QUANTITATIVE WELFARE ANALYSIS OF ROAD PRICING/TOLL PRICING - POST EVALUATION

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Abstract

It is important to all the decision makers and road users to have post evaluation in terms of quantification of welfare benefits arising out from implementing the road pricing/toll pricing. A step forward in this direction, the study aimed at quantifying the welfare benefits from road pricing/toll pricing in the form of Benefit Incidence Table (BIT), showing the equity and efficiency. We have given about four study cases giving in detail about major sectors. From road users point of view a quantitative values, and from land users and landowners point view a qualitative discussion have been given. At the end we have explained comprehensively, which gives the performance level and broad understanding about each scheme/project.

1. Introduction

If we see the past history of toll road systems, we observe some old toll pricing practices in France, Italy, United States of America, Rome, and Japan etc… Recently there are handful of road pricing schemes (London congestion pricing, Norwegian toll rings, Paris –Lille A1 Motorway pricing, Rome cordon pricing, Swiss HVF truck km charge, California's HOT and Priced lane pricing etc..), which are succeeded in combating the congestion, and enhance the mobility and network performance with the help of newly developed technology and road pricing techniques. Literature in this area (Harrington et al.2001, Ison 2000, Jones1991, RAC foundation for motoring, 2003) had shown that the acceptance of road pricing gaining support from the users. The recent trends in road pricing have been concentrating on toll revenue in terms of equity and efficiency. Some of the studies in this direction (Cohen, 1987, Small 1983,1992a, Small and Yan, 2001, Anderson & Mohring's1997 and Elena Safirova et al.2003) had given some useful thoughts.
It is evident that the road pricing is picking up at rapid pace, as decision makers realized that this is also one of the sources to fund infrastructure. After implementing the road pricing schemes it is important to study/quantify the welfare benefits of road pricing schemes, which will helpful for the implementing agencies and various stakeholders to look positively in

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implementing, to improve the scheme, which is already under implementation, and to realize the equity and efficiency of the road pricing. A step forward in this direction, this paper aimed at quantification of welfare benefits in the form of Benefit Incidence Matrix Table(BIT), which gives the clear understanding of various sectors in the scheme with equity and efficiency.

Further, we have briefly explained in section 2 about the BIT, section 3, BIT of London congestion pricing, in section 4, BIT of 91-Express lanes, Orange county California (SR-91), in section 5, BIT of I-15 HOT Express lanes/Fas Trak, San Diego, California (I-15), in section 6, BIT of urban road pricing-Lyon, have been explained. Finally we conclude the paper with conclusions in section 7.

2. BIT (Benefit Incidence Table) for road pricing/toll pricing

Benefit incidence table shows the amount and incidence benefit of road pricing/toll pricing in a table format, that is those represent the structure of generation, transfer and final return on both benefits and costs. The items of benefits and the sectors that eventually differ according to the aim of the application of road pricing schemes, such as pricing aimed at reducing urban congestion and air pollution, project aimed at financing the infrastructure etc. and the regional features. If a sector takes a benefit in terms of final return, the amount of the benefit is positive, and if it takes loss, the amount is negative. If all the items of effect in the BIT can be measured in monetary terms, then benefit/cost in the cells can be summed up row-by-row or column-by-column. The sum of cells in a column indicates the net benefit of the sector, and the sum of cells in a row does the net social benefit of the item as a part of the net social benefit. The total from the cells in the whole table, indicated in the right bottom corner, is the net social benefit. Hence, the net social benefits are decomposed into sectors in the very bottom row, and to items of benefit /cost in the very right column. It should be noted that some items of benefit/cost, like increase in income, change in prices of commodities or service, and increase in land values results in a zero sum, or that the sum of the cells in such a row is equal to zero. These items of benefit/cost, which are spillover effects on competitive markets, have the property that the benefit in one side of demand or supply should be cancelled out with the loss of another. In contrast, other items of benefit/cost may usually result in the non-zero sum, as contained in the every right column.

The efficiency of road pricing/toll pricing scheme can be judged from the magnitude of the net social benefit. The larger the net social welfare benefits the more efficient is the project. On the other hand, the equity balance between sectors should be judged on the basis of the distribution of the net benefit indicated in the very bottom row. This BIT will directly give the both efficiency and equity. For more details on BIT refer Hisa Morisugi et al., (1992,1993 and 2000).

