Impact Assessment of Induced Traffic on Feasibility of Highway Projects

Balaji. PONNU[a], Subodh Kant DUBEY[b], Shriniwas. S. ARKATKAR[c] Ashoke SARKAR[d]

[a,b,c] *Birla Institute of Technology and Science (BITS) Pilani, Rajasthan, 333031, India*
[a] *E-mail:balaji.bitsp@gmail.com*
[b] *E-mail: subbits@gmail.com*
[c] *E-mail: sarkatkar@gmail.com*
[d] *E-mail: asarkarbits@gmail.com*

Abstract: Induced travel that alters the traffic growth rate of highway projects and their economic and environmental benefits has been studied in this paper. Most of researchers on induced traffic have used the static lane-km elasticity whereas it is in fact change in travel cost that users react to when the lane-km changes. Hence this work uses travel-cost elasticity and studies the effects of induced traffic for an Indian highway project in terms of economic and environmental impacts and compares the results with the conventional lane-km elasticity method. It has been found from this study that considering induced traffic by both these methods changes the economic and environmental indicators by different amounts. Hence, ascertaining the best method by comparing with real traffic counts assumes great importance. This paper also suggests preferring travel cost elasticity as even lane-km indirectly accounts to travel cost savings due to additional lane-km added to the facility.

*Keywords***:** Induced Traffic, Elasticity, Travel Cost, Traffic Projections

1. INTRODUCTION

Induced traffic is the additional traffic that is generated when the user costs associated with a road facility decreases. This decrease in cost may arise from anything ranging from minor improvements like filling up of pot holes or patches to major alterations such as widening of the road. In the first case, the cost of the trip decreases due to better riding quality and in the second, it decreases due to increased lane width for a given amount of traffic flow. Research has proven that such a decrease in trip cost makes the users to undertake more trips and this occurs irrespective of the roads being in either urban or rural setting. Travel cost refers mainly to the vehicle operating costs and includes two components namely distance related and time related costs. An improvement of the road, as discussed above may result in decrease of both these components.

The phenomenon of latent demand or induced traffic has often been ascribed very less importance in Indian highway (rural roads) projects which are being extensively upgraded by the National Highway Development Program (NHDP), since the year 2000. Induced traffic is very much relevant for Indian rural road networks, as improving connectivity in rural areas of developing countries kindles a spur of associated activities in the adjoining area. Thus, traffic growth projection rates calculated for evaluation of economic feasibility of these projects become erroneous when induced traffic is neglected.

Recognizing the importance of induced traffic; the researchers in developed countries [for example: (Hamilton, 2003); (Cervero and Hansen 2002) and (Cervero 2003);] have dedicated a vast amount of research on induced traffic and have considered the same for both urban road networks and for freeways or intercity highways. Nevertheless, most of the researchers have only adopted lane-km elasticity, which calculates the amount of induced traffic as a proportion of the change in lane-km. This method though widely accepted, lacks a dynamic component as lane-km increase is a onetime post construction change, till the horizon year. Also, this method does not account for congestion, which has a great effect on the trip making behaviour of the road users. Yet another and most important disadvantage of this method is that it leads to increased traffic growth rate estimation in case of uncongested facilities where there is very less change in travel cost before and after improvement. So, parameters that can explain induced traffic as well as congestion effects would give more robust estimates of induced travel. Travel cost that includes vehicle operating costs (VOC) and value of time (VOT) is one such parameter and is significantly affected by a roadway improvement project. For instance, paving a currently unpaved road reduces costs for all road users and increasing design speeds reduces time costs per vehicle-kilometre, particularly for higher speed modes such as private automobiles. Similarly, expanding un-priced urban highways reduces traffic congestion and therefore time and money costs, expanding tolled urban highways reduces time costs but increases money costs, so it will tend to increase vehicle travel by higher-income motorists and adding bus lanes reduces time and operating costs for public transit vehicles. Many researchers have studied the relation of travel cost with the vehicle kilometres travelled has been studied by some researchers [for example: (Hamilton 2003) and (Lee and Burris 2002)]. Hence, studying the effect of induced traffic with reference to travel cost would give a better estimate of induced traffic.

