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Research Paper

Elasticity Analysis of Effect of Economic Parameters on Travel Demand in Delhi, India

Architecture

KEYWORDS : Elasticity, Economic parameters, Transport demand

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ABSTRACT

The demand for travel arises due to differential placement of sources of supply and demand. The travel demand is considered to be derived demand as demand as users of transport are very often consuming the service not because they benefit from consumption directly (except in cases such as pleasure cruises), but because they wish to partake in other consumption elsewhere. Travel demand in a city refers to the number of passenger trips and the length of the trips. The travel demand is measured in terms of passenger km i.e summation of all distance (in Kms) travelled in each trip. The travel demand in a city depends on variety of demographic, geographic and economic factors such as population, level of urbanisation, growth pattern of city (vertical or sprawl), employment rate, income and distribution thereof, rate of inflation, GDP, land use pattern, lifestyle, age, road/rail network, availability of transport options, parking policies and so on. The travel demand is sensitive to all these factors to different degrees. The sensitivity of demand with respect to any factor is measured in terms of elasticity of demand. The elasticity of demand with respect to any factor is defined as % change in the demand as a result of 1% change in the factor concerned. The Pricing impacts are commonly measured using elasticities, the percentage change in consumption (in this case, in travel activity) that results from each 1% change in price,

In this paper the some of the important economic parameters like per capita income, GDP of the city and rate of employment have been considered for determination of elasticity with respect to these parameters for Delhi, the capital city of India. The study has found that the travel demand is directly related to per capita income in the city. A rising income spurs the growth of travel demand in the city. The elasticity of travel demand w.r.t income is positive in nature. The similar trends have been observed w.r.t GDP of the city and the rate of employment as to some extent these factors are interlinked. The study would help in understanding the trend of travel demand over the time with increase in economic activities in the city. The study can be further extended to develop a multi variable model to estimate future travel demand in an economically vibrant city.

INTRODUCTION

The travel has been one of the basic needs of the mankind from time immemorial. The industrial revolution in Europe started with the invention of steam engine which was first deployed to run the trains. An efficient and integrated transport infrastructure is fundamental to the development of a region. The socio-economic development of a city is very much dependent on transport infrastructure in the city.

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Travel demand in a city refers to the number of passenger trips and the length of the trips. The travel demand is measured in terms of passenger km i.e summation of all distance (in Kms) travelled in each trip. The travel demand in a city depends on variety of demographic, geographic and economic factors such as population, level of urbanisation, growth pattern of city (vertical or sprawl), employment rate, income and distribution thereof, rate of inflation, GDP, land use pattern, lifestyle, age, road/rail network, availability of transport options, parking policies and so on. The travel demand is sensitive to all these factors to different degrees.

In this study an attempt has been made to analyse the effect of Net Domestic Product of the Delhi, per capita income on travel demand. It is expected that the travel demand will increase with Net Domestic Product, per capita income as Net Domestic Product is an indication of the economic vibrancy of the city and per capita income indicates the increase in purchasing capacity of the city dwellers.

The study has also analysed the effect of change in NSDP (Net State Domestic product) of Delhi for primary (Agriculture), Secondary (Manufacturing) and Tertiary (Service) sector of the economy on travel demand.

Travel demand data

The travel demand data in terms of Passenger Kms or passenger trips are not readily available. The data for PKM for road transport has been picked up from the secondary sources and PKM. The PKM for Delhi Metro is available in the records of Delhi Metro since the opening of Delhi Metro i.e Dec 2002.

Travel Demand for road transport

P K Sarkar, Saikat Bose & Pritha Ghosh[1] in their paper " A critical Appraisal of Traffic and Transportation sector in Delhi and possible solutions" have indicated the transport demand from road sector in Delhi as under:

Table 1: passenger travel demand and its distrubution by different modes of transport

Year			1990-91	1995-96	2000-01	2005-06	2010-11
Share of Travel Demand by Different Types of Technology in each Mode (per cent)	Two-Wheeler	2 Stroke	14.85	14.88	12.34	9.37	7.2
		4 Stroke	0.59	0.78	0.93	0.93	0.89
	Three Wheeler		8.55	8.27	7.75	6.42	5.2
	Car/Jeep	Pre 1984	4.5	3.39	1.76	0.44	0.2
		Post 1984	15.88	16.96	13.2	10.27	6.98
		Cat. Conv	0	0.45	3.74	6.56	7.97
		Diesel	1.68	1.81	3.3	4.59	4.78
	Texi	Petrol	0.63	0.2	0.12	0.06	0.02
		Diesel	0.42	0.46	0.47	0.52	0.46
	Bus	Diesel	52.9	52.8	56.4	60.83	66.3
Total Annual Travel Demand (10^9 pkm)			47.05	64	88.05	110.98	143.08

