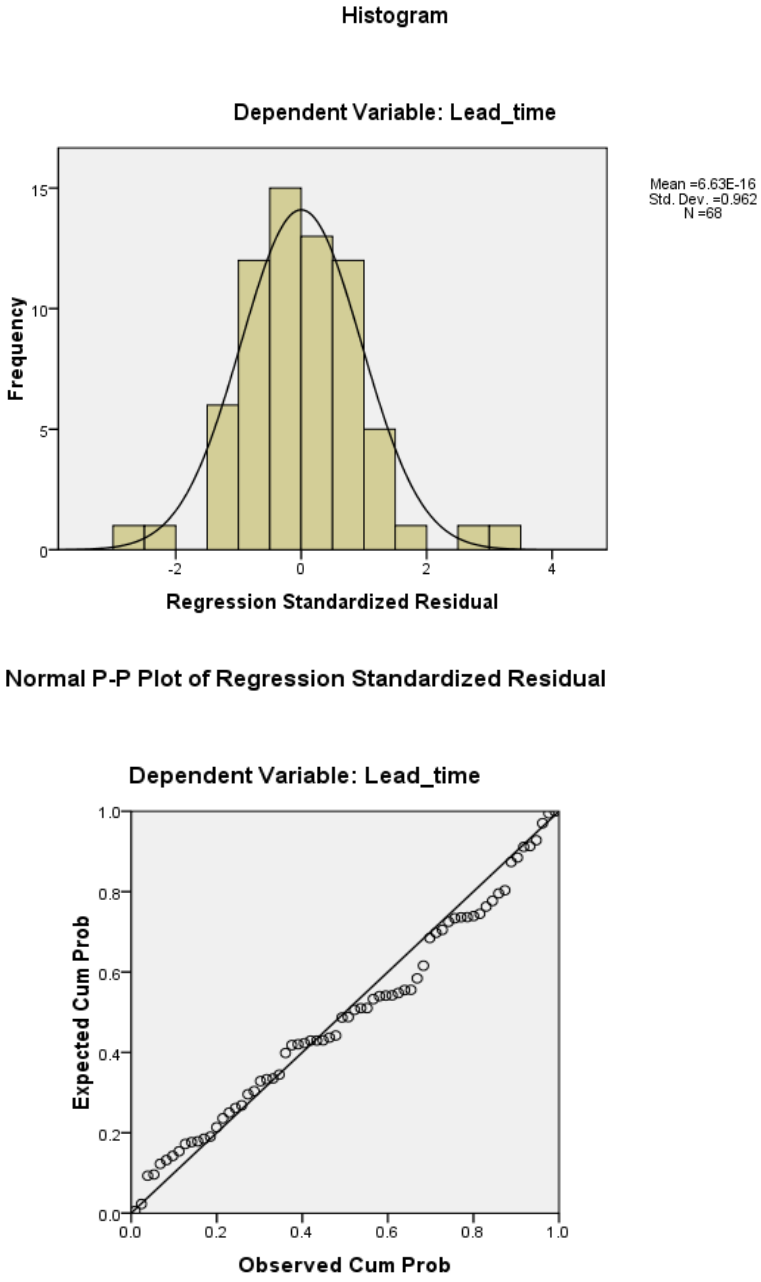

Figure 2. Residual Plots

normality of the residuals. Moreover, this is one of the test for robustness for normality, which satisfies the condition for residuals.

4. CONCLUDING REMARKS

In the countries like India, infrastructure development in terms of strengthening of road transport infrastructure plays a pivotal role for economic growth. Several studies have evaluated this phenomenon, attempting to quantify the contribution of infrastructure development to economic growth. Aschauer (1989a, 1989b) concluded that infrastructure

endowments were a factor of enormous importance in explaining the evolution of economic growth in the USA. Banister and Berechman (2000) made an extensive study of the relationship between economic growth and transport infrastructures. They arrived at a conclusion that development of transport infrastructures contribute positively to economic growth. Investment in infrastructures and more specifically in new roadways favoured the economic growth of the most urbanised regions as well as the territories they crossed (Rephann & Isserman, 1994; Chandra & Thompson, 2000).