As induced traffic is often neglected in evaluating feasibility of highway projects in India, this work aims to highlight some of the implications of doing so. National Highway No 2 from Delhi to Agra, which is due to be widened from four to six lanes in two to three years from now (http://www.nhai.org/fundedbot.asp), has been chosen as an example for the analysis. Using the relevant project data, travel costs for traversing the stretch by different types of vehicles were calculated and from the cost differences, induced traffic was calculated. Further, economic analysis was done with reference to do nothing scenario (base case) against improved road for normal and induced growth rates of traffic scenarios. To understand the economic implications of induced traffic on highway projects, parameters like Net Present Value (NPV) and Internal Rate of Return (IRR) of each type of growth rate were calculated. To emphasize on the environmental impact of such a change in traffic growth, vehicular emission indicators such as carbon dioxide, particulate emissions and nitrogen oxides were also quantified.

2. LITERATURE SURVEY

A lot of research has been done on induced traffic in developed countries and most of the works are confined to induced traffic due to lane-mile elasticity. Hanson and Huang (1997), obtained an elasticity of vehicle miles travelled (VMT) with respect to lane miles of 0.6–0.9 for state highways in California. Noland (2001), used time series data of US roads from the year 1984 to 1996 to develop regression models involving variables namely vehicle miles travelled (VMT) and lane-km. Cervero and Hansen (2002), developed relationships between VMT and lane miles for 22 years time series data of California State and have found the elasticities of VMT with respect to lane-miles to be 0.6 and 0.8 respectively. Cervero (2003) conducted a study using a 15-year time series data of California freeways and found elasticity of VMT with respect to lane miles: 0.10 in the short run and 0.39 in the long run. Other types of elasticities have been investigated by few researchers. Lee and Burris (2002), suggested elasticity values of VMT with generalized costs as –0.5 to –1.0 in the short run, and –1.0 to –2.0 over the long run. Booz Allen Hamilton estimates the elasticity of VMT with generalized cost of travel in Canberra to be –0.87 for peak, -1.18 for off-peak, and –1.02 overall. (Hamilton)

Induced traffic still being one of the areas, where a lot of research and debates go on in developed countries, very few authors write about this in the developing countries. Özuysal and Tanyel (2008) made a case study in Turkey, which is a developing country and found that induced demand is valid for developing countries. They used two parameters for measuring the additional travel, namely, VMT and TPV (Travel per Vehicle), which were correlated with lane miles. They also found that TPV is a more consistent estimate for induced travel rather than VMT and vehicle numbers and hence should be considered in the case of developing countries. Elangovan et al. (2010), have considered induced travel along with normal growth and diverted trips with reference to travel time elasticity of 0.67 for evaluating the traffic potentials of a tolled road in Kerala, India. Singru et al. (2010), reported that current ADB project appraisals in developing countries do not account for induced traffic and this has profound effect on the amount of traffic and related CO_2 emissions. Using the transport emissions evaluation model for projects to evaluate a typical national highway shows that CO_2 emissions for a typical national highway are 17%–58% higher when induced traffic is appropriately accounted for at a lane-km elasticity value ranging from 0.25 to 1.0 for three different corridors.

In addition to the fact that induced traffic is neglected when the feasibility of Indian projects are studied, the above literature clearly shows that researchers both in developed and developing countries have used lane km elasticity for quantification of induced traffic. Hence it necessitates a study to emphasize the importance of accounting of induced traffic for Indian highway projects with a more reliable elasticity parameter such as travel cost.