3. BIT of London Congestion Pricing

Congestion charging was successfully introduced in central London on 17th February 2003. After the Transport act, this gave local authorities in England and Wales powers to introduce road user charges to tackle the congestion. The objectives of introduction of road pricing are:

To reduce the congestion
To make radical improvements in bus services
To improve the journey time reliability

To make distribution of goods and services more efficient way.The indirect effects are, improving the civic life and environmental quality. Though the Singapore road pricing in implemented way back in 1975, the success of London road pricing have been made a revolutionary in implementation of cordon pricing schemes. There by now there are so many cities are eagerly looking forward to implement the success story of road pricing today. The Transport for London(tfl) gives valuable information about the function and monitoring of the scheme, which is useful for the researchers and stack holders in this sector. Here we have discussed how the welfare benefits could be quantified in comprehensively and equity and efficiency among the various sectors

Form the Table 1. BIT for London Congestion pricing, we have discussed the major sectors such as road users, households, producers (firms) in side CBD and out side CBD, Land Owner benefits and implementing agency (Government).

3.1 Road users

Road users are classified into individual vehicle user and public transport users. A road user fee £5 per entry will be charged to individual vehicle users, further with various discount charges as per the provisions made. According to the latest report, the approximated total annual revenue from pricing is about £165 million, which comprises of £ 115 million collected from direct charging and £ 50 million from penalty charges. As a result of congestion charge about 70,000 car trips are reduced to enter the charging zone selecting various options like; 20 to 30% are diverted around charging zone and 15 to 20% had opted out to other options such as changing travel timings and changing modes etc. Welfare benefits have achieved with respect to individual vehicle users in the form of congestion relief, resulting 30 percent reduction in congestion, reduced delays from 1.9 min/km to 1.5 min/km and increase in speeds to 17kmph. These welfare benefits are amounting to £135 million after deducting the disbenefit of potential car users who are (9 percent) transferred to improved facilities and public transport with effect of pricing. It is encouraging to note that, there was an improved amenity, environment quality and reduction in accidents have resulted a welfare gain of £ 15 million. Over all from the road users sector, a loss of £ 15 million pounds from individual road users and a gain of £ 30 million pounds from public transport users have resulted a net welfare gains about £15 million and to some extent indecisive. However, once the system is in full operational to marginal cost with latest pricing techniques such as time varying charges, charges based on type of vehicle and charges based on vehicle occupancy etc., there will be definitely more welfare gains from this sector further in future. From equity point view as some part of revenue is funded for improving the public transport facilities apart from its own maintenance and operating costs, shows that the Horizontal equity is attained to some extent and further details about equity are given in section 7.

3.2 Households and Firms Within and out side CBD

From the households point of view, residents in the charged zone are enjoyed the benefits in terms of reduction in congestion levels and emission reductions of NO_x, PM_{10} levels, has changed the public perception to some extant within CBD area, resulting a small increase in acceptance level. Where as in case of producers (firms); one percent increase in service sector, three percent reduction in retail, tourism, and distribution sectors, has resulted in mixed response as no appreciation in acceptance level within CBD area. Similarly decrease in service

Table 1. BIT of London Congestion Pricing

Sector		*Road Users*		**House holds (CBD)**	**Producers (Firms) CBD**	**Producers (Firms &Households) outside CBD**	**Land owner**	**Government (Revenue)**	**Total (Mill. pds)**
		Road	*Public Transport*						
Road User Benefits	Pricing	- **165** **(115 from charge+ 50 from penalty)** (5 pounds/entry) 1.About 70,000car trips are reduced 2. 20 to 30% above diverted around charging zone 3. 15 to 25%, other options such as changing timings of travel	+ (No change in fares) Out of above reduced car trips 50 to 60 % transferred to PT	+ Small increase in acceptance level	+/– No appreciation in acceptance level	+/– No appreciation in acceptance level		+ **165**	0
	Congestion relief	++ **+155** **(- 20 disbenefits to car users)** 1. 30% reduction. 2. Delays reduced from 1.9min/Km to 1.5min/Km. 3. Speeds increased to 17kmph	++ **+30** 1.Improved frequency. 2. Bus speeds increased by 6 % 3. 38% increase in bus patronage						+ 165
Accidents, Amenity and Environment		+ +**15** 1. Reduction in accidents		+ 1. 12% emission reductions of Nox, PM10 2. No evidence of noise reduction	+ 1. 12% emission reductions of Nox, PM10 2. No evidence of noise reduction				+ 15
Business and Economic Impacts	Service Sector				+ 1% increased	- Decreased			0
	Retail, Tourism, Distribution				- 3% decreased	+ Increased			0
Land user Benefits							+/-	+/-	0
Operating Costs								- **110** -(**20** For additional bus costs)	- 130
TOTAL		- **15**	+ **30**	+	+/-	+/-	+/-	+ **35**	+ **50**

sector and increase in retail, tourism and distribution sectors has resulted in mixed response out side CBD area, as no appreciation in acceptance level.