The PKM after every five year is known from the table, the yearly PKM has been interpolated using compound growth formula i.e. **% growth for each year= ((Ending Value/Beginning Value) ^ (1/# of Years))-1**

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Travel Demand for Metro

Delhi Metro has maintained data for PKM since its inception i.e Dec 2002. The PKM data for Metro services has been sourced from DMRC.

Total Travel Demand

The total travel demand has been estimated by summing up PKM from road sector and PKM from Delhi Metro. The PKM due to walking has not been considered as walking is restricted to very small distances. Although number of walk trips are usually high but PKM from walking is generally insignificant.

Table 2: Travel demand from 2004-05 to 2011-12

Year	PKM from Road (*10^9)	PKM from Metro	Total PKM
2004-05	105.96	0.34	106.30
2005-06	110.98	0.84	111.82
2006-07	116.76	1.98	118.75
2007-08	122.85	2.46	125.31
2008-09	129.25	3.05	132.30
2009-10	135.99	3.60	139.59
2010-11	143.08	6.15	149.23
2011-12	148.39*	8.83	157.22

*extrapolated from the available data

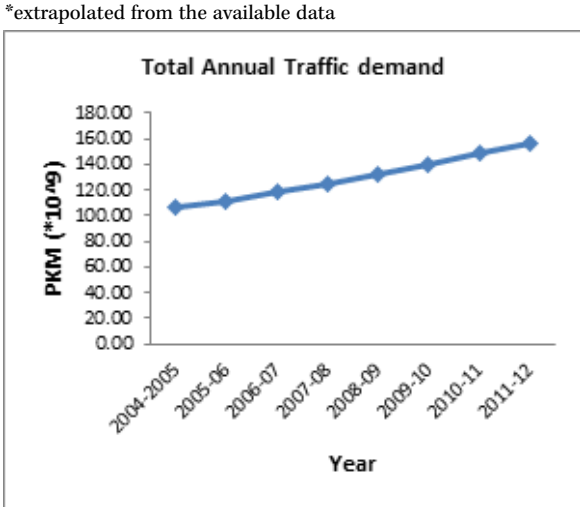


Fig 1.0 Growth of travel demand over a period of time

2.0 Elasticity of Demand

Elasticity of demand w.r.t any parameter is the ratio of % change in demand to % change in the value of parameter.

Lets us say travel demand for a parameter of value X is Y

The elasticity (e) is computed using following formula:

$$e = \frac{\frac{dY}{Y}}{\frac{dX}{X}}$$

For a series of data, the elasticity is computed from the slope of graph between logarithmic of Y with respect to logarithmic of X.

Log Y = e x Log X + C ----------(Formula 1.0)

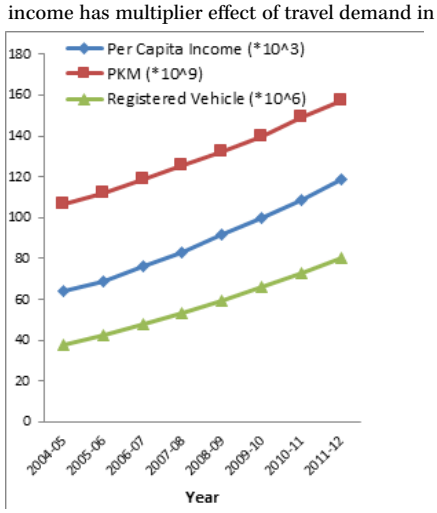
If e=1, a 10% change in the Y results in 10% change in travel demand –X, it is termed as unitary elastic.

If e<1, a 10% change in the Y results less than 10% change in travel demand –X, it is termed as inelastic.

If e>1, a 10% change in the Y results in more than 10% change in travel demand –X, it is termed as elastic.