3. TRAVEL COST ELASTICITY

This is defined as the percent change in vehicle-kilometers travelled (VKT), when there is one percent change in travel cost. Induced traffic due to travel cost improvements is the additional traffic caused due to decrease in travel cost of the users due to improvement of facility. VKT is negatively elastic with reference to the travel cost (Litman 2009). Travel cost elasticity can be expressed as shown in Equation (1).

$$e_{tc} = -\frac{\partial \log(VKT)}{\partial \log(TC)} = -\frac{TT}{VKT} \cdot \frac{\partial (VKT)}{\partial (TC)} \quad (1)$$

where,
TC : Total travel cost and TT : Total travel time

4. DATA COLLECTION

The NH-2 from Delhi to Agra is a four-lane divided carriageway of 179.1 km and is proposed to be widened to six lanes. The construction has started in January 2011 and is scheduled to be completed in January 2014 (http://www.nhai.org/fundedbot.asp). The project details have been collected from its feasibility report (National Highway Authority of India 2009). The horizon period considered for the analysis in the report is till 2030. The project road has been divided into four homogeneous sections for design as given in Table 1. The section-wise traffic is given in Table 2 which shows that first section between Delhi-Palwal has the heaviest traffic, nevertheless lesser than the capacity of 80000 pcu/day. The other stretches are grossly underused. Table 3 shows the annual growth rate of traffic of the project for different categories of vehicles which shows a decreasing trend towards the horizon year. Such a decrease is associated with the economic improvement of the region and increase in vehicle numbers but not with the induced traffic the project would generate.

Table 1.Section-wise NH-2 Project Details

Section No	Stretch Name	Length (km)	Peak Hour Factor(PHF)	Lane Distribution factor
1	Delhi-Palwal	39.5	6.19%	52.00%
2	Palwal-Kosi	44	6.00%	52.00%
3	Kosi-Mathura	38	6.33%	50.10%
4	Mathura-Agra	57.6	5.94%	52.00%

Table 2.NH-2 Section-wise daily Traffic Details (ADT) *

Vehicle Type	Section-1	Section-2	Section-3	Section-4	PCU
2-Wheeler(2W)	12843	5129	3975	5290	0.5
Car(PC)/ 3-Wheeler(3W)	20767	13287	9080	8547	1
Light Commercial Vehicle(LCV)	3603	1034	1216	1569	1.5
Bus	1096	702	560	569	3
2-axle truck(2AV)	3733	3189	2301	2601	3
3-axle truck(3AV)	1590	1442	1011	1393	3
Multi axle truck(3AV)	1631	1307	1078	774	4.5
Total (Vehicles/day)	51357	26302	19371	21866	
Total(PCU/day)	45263	26090	19221	20743	

*For analysis, vehicles with same PCU are taken as same category

Table 3.Normal (Projected) Growth Rates. (As per the feasibility report [5])

Period	Car	Bus	Truck/LCV	2W
2010-2015	6.6%	5.5%	5.5%	7.2%
2015-2020	6.1%	5.5%	5.5%	6.1%
After 2020	5.5%	5.0%	5.0%	5.5%

LCV: Light Commercial Vehicles

5. DATA ANALYSIS

The travel cost in which the vehicle operating cost (VOC) is the main component has been calculated using IRC SP 30 (Manual on Economic Evaluation of Highway Projects in India

1993) in the following manner. The vehicle operating cost equations for single, intermediate, two and four lane equations for different categories were developed during the Road User Cost Study (RUCS) conducted by Central Road Research Institute, New Delhi on Indian Highways in 1992 which was updated in the years 2001. These studies dealt with developing VOC equations for rural roads up to four lane divided carriageways. But as the project under this case study involves widening of a 4-lane divided road to 6-lane divided road, equations for six-lane road have been extrapolated from four lane equations. The equations used are given in the Tables 4 and 5 below.