3.3 Land Owner Benefits and Government (Implementing Authority)

With the implementation of road pricing, it is not yet clear that, how the value of land is changed. However, at initial phase, it may be negative impact on CBD, depending upon the improvements impact there going to be a increase in land values. However the net effect will be balanced within the sector.

3.4 Government (Implementing Authority)

Finally, there is a low net revenue below the expectations in the first year of its operation, this may be attributable to 1) greater decline in tollable traffic, 2) more exemptions and discounted tolls and 3) higher level of violations and non-collections. The reflection high initial cost of the system, due its higher operating costs, heavy customer service, enforcement services and surveillance camera costs. The net cost revenue ratio will be at the order of 0.57 (95/165=0.57), against the most of toll schemes have operating costs somewhere in between 0.05 to 0.20 range, However in future course of time the administration and operating costs will going to reduce drastically, which result in more welfare gains. Hence the peculiarity of this scheme is that, at least it is managing its own operating costs as well as some part of improved facilities costs. This is a good sign to the world to look forward to implement in their respective cities.

4. BIT of 91 Express Lanes, Orange county, California (SR-91)

Due to scarcity of funds and unsuccessful attempts to build new infrastructure facilities through normal taxation to cope with increasing congestion and growing travel demands have raised the interest to build a newly priced lanes adjacent to the existing freeway lanes. SR-91 Freeway is the first in this category implemented successfully in 1995. The 91-Express Lanes is a first fully automated four lane 10 mile toll road, built in the median of California's River side Freeway (State Route-91) between the Orange /Riverside County line and the Costa Mesa Freeway (State Route 55). This State Route-91 a single highway (12 lanes Freeway) section serving as an urban commute corridor, connecting the employment centers of Orange County to the residential developments of Riverside County. The newly priced toll facility provides two lanes in each direction, separated from the adjacent freeway lanes by a soft barrier consisting of a painted buffer with pylons. The toll lanes operated as an express facility having entry and exit facilities at north and south directions only. The primary objectives of these newly built priced lanes was to reduce congestion on the SR-91 Freeway and provide a faster alternative for those who are willing to pay a toll. In January 2003, the OCTA (Orange County Transportation Authority) purchased assets and liabilities of the franchise interest for $207.5 million, consisting of cash $70.5 million and certain assets, and the assumption of certain liabilities. The California Senate Bill 1010 has provided authority for OCTA to collect tolls and pay related financing costs to CPTC no later than 2030. (For further details kindly refer 91- express lanes)

Table 2 gives BIT of 91-Express lanes, Orange County, California (SR-91). We have discussed briefly about major the sectors such as road users from pricing and congestion relief point of view, and equity among the various sectors as an effect of newly built priced lanes.

Table 2 .BIT of 91 Express Lanes, Orange County, California (SR-91)

Sector		Road Users			Transport Authority (OCTA)	Total ($Million)
		91 Express Lanes		GPL Users		
		HOV	*SOV*			
Road User Benefits	**Pricing**	**-** **4.46** 1.No charge for HOVs having three or more persons, except on Mondays between 4 pm to 6pm half of the displayed charges to be paid 2. No charge for Zero emission vehicles 3. No charge Motor cycles, 4. No charge Disabled plates and veterans	**-** **22.1** 1.Toll charge varies from $1.05 to $ 7 depending up on travel situations 2.No charge for Zero emission vehicles 3. No charge Motor cycles, 4. No charge Disabled plates and veterans	+ No charge	+ **26.56**	**0**
	Congestion relief	+ **24.57** 1. Speeds are increased to 65 kmph. 2. Travel time savings are increased between 30 to 60 minutes 3. Vehicle occupancy is increased from 1.38 to 1.48 4. Increase in safety 5. Savings in VOC	++ **67.5** 1. Speeds are increased to 65 kmph. 2. Travel time savings are increased between 30 to 60 minutes 3. Savings in VOC 4. Increase in safety	+ 1. Reduced travel flow 2. Speeds are increased to 20 kmph 3.Savings in VOC		**+** **92.07**
Operating costs/Implementation costs					**-** **4.994** $207.5 Million ($135 mil project cost+ $72.5 mil cash)	**-** **4.99**
TOTAL		+ **20.11** Savings in VOC, increased mobility and savings in travel times	+ **45.4** Travel time savings, increase in level of service and comfort, and savings in VOC.	+ Reduced flows on general pool lanes	+ **21.57** Acceptance level increased to 90 percent, with the time varying tolls toll benefits will increase further, over all entire scheme is successful in implementation.	**+** **87.08**