From the model it can be observed that connectivity between the places by infrastructure development has to be considered as a top priority by the government by converting most of the 2 Lanes to 4 Lanes and laying bypasses. Therefore, the Central and State governments should focus more on infrastructure development and make sure that the policies towards the development of this would improve.

ОБЈАШЊЕЊЕ ЗНАЧАЈА ТРАНСПОРТНОГ ВРЕМЕНСКОГ ЦИКЛУСА У ИНДИЈСКОЈ ДРУМСКОЈ ЛОГИСТИЦИ: ЕКОНОМЕТРИЈСКА АНАЛИЗА

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Извод

У овом раду аутори користе економетријске алате и технике које се обично користе за одређивање повезаности утицаја различитих промењивих и њихових последичних дејстава присутних у литератури из области економије транспорта. Студија покушава да емпиријски анализира утицај варијабли као што су просечни број возила за брзи транспорт по дану, просечни број возила за спорији транспорт по дану, број сати за одмор возача, просечни однос лаких и тешких возила и број становника у областима дуж одређених рута на трајање временског циклуса транспорта (трајање путовања од поласка до крајње дестинације), за изабране 68 руте у Индији. Студија је подељена у три дела. Део 1 даје кратку позадину сектора друмског транспорта у Индији и даје преглед литературе из ове области. Део 2 покушава да покаже како се економетријске технике могу применити на процену утицаја различитих промењивих на време трајања циклуса транспорта. Део 3 истиче резултате и предлаже одређене конкретна решења, која су од користи за даља истраживања и примену резултата овог истраживања.

Кључне речи: Транспортна мрежа, циклус транспорта, товар, инфраструктура, Индија

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Appendix 1. The Selected Routes and National Highways

Routes	
Kolkata-Chennai	Hyderabad –Kolkata
Kolkata-Delhi	Hyderabad –Chennai
Kolkata-Mumbai	Hyderabad –Delhi
Chennai-Delhi	Hyderabad –Mumbai
Chennai-Mumbai	Jaipur-Kolkata
Delhi-Mumbai	Jaipur –Chennai
Ahmedabad -Kolkata	Jaipur –Delhi
Ahmedabad –Chennai	Jaipur –Mumbai
Ahmedabad –Delhi	Kanpur-Kolkata
Ahmedabad -Mumbai	Kanpur –Chennai
Bangalore-Kolkata	Kanpur –Delhi
Bangalore -Chennai	Kanpur –Mumbai
Bangalore -Delhi	Kochi-Kolkata
Bangalore -Mumbai	Kochi-Chennai
Bhopal-Kolkata	Kochi-Delhi
Bhopal -Chennai	Kochi-Mumbai
Bhopal -Delhi	Lucknow-Kolkata
Bhopal -Mumbai	Lucknow –Chennai
Bhubaneswar Kolkata	Lucknow –Delhi
Bhubaneswar -Chennai	Lucknow –Mumbai
Bhubaneswar -Delhi	Nagpur-Kolkata
Bhubaneswar -Mumbai	Nagpur –Chennai
Chandigarh-Kolkata	Nagpur –Delhi
Chandigarh -Chennai	Nagpur –Mumbai
Chandigarh -Delhi	Patna-Kolkata
Chandigarh -Mumbai	Patna-Chennai
Coimbatore-Kolkata	Patna-Delhi
Coimbatore -Chennai	Patna-Mumbai
Coimbatore -Delhi	Pune-Kolkata
Coimbatore -Mumbai	Pune-Chennai
Guwahati -Kolkata	Pune-Delhi
Guwahati -Chennai	Pune-Mumbai
Guwahati -Delhi	Siliguri-Kolkata
Guwahati -Mumbai	Siliguri-Chennai