Per capita income and travel demand:

Increase in per capita income in a city is an indication of improvement in prosperity and purchasing power of the city dwellers. The increase in income is mostly attributed to growth of economic activities, high employment rate and higher wages. However, in an economy if inflation is high, the real increase in wages may not be much or may even be negative if rate of inflation is higher than the rate of increase of wages. So it the inflation adjusted rate of change of income called real income that affects the travel demand. The increase in real wages leaves more disposable income for travel, more and longer leisure/entertainment/ shopping trips. People are ready to travel longer distances for higher wages thereby increasing the number and length of work related trips also. Further, people from the suburban areas like to travel to city centre if wages are high. With increase in prosperity, the number of registered private vehicle in the city is also increasing exponentially. As per some estimates, the private vehicle owner makes three times the trip made by non owner of a private vehicle thanks to convenience of travel offered by private vehicles. Evidently, increase in real per capita income has multiplier effect of travel demand in a city.



The Fig 2. Change in real income, transport demand and number of registered vehicles.

There has been a sustained growth in real income, transport demand and number of registered vehicles over the time. The relationship between travel demand and real per capita income is illustrated in Fig 3.0 below:

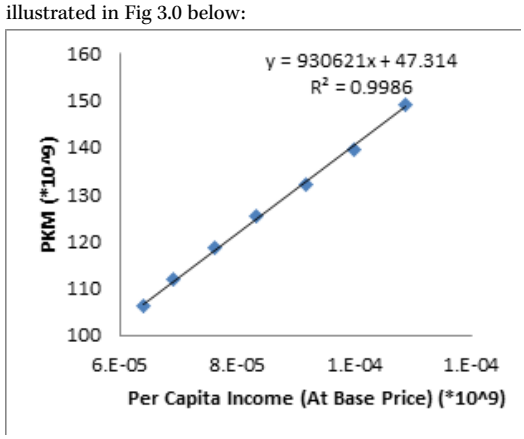


Fig 3.0 Relation between Per Capita Income and PKM

There is a perfect linear relationship (R^2=0.998) between real per capita income and the travel demand.

Elasticity of travel demand w.r.t real per capita income

Elasticity of travel demand w.r.t real per capita income indicates sensitivity of travel demand for real per capita income. The elasticity has for real per capita income has been calculated using formula 1.0

Table 3.0 Elasticity of travel demand with respect to real per capita income

Year	PKM (*10^9)	Per Capita Income (*10^3)	Elasticity	Average Elasticity
2004-05	106.3	63.87		0.625
2005-06	111.82	69.13	0.64	
2006-07	118.75	76.24	0.61	
2007-08	125.31	83.24	0.61	
2008-09	132.3	91.85	0.55	
2009-10	139.59	100.05	0.63	
2010-11	149.23	108.88	0.79	
2011-12	157.22	119.03	0.59	

Inference: A 10% increase in real income results into 6.25 % increase in the travel demand.

Net State Domestic Product (NSDP) and travel demand:

Gross state product (GSP) is a measurement of the economic output of a state. It is the sum of all value added by industries within the state and serves as a counterpart to the gross domestic product (GDP).The estimate of net state domestic product is arrived at by deducting the consumption of fixed capital from the gross state domestic product for each sector. Increase on NSDP may be attributed to growth in primary, secondary and tertiary sectors of the economy of the state. The primary sector is predominated by agriculture and allied fields, the secondary sector refers to manufacturing and the tertiary sector constitutes the service industry in a city. The trend of growth in total NSDP and NSDP sector wise is presented in Fig 4.0 below:

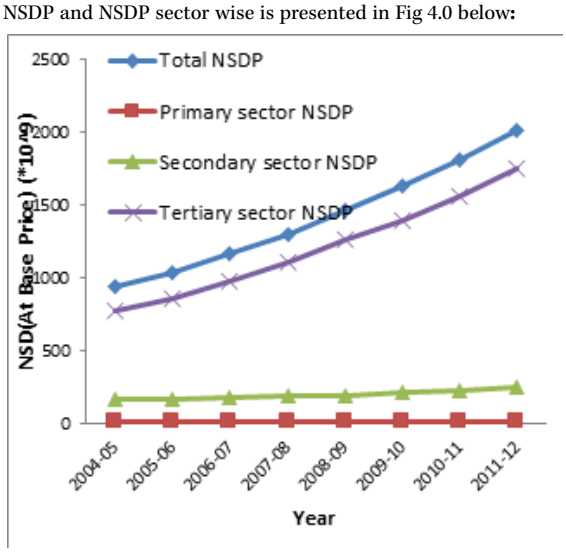


Fig 4.0 The trend of growth in total NSDP and NSDP sector wise

There has been sustained growth in the total NSDP and NSDP from secondary and tertiary sectors. The growth in NSDP from primary sector (agriculture) has been comparatively low which is understandable as agriculture is a very small part of economy in Delhi. Moreover, the growth in agriculture doesn't necessarily cause an increase in transport demand as the workers in a field mostly stay near the field or in the field only. The tertiary sector in Delhi is booming due to increase in software, financial, real estate sectors. The secondary sector is also witnessing a sustained growth as number of industrial units and output of industrial units are on rise.