Table 4.VOC Distance Related Congestion Factors

Vehicle Type	4-lane road	6-lane road
PC	CF*=0.8(0.9+0.9VCR**)	CF=0.8(1+0.9VCR)
2-AV	CF=0.8(1+0.75VCR)	CF=0.8(1.2+0.5VCR)
Bus	CF=0.8(1+0.75VCR)	CF=0.8(1.2+0.5VCR)
3-AV	CF=0.8(0.9+0.7VCR)	CF=0.8(0.9+0.5VCR)
MAV	CF=0.8(0.9+0.7VCR)	CF=0.8(0.9+0.5VCR)
LCV	CF=0.8(0.9+0.7VCR)	CF=0.8(0.9+0.5VCR)
2W	CF=0.8(1.00)	CF=0.8(1.00)

*Congestion Factor, **Volume Capacity Ratio

Table 5.VOC Time Related Congestion Factors

Vehicle Type	4-lane road	6-lane road
PC	CF=0.8(92.79-0.0075q*)	CF=0.8(93-0.0074q)
2AV	CF=0.8(63.25-0.047q)	CF=0.8(65.5-0.0038q)
Bus	CF=0.8(74.48-0.0042q)	CF=0.8(79-0.0048q)
3AV	CF=0.8(48.07-0.0036q)	CF=0.8(51-0.003q)
MAV	CF=0.8(57.21-0.0062q)	CF=0.8(51-0.003q)
LCV	CF=0.8(70.94-0.0067q)	CF=0.8(71.5-0.007q)
2W	CF=0.8(57.2 1-0.0062q)	CF=0.8(60.5-0.006q)

*hourly traffic flow calculated from ADT in PCU for all 24 hours with a PHF of 10%

Congestion factor is a multiplier for unit time and distance costs and accounts for speed flow relationships separated into time and distance related components (Manual on Economic Evaluation of Highway Projects in India 1993). VOCs (per vehicle per km) are evaluated by multiplying the distance and time related congestion factors as shown in the Tables 4 and 5, with the unit distance and time costs shown in Table 6. As these equations were developed only for a peak hour flow, a factor of 0.8 has been used in all the equations to use them for non-peak hours. This has been calibrated by CRRI in their study on Indian highways of different states of India. For further details please refer to (Manual on Economic Evaluation of Highway Projects in India 1993). Table 6 contains the unit operating costs for different vehicle categories for six lane divided roads extrapolated from roads of other configuration such as single, intermediate, two and four lane roads. As per the feasibility report (National Highway Authority of India 2009), the project road is asphaltic and has a smooth surface, with a roughness of 2000 mm/km. The rise and fall (RF) required for calculating the unit costs is taken as zero as the road is plain terrain. As the report was written from a study made in 1992, the prices are inflated using the wholesale price index (WPI) to project them to 2011 prices ((http://eaindustry.nic.in/).

Table 6.Unit Vehicle Operating Costs

	Road Type	Unit Cost(Rs per vehicle per km)	
		Distance Related	Time Related
PC	Single lane(3.5 m wide)	0.70	0.74
	Intermediate lane road(5.5 m wide)	0.71	0.72
	Two lane(7 m undivided)	0.83	0.52
	Four lane(14 m divided)	0.87	0.49
	Six-lane(21 m divided)	0.88	0.47
2AV	Single lane(3.5 m wide)	2.07	4.45
	Intermediate lane road(5.5 m wide)	1.82	4.09
	Two lane(7 m undivided)	1.67	3.72
	Four lane(14 m divided)	1.68	3.62
	Six-lane(21 m divided)	1.45	3.26
Bus	Single lane(3.5 m wide)	1.97	3.84
	Intermediate lane road(5.5 m wide)	1.83	3.52
	Two lane(7 m undivided)	1.76	3.21
	Four lane(14 m divided)	1.79	3.06
	Six-lane(21 m divided)	1.65	2.74
3AV	Single lane(3.5 m wide)	3.38	7.46
	Intermediate lane road(5.5 m wide)	2.97	6.85
	Two lane(7 m undivided)	2.75	6.27
	Four lane(14 m divided)	2.77	6.12
	Six-lane(21 m divided)	2.36	5.51
MAV	Single lane(3.5 m wide)	3.38	7.46
	Intermediate lane road(5.5 m wide)	2.97	6.85
	Two lane(7 m undivided)	2.75	6.27
	Four lane(14 m divided)	2.77	6.12
	Six-lane(21 m divided)	2.36	5.51
LCV	Single lane(3.5 m wide)	1.11	4.53
	Intermediate lane road(5.5 m)	0.97	4.28
	Two lane(7 m undivided)	0.96	3.72
	Four lane(14 m divided)	1.00	3.57
	Six-lane(21 m divided)	0.86	3.32
2W	Single lane(3.5 m wide)	0.23	0.46
	Intermediate lane road(5.5 m)	0.24	0.45
	Two lane(7 m undivided)	0.23	0.45
	Four lane(14 m divided)	0.24	0.45
	Six-lane(21 m divided)	0.25	0.44