Though we have discussed about the impacts of accidents and environment, land user and business impacts, we have not given any values quantitatively in this table, further details are as given below.

4.1 Road users

Basically road users are broadly categorized into 91-Express lane users and GPL (General Purpose Lane) users, further 91-Express lane users are divided into HOV users and SOV users. According to the latest data 2003, total trips on priced lanes are increased to 11.2 millions, comprising of 2.2 millions HOVs representing 20 percent and rest 9 millions trips are SOVs constituting about 80 percent. Over all the traffic volume on priced lanes have increased by 12.1 percent compared to its previous year. Though the toll charges are time varying, if we observe the past toll data the average toll charge per trip is around $2.46. Accordingly, annual toll charges paid by SOVs and HOVs are around $ 22.1 million and $4.46 million respectively (HOVs are supposed to pay half of the displayed toll charges on Monday between 4pm to 6pm). In total toll charges paid by the user to use priced lanes are around $26.56 million against these, the social welfare benefits gained by HOVs are direct benefits in the form of non payment of toll charges due to free of cost and perceived benefits in form of savings in travel times, increase in level service and safety, increase in speeds and savings vehicle operating costs which accumulated to around $24.57 million. The total benefits gained by SOVs are in the form of direct and perceived benefits around $67.5 million. Apart from the above, the GPL users are gained welfare benefits in the form of reduced travel flows, savings in delay costs etc. Hence by charging about $ 26.56 (=4.46+22.10) million on priced lanes gained the travel related welfare benefits about $65.51 (=20.11+45.40) million, achieving equity among the all road users to some extent. In addition to the above, toll policy measures have encouraged the vehicle occupancy resulting an increase in AVO (Average Vehicle Occupancy) to 1.42. The presence of employer rideshare and transit incentive programs was found to be associated with more frequent toll lane use, probably due to those companies having more HOV commuters, who use the toll lanes more than SOV commuters. From the above discussion it indicates that, These welfare gains among all the road users and impacts on households and firms have created a positive response towards this project resulting a ninety percent in acceptance level, though there are some reservations in the public at the initial stages of its operation.

4.2 Business impacts

According to the information available, half of the surveyed business indicated that the new express lanes improved comfort and reliability of travel, not only for their workers but also for their customers, suppliers and the firm's own work related travel. About 63 percent of companies interviewed stated that the express lanes are good for local business, however the quantitative results are yet to obtained.

4.3 Transportation Authority (OCTA)

The prime objectives of newly prices lanes have been achieved in reducing congestion and providing new alternative priced lanes to the users who are willing to pay to use the facility. From the social perspective, net welfare gains are around $65.51(=20.11+45.4) million, against a toll charges of $ 26.56 million among all the road users, the net perceived welfare gains to the society in implementing this project are around $87.08 (=65.51+21.57) million, this can easily out weighed by the amount $135 million invested towards project cost until

2030. The operating cost –revenue ratio is around 0.18(4.99/26.56=0.18) encouraging, a good sign to this project as compared to other pricing schemes under operation and also the new toll policy measures which are updating time to time will yield more revenues further. OCTA refinanced using lower interest tax –exempt bonds in November 2003, as a move to ensure the financial stability of 91 express lanes, which have been projected to save approximately $ 24.3 million until 2030. In addition to it, a self –sustaining enterprise had setup, which uses the toll income to fund operational and maintenance expenses and to meet bond covenants and reimburse OCTA's loan to CPTC consortium towards the assured lane cost.
The 91-Express lanes are highly regarded by its users because of the perceived time savings over general-purpose lanes. This is a first privately funded project; had seen as great opportunity for the state because the private sector took the financial risk while the state gets congestion relief resulting at no cost to the taxpayers. Though it may have some impacts regarding the environmental pollution due to the increased speeds, the encouragement of zero emission vehicles at the free of cost will definitely given as positive impact. In general this is a big success in proving the alternative facility to the road users as well as various stakeholders made into reality with help of private consortium.