The relationship between travel demand and Total NSDP, NSDP from Primary, Secondary and Tertiary sector has been presented in, Fig 5.0, Fig 6.0, Fig 7.0and Fig 8.0 below:

Relation between total NSDP and PKM

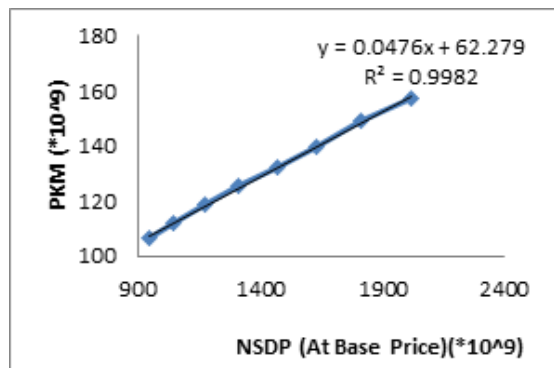


Fig 5.0 Relation between NSDP and PKM

Table 4.0 Elasticity of travel demand with respect to NSDP

Year	PKM	NSDP	Average Elasticity
2004-05	106.3	947.16	0.516
2005-06	111.82	1044.73	
2006-07	118.75	1174.44	
2007-08	125.31	1306.83	
2008-09	132.3	1469.61	
2009-10	139.59	1631.61	
2010-11	149.23	1809.74	
2011-12	157.22	2016.53	

Inference: A 10% increase in NSDP results into 5.16% increase in the travel demand

Relation between Primary sector NSDP and PKM

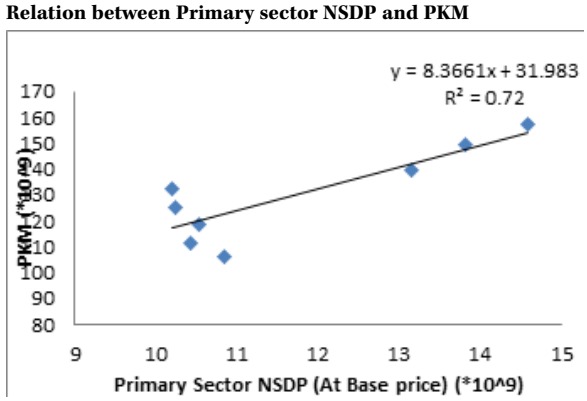


Fig 6.0 Relation between Primary sector NSDP and PKM

R^2= 0.72 for relation between NSDP (primary sector) and travel demand indicates a poor relation. The elasticity of travel demand for NSDP (Primary sector) has not been computed due insignificant relationship between two parameters.

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Relation between Secondary sector NSDP and PKM

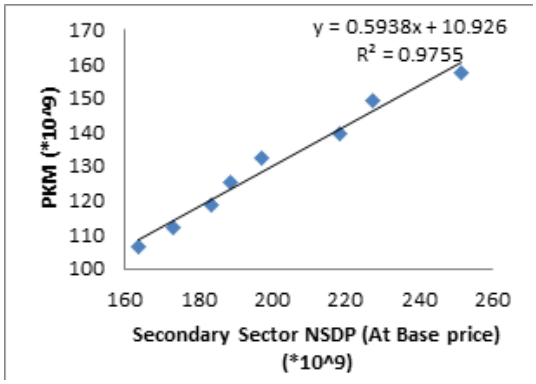

Fig 7.0 Relation between Secondary sector NSDP and PKM

Table 5.0 Elasticity of Travel demand w.r.t. secondary sector NSDP

Year	PKM (*10^9	Secondary Sector NSDP (*10^9)	Average Elasticity
2004-05	106.3	163.87	0.934
2005-06	111.82	173.4	
2006-07	118.75	183.66	
2007-08	125.31	188.72	
2008-09	132.3	197.08	
2009-10	139.59	218.67	
2010-11	149.23	227.77	
2011-12	157.22	251.86	