These costs (VOC/vehicle) are same for the whole year, as the flow is assumed to be constant for the whole year. An elasticity of -0.5 of VKT with respect to travel cost has been taken as the project road is a toll road which may offset the user benefits due to improvement. Induced traffic starts to flow from the year when widening is complete, due to the reduction in travel cost and goes on till the point of time when there is no decrease in travel cost in any two consecutive years. Induced traffic reduces to zero in this year when there is no travel cost decrease and from then on, traffic growth is only due to socio-economic factors (normal growth) and not due latent demand. Though traffic could be 'induced' due to many other factors, this method attributes induced traffic only due to travel cost changes. The volume of induced traffic generated every year from the second year till the horizon year as per this method are shown in the Table 7 below.

Table 7.Induced Traffic by Travel cost method.

Year	Normal growth (VKT)	Change in travel cost (%)	Change in VKT (%)	Induced traffic (VKT)
2011	3203913337	N.A.	N.A.	N.A.
2012	3396624329	N.A.	N.A.	N.A.
2013	3601052369	N.A.	N.A.	N.A.
2014	3817917783	11.54%	0.29%	11601579
2015	4047985674	10.97%	0.27%	11627258
2016	4281083268	10.35%	0.26%	11515510
2017	4527639191	9.63%	0.24%	11226157
2018	4788432566	8.82%	0.22%	10741143
2019	5064287744	7.92%	0.20%	10016633
2020	5272391645	7.44%	0.19%	9802822
2021	5456782545	6.92%	0.13%	6543213
2022	5650793187	6.32%	0.12%	6049376
2023	5854926569	5.67%	0.10%	5411220
2024	6069712051	4.96%	0.08%	4602830
2025	6295706735	4.27%	0.06%	3714658
2026	6533496928	3.78%	0.05%	3102747
2027	6783699672	3.06%	0.03%	2092377
2028	6976552407	2.26%	0.01%	846718
2029	7149269696	1.73%	0.00%	76087
2030	7330994356	1.68%	0.00%	0

It can be seen from Table 7 that the first three years i.e. the years of construction, there is no induced traffic as the road capacity remains essentially the same. But in 2014, when the widened facility is thrown open, new trips (VKT) get added due to reduced costs which are shown as induced traffic. This trend continues till the travel cost on the road reaches the same value as before improvement. In this study this happens in the year 2030 and this depends on the traffic potential and congestion in the facility under consideration.

6. ESTIMATION OF GROWTH RATES

One of the main objectives of the paper is to calculate annual traffic growth rates for different scenarios of growth such as normal (socio-economic) and induced traffic due to travel cost. Annual growth rate is defined as the percentage increase in the traffic that uses the facility in any two consecutive years. The growth of traffic in each scenario is ascertained subjected to the constraints such as capacity of the facility and congestion. In the case of normal growth, the traffic for base case (four lane road) has been subjected to the limiting capacity of 80000 pcu/day (Velmurugan *et al.*2010). For improved road (six lane), for normal growth pattern, the limiting capacity is 120000 pcu/day (Velmurugan *et al*. 2010). Induced traffic becomes zero when the travel cost difference between two consecutive years is non positive. From this year onwards, only normal growth rates are considered till horizon year. When induced traffic is considered, the capacity is reached faster than it is for the normal growth scenario, due to the additional contribution of induced travel.