5. BIT of I-15 HOT Express Lanes/Fas Trak, San Diego, California (I-15).

This is a one of the best example for 'value added pricing' schemes operating under dynamically time varying tolls, in which the under utilized HOV (High Occupancy Vehicle) lane capacity will be used efficiently by converting into HOT (High Occupancy Toll) lanes with reversible lane facility to combat congestion to meet the growing travel demand and infrastructure requirements. San Diego Fas Trak pricing was implemented from April 1999 by improving the already operating toll system, which had been in place since 1996. Under this pricing SOVs (Single Occupant Vehicle) pay dynamically time varying toll charges varying from $0.5 to $4 per eight mile stretch, charges can also be as high as $8/trip depending upon the congestion levels on HOT lanes. California Senate Bill 313 in 2001 had given the authority to SANDAG to collect and continue value-pricing system. Currently value-pricing program was applied to an eight-mile section of reversible HOV lane, extending along I-15, between SR-163 and Ted Williams Parkway. Now plans are under way to extend the scheme (for further details kindly refer I-15 Fas Trak project). The basic objectives of this scheme are as follows:

- Use the excess capacity on the HOV lanes which are under utilized for most of the period
- Improve the transit and rider share services along I-15, and provide travel choice for I-15 commuters.
- Impact of value pricing to relieve congestion

Table 3 gives BIT for HOT Express Lanes/Fas Trak, San Diego, have discussed the major sectors among road users and toll corporation point of view. Though the business impacts and land owner benefits have been discussed in the subsequent paragraphs, we have not given in values because of little impact of this project on these sectors. It still require some more time to have significant changes in households decisions, which in turn influence land values and similarly in case of firms, further the details discussed are as given below.

Table 3. BIT of I-15 HOT Express Lanes/Fas Trak, San Diego, California (I-15).

Sector		Road User				Toll Corporation (SANDAG)	Total ($ Million)
		HOT user		*GPL users*	Transit User		
		HOV	SOV				
Road User Benefits	**Pricing**	+ **0** No charge for 1. HOVs with two or more persons 2.Carpools 3.Van Pools 4. Motorcycles	- **2.2** $0.5 to $8 /eight mile, time varying toll	+ No charge	+ No change in fares	+ **2.2**	**0**
	Congestion relief	+ **24.86** ($20.6 from travel time savings+ $4.26 from pricing) 1.LOC 'C' is maintained. 2. In crease in vehicle occupancy 3. Improved safety 4. Savings in VOC	+ **9.31** 1. Travel time Savings 2. Increase in speeds and level of service 3. Improved safety 4. Savings in VOC	+ Increase in speeds due to reduced flows and other perceived benefits	+ Increase in frequency, fleet and reliability other perceived benefits		+ **34.17**
Operating cost/Impl.cost						- **0.81** ($10.23 Million Implementation cost; ($ 8 (FWHA),$2 (San Diego),$0.23 l (FTA))	- **0.81**
Total		+ **24.86** Increase in VOC, and mobility.	+ **7.11** Increase in speeds, level of service and travel time savings	+ Smaller gains	+ Increase in frequency, fleet and reliability of service	+ **1.39** Acceptance level is at 92 percent, it encourages the vehicle occupancy, use the excess capacity from HOV lanes and also funding about one million to transit improvements from this revenue, over all it is good success.	+ **33.36**