Inference: A 10% increase in NSDP results into 9.34% increase in the travel demand

Relation between Tertiary sector NSDP and PKM

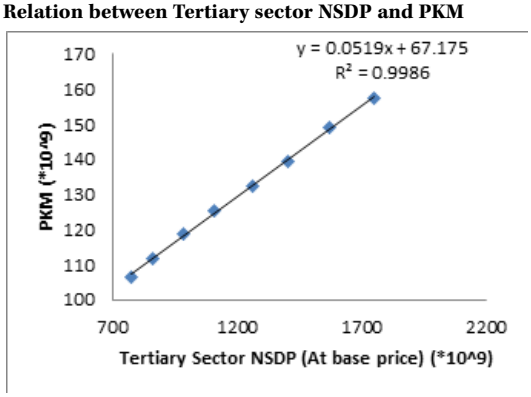

Fig 8.0 Relation between Tertiary Sector NSDP and PKM

Table 6.0 Elasticity of Travel demand w.r.t. tertiary sector NSDP

Year	PKM	Tertiary Sector NSDP	Elasticity	Average Elasticity
2004-05	106.3	772.45		0.475
2005-06	111.82	860.91	0.47	
2006-07	118.75	980.23	0.46	
2007-08	125.31	1107.88	0.44	
2008-09	132.3	1262.38	0.42	
2009-10	139.59	1399.78	0.52	
2010-11	149.23	1568.14	0.59	
2011-12	157.22	1750.08	0.48	

Inference: A 10% increase in NSDP results into 4.75 % increase in the travel demand

Summary of results:

The elasticity of demand for different economic parameters is presented in Table 7.0 below

Table 7.0 Elasticity of travel demand w.r.t per capita income, total NSDP, Secondary and tertiary sector NSDP

	Real per capita Income	Total NSDP	Secondary sector NSDP	Tertiary sector NSDP
Average Elasticity	0.625	0.516	0.934	0.475
R^2	0.998	0.998	0.975	0.998

There is a strong relationship (R^2= 0.998) between travel demand and real per capita income with a elasticity of 0.625 i.e A 10% increase in real income results into 6.25 % increase in the travel demand. The per capita income in Delhi, although increasing, is still on lower side in comparison to other international cities. Due to low per capita income, the people prefer to spend additional income on other priorities like food, shelter, education rather than on transportation.

The elasticity of travel demand for secondary sector of economy is the highest among the parameters considered in the study. The secondary sector represents the manufacturing & industries. Development of manufacturing and industries lead to concentration of work force at the place of the manufacturing/ industrial unit. Most of the manufacturing/industrial units are still labour intensive and most of the labour class live in the outskirts of the city. These factors have multiplier effect on demand of travel consequent to development of manufacturing/industrial units which results into higher level of elasticity of demand. However, the contribution of secondary sector in total NSDP is only around 14%. The growth in the secondary sector has not spurred the travel demand in the city due to its limited contribution in the total NSDP.

The elasticity for travel demand with respect to NSDP (tertiary sector) seems to be lower side. The tertiary sector mainly represents the service sector. Recent days, the service sector has witnessed significant growth. The tertiary sector contributes to the extent of 85% the NSDP in the economy of Delhi state. Although development of tertiary sector promotes travel demand in the city but to a lesser extent as compared to secondary sector as the high value tertiary sector (IT services, Financial services etc) is not labour intensive.

There is a strong relationship (R^2= 0.998) between travel demand and total NSDP with elasticity of 0.516 respectively. A 10% increase in NSDP results in around 5.16 % increase in the travel demand. The growth in NSDP indicates the increase in economic activities and travel demand increases accordingly. Due to high proportion of tertiary sector in the economy of Delhi, the elasticity of travel demand w.r.t total NSDP is also on lower side.

Conclusion

The urban travel demand being a derived demand depends of wide range of economic parameters in a city. The travel demand is more sensitive to development of secondary sector of the economy being labour intensive in nature. The service sector, although booming, has promoted the travel demand to a limited extent. The travel demand is also moderately sensitive to the real per capita income in the city. The increase in per capita income leaves more disposable income for transportation; however, other basic needs get priority over transportation.

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