Growth rates are very important inputs for analyzing the economic soundness of the project under consideration. As per the feasibility report (National Highway Authority of India 2009), though the growth rates are gradually decreased as shown in Table 3, these growth rates have not been accounted for the induced traffic component but rather only considering limiting capacity. For example, growth rates given in Table 3 are lesser than that of Table 8 for the years 2012-2019 (average) and it is the reverse for the years 2020-2030. Such differences in growth rate predictions can lead to erroneous economic estimates. These differences will be more pronounced in the projects that relieve a greater deal of congestion on the existing road than the road considered in the present study.

Table 8.Growth rates Estimated by Travel Cost Elasticity Method

Year	Car	Bus	Truck/LCV	2-wheeler
2012	6.60%	5.50%	5.50%	7.20%
2013	6.60%	5.50%	5.50%	7.20%
2014	6.91%	5.80%	5.80%	7.51%
2015	6.87%	5.77%	5.77%	7.48%
2016	6.34%	5.74%	5.74%	6.34%
2017	6.31%	5.71%	5.71%	6.31%
2018	6.28%	5.68%	5.68%	6.28%
2019	6.08%	5.48%	5.48%	6.08%
2020	4.68%	4.23%	4.23%	4.68%
2021	4.21%	3.84%	3.84%	4.21%
2022	4.19%	3.82%	3.82%	4.19%
2023	4.17%	3.80%	3.80%	4.17%
2024	4.15%	3.78%	3.78%	4.15%
2025	4.13%	3.76%	3.76%	4.13%
2026	4.12%	3.74%	3.74%	4.12%
2027	4.10%	3.72%	3.72%	4.10%
2028	2.78%	2.53%	2.53%	2.78%
2029	2.71%	2.46%	2.46%	2.71%
2030	2.71%	2.46%	2.46%	2.71%

7. ECONOMIC ANALYSIS

The NPV and IRR of the project have been calculated for two scenarios viz. normal and travel cost elastic growth vs. the base case (do nothing alternative). A discount rate of 12% that is generally used for economic opportunity cost of capital in ADB financed road projects has been adopted for the calculation of NPV (Manual on Economic Evaluation of Highway Projects in India 1993). As the vehicle operation costs given by (Manual on Economic Evaluation of Highway Projects in India 1993) are for the year, 1993, they are inflated to apply them to the year 2011 on the basis of WPI of 1993 and 2010 (http://eaindustry.nic.in/). Table 9 shows the vehicle operation costs (VOC) and maintenance costs for all four scenarios. The emission indicators such as carbon dioxide CO_2, particulate matter (PM) and nitrogen oxides (NO_x) from the project have been calculated using the TEEMP tool (Transport Emission and Evaluation Model for Projects) given by (Singru et al.2010). The summary of both economic and emission analysis is given in Table 10.

Table 9 Costs Summary (in million Rs).

Year	VOC		Construction + Maint. Cost Improved road scenario	VOC	Maint. Cost Base case scenario
	Normal growth scenario	Induced growth Travel Cost scenario		Base Case scenario	
2011	7670	7670	3733	10227	25
2012	8121	8121	7467	10836	25
2013	8602	8602	7467	11281	25
2014	9114	9143	15	11730	25
2015	9662	9720	15	12207	25
2016	10235	10324	15	12712	25
2017	10847	10965	15	13247	25
2018	11510	11666	15	13826	25
2019	12243	12395	15	14448	25
2020	12772	12893	15	14951	25
2021	13237	13377	15	15339	25
2022	13733	13890	15	15752	25
2023	14258	14431	15	16208	25
2024	14815	15000	15	16696	25
2025	15404	15602	15	16976	25
2026	16033	16243	15	17002	25
2027	16731	16958	15	17002	25
2028	17261	17412	15	17002	25
2029	17725	17878	15	17002	25
2030	18218	18372	15	17002	25

Note:

1. Construction cost of six lane road = Rs. 18667 million (inflated to 2011 prices) taken in the proportion of 1:2:2 in the first three years (National Highway Authority of India 2009).
2. Maint. Cost of four and six lane roads = Rs. 15 and 25 million respectively (National Highway Authority of India 2009).