5.1 Road users

For this analysis the road users are basically classified into, HOT users, GPL (General Pool Lane) users and Transit Users. HOT lane users are further divided into HOV users and SOV users. According to 2003 data, the daily carpools on the HOV lanes have increased from 7,700 to 17600 representing an increase of 129 percent. The average daily traffic on the HOV lanes has increased from 9400 to 22,700 vehicles per day resulting an increase of 143 percent. It is evident that about 9900 HOVs average daily traffic are added to the HOT lanes using facility at the free of cost, on an average around 5100 SOVs, average daily traffic using the HOT by paying the toll charges accounting a revenues generation of $ 2.2 million. From this if we observe on an average the toll charges for per vehicle are comes out to be $1.18 per trip. The price benefit to HOVs are around $4.26 million in addition to the perceived ravel benefits in terms of travel time savings, increase in level of service, increase in safety and savings in vehicle operating costs have resulted $20.6 million, hence the total benefits to the HOVs are increased up to $24.86 (=20.6+4.26) millions. Similarly the benefits gained by the SOVs against their total annual charges ($2.2 million) are in the form of travel time savings, increased level of service, increase in safety and savings in vehicle operating costs have resulted $ 9.31 millions. Apart from above, the reduced traffic flows on GPLs have resulting welfare gains in the form in reduced in travel times and increased safety. About a million from the revenues earned by charging have been invested in improving the transit facilities, this resulted additional time savings, reliability and increase transit fleet. In total the net benefits to the road users, which also include the perceived benefits, are around $31.97 (=24.86+7.11) as against the $2.2 million toll charges. This impact caused a positive approach towards this scheme resulted to ninety two percent acceptance level. From the equity point of view the SOV users are paid to use the facility to get increased level of service, comfort, travel time savings and benefits in vehicle operating costs, where as opting out of the facility by non user, the welfare benefits are gained in the form of increased safety, reduced flows, savings in vehicle in vehicle operating costs, increase in transit fleet and reliability of transit services. Hence this pricing is better -off to some extent from the horizontal equity point view among the road users. However, it may be seen that due to increased flows on HOT lanes, may be the level of service to the already existing HOVs (7700 vehicles ADT) may suffer, but these are eliminated by fixing level of service to grade ‘C’ and dynamically adjusted toll charges by every 6 minutes.

5.1 Business Impacts

According to the report published in 2000, the impact of the I-15 pricing scheme on businesses remained slight. There was some indication that the FasTrak per trip pricing was considered less important to business than Express pass version that allowed unlimited use of the I-15 Express lanes rather than inexpensive fixed monthly fee. The study findings also shown that the perceived dependency on the I-15 corridor was the variable most strongly associated with business. However, it may require some time to get significant changes on firms along the corridor.

5.2 Land User benefits

The impact of landuser benefits indicates that, there is an importance of the I-15 Fas Trak program as a factor for housing choice is growing over time. This growth is however is not large enough to be statistically significant and these benefits are balanced within the system.

5.4 Transport Authority(SANDAG)

From the social perspective, the most promising attributes of the HOT lane policy are its congestion –reducing effect through efficient utilization of the existing road network has been achieved. Not only does the policy bring in $ 2.2 million per year revenue to the government; but also gives travelers welfare gain of $31.97 million. This consists net of all the travel related benefits and costs, and its large positive value indicates that the travel related benefits are greatly outweigh the costs. Hence, the $10.23 million by government ($8 million grant by Federal Highway Administration (FHWA) contributed under the congestion pricing pilot program, $2 million by San Diego region as a matching grant, $0.23 million by Federal Transit Administration (FTA)) had well spent on HOT policy provides a net welfare gains to the society about $33.36 million, justifying the all users better-off from equity point of view.

The operating cost - revenue ratio is around 0.36(0.81/2.2=0.36), it is fair as compared to other pricing schemes in operation. Now the project is self-supporting in its operation and maintenance, in addition to it, it is also funding some of the transit facilities improvements. However in future up to certain extent only HOT can be sustainable (Myron Swisher, P.E et al., 2003), further once share of HOVs have increased due to the free rider ship and heavy discounts on HOVs, HOT lanes also may effect the level of service. Hence the new toll pricing policies and exploring more HOT lanes, which in turn increase the revenue and there by it may be possible to float bonds to have HOT lanes/New lanes to combat the congestion, mobility and some extant to solve the needs of infrastructure.

6. BIT of Urban Road Pricing –Lyon

The northern Boulevard Peripherique –Lyon a free Boulevard Peripherique extending towards eastern direction and bypassing city centre to the north by crossing a highly urbanized zone. Total length of project was 10 kms, which includes 1.5kms long viaduct and three tunnels with one tunnel having 3.5 kms long. About two thirds of the project length is in underground due to highly urbanized nature of the area. Total cost of the project was estimated around FF6000 million in 1997 and funding was planned in such way that about 52 percent of it would be from public funds and rest will be from toll charges on motor vehicles using the facility. When it was opened by a private developer in August 1997 under the name TEO (“Trans Est-Ouest”) because of fierce public opposition due to capacity restrictions on exiting parallel roads and high toll charges during peak hours led to public rejection. Again it had been reopened by local authority as a concessionaire in the name of Boulevard P’eripherique Nord de Lyon” (BPNL) in June 2000 with reduced toll rates and charging only a central part of 3.5 kms tunnel while lifting the capacity restrictions on parallel roads. Here we would like to show with help of BIT why the initial toll pricing operations are failed to get the users/public acceptance in spite of providing a new facility. (For further details about this project refer to Charles Raux et al., 2004, which we have taken as reference to form the BIT for this case study.).

Table 4 BIT for urban road pricing –Lyon under TEO operation and Table 5 BIT for urban road pricing –Lyon under BPNL operation explains how the project at the initial stages of opening is failed to get the public acceptance and subsequent implementation by BPNL. We broadly classified road users into Individual mode user (car/motor user) on toll road, user who are changing the mode from car/motor to public transport, public transport users and non-toll road users. Here we have discussed the equity issues giving some brief introduction to spatial, horizontal and vertical equities and their impacts among all the road users, and at the end we

have given some comments on economic efficiency. Spatial equity is a guarantee to right of access to services, goods and jobs etc., can be evaluated by measuring accessibility from different zones in an urban area of the project. This can be measured by combining the average travel time durations and price for inter zonal trips as an effect of improvement in transportation. Hence the gain in accessibility implies that greater time savings against the toll payment or loss in accessibility (users consumer surplus) implies either cost of time savings is not enough against the toll paid or increased congestion, delay and vehicle operating costs in case of non- toll road users. From table 4 spatial equity observed in the form of accessibility from each zone indicates that residents who live in zones near to toll road are gained maximum benefits compared to residents in other zones, with more uneven distribution of loss of surplus in most of the zones, the spatial equity is compromised even worse than previous case (do nothing). Horizontal equity is the equality of treatment among the different users, it implies that user pay the damage he/she causes to society and pay for a "good", this is in accordance to Pigouvian taxation for which the public still needs to be convinced. With respect to horizontal equity the direct and perceived benefits are much more lesser against the charges paid and travel time savings are not sufficient to gain in the form of enough excess surplus benefits. Where as there is a little changes in user surplus in mode change category from car/motor user to public transport are around FF 4.78 million and due to increase in fleet of public transport, we also observe user surplus change in public transport around FF5.98 million. In case of non –toll road users who are avoiding toll payments and also changed in their travel patterns due to capacity restrictions on parallel roads have greatly effected in form of increase in congestion, delays, travel times and VOC. Hence from the road users point of view, even though the user saved travel time by paying toll, the time saved is not enough to gain in form of benefits, mainly due to lesser travel time savings and higher toll rates, overall the consumer surplus loss to the road users who likely continues to use the car/motor is around FF 272.84 million and together with the other modes are even at higher order. These losses in the user surplus is not compensated in providing considerable improvement in other modes or reducing the toll rates or reducing fiscal burden, this created an opportunity further to private operator to cash this excess surplus. Vertical equity corresponds to social in equalities and their consequences with regard to transportation, in other words assessing the policy outcomes /impacts on society well being of the most disadvantaged /low income groups. From the vertical equity point of view the direct and perceived travel time savings against their toll payments are not distributed evenly among the all the classes of income. Higher benefits are observed at the higher income groups and lesser/ losses to lower income groups even at the saving of 27 minutes of travel time. Finally, in nutshell introduction of this toll pricing broadly not full filled the travel needs and logistics of any user group lead to unrest among the users to reject the facility.

However, in June 2000 it has been opened by BPNL charging only 3.5 kms tunnel at reduced price FF10 per trip while lifting the capacity restrictions on parallel roads. From Table 5 it is evident that spatial equity is still not distributed evenly, but it has improved to a large extent over the previous case (TEO) under this Northern zones residents got the maximum benefit gains relatively other zones. Regarding the horizontal equity due to removing the capacity restrictions on parallel roads all road users gained the benefits particularly the non-toll road users are gained the benefits in the form of reduced congestion, travel times savings, reduce in delays costs and vehicle operating costs and road users on toll road are gained direct benefit in

Table4. BIT of Urban Road Pricing –Lyon (Operation under TEO, 1997-98)

Sector			Road Users																Road Corporation (TEO)	Total (FF million)
			Zones near to toll road								*Zones away from toll road*									
			Car/Motor User		Mode change User		Public Transport		Toll free road		Car/