From Table 9, it can be seen that the VOC for both the improved scenarios is higher than the base case. This is due to the fact that the existing four lane road has a lesser capacity than the proposed six lane road and hence allows lesser vehicles to use the facility resulting in lesser total VOC after 2028 even when the unit VOC per vehicle is less. Also, the VOC for the induced traffic scenario is higher than the normal growth due to more number of vehicles using the facility in the latter.

Table 10.Summary of Findings.

Scenario	NPV Million Rs	IRR %	CO_2 tons/km /year	PM tons/km /year	NO_x tons/km /year
Base Case	-	-	161391.42	614.48	620.89
After Improvement					
Normal growth	1940	16.63%	216046.12	707.31	684.88
Induced growth(TC)	1318	15.33%	216696.59	709.56	687.87
Induced growth(LK)	3325	16.31%	217934.62	703.84	679.81

The comparison between the economic and environmental indicators is given in Table 10. As an additional measure, the same indicators for induced traffic through lane-km method are also summarized as given below:

1. It can be noted from Table 10 the results are different from the normal growth method when induced traffic is considered in the analysis. In this case study, induced traffic by travel cost method decreases the economic soundness of the project as indicated by both IRR and NPV values by about 32 and 8 % respectively. Also, the emissions viz. CO_2, PM and NO_X from the project also increase by about 0.3% each when this method is considered.
2. The NPV in case of induced traffic by the static lane-km method is about 71% more than when no induced traffic is considered, but IRR decreases by about 2% by this method. The emissions viz. CO_2, PM and NO_X from the project changes by about 0.9%, -0.5% and -0.7% respectively when lane-km elasticity is considered.
3. It can be thus inferred that while the economic and environmental prospects of the project decrease when travel cost based induced traffic is considered, the economic soundness of the project increases in terms of its present value and decreases in terms of its rate of returns. Also, in case of the static lane-km method, the present value of the project increases and the dividend that the project would pay decreases with respect to normal growth rate method.
4. It is clear from the above inferences that economic and environmental indicators are different when these two methods viz. lane-km and travel cost are used. Hence further investigations and annual traffic count data are needed to find out which method is more accurate. The importance of including induced traffic in highway project economic analysis and ascertaining the correct method for calculating induced traffic are the main contributions of this paper.

CONCLUSIONS

The important conclusions drawn from the present study are as follows:

1. The economic and environmental indicators with induced traffic taken into account in the analysis differ from that of the normal growth rate method and hence it becomes imperative to include induced traffic in economic and environmental impact analysis of highway projects.
2. Different elasticity viz. lane-km and travel cost lead to different economic and environmental indicators and hence zeroing on a correct method for induced traffic growth calculation assumes high significance.
3. It is suggested that until both these methods are calibrated with the ground traffic data and the better one found, travel cost elasticity should be used for calculation of induced traffic as even lane-km indirectly deals with the change in user cost associated with the increase in lane-km of the facility in question.
4. Additional emissions due to induced traffic should be treated as social costs by assigning appropriate monetary value and thus should also be included in the feasibility studies.
5. This paper also suggests that in view of many highway projects coming up and induced traffic that affect the economic viability of the project, the Indian highway authority should invest more funds on induced traffic research.

FUTURE SCOPE OF RESEARCH

1. Travel cost elasticity of VKT for the highway under consideration should be calibrated in the field before using in the analysis instead of adopting the same from works done in developed countries.
2. Induced traffic due to travel cost elasticity could be compared with induced traffic due to travel time elasticity.
3. Effect of toll on elasticity values have to be studied as toll price offsets user benefits.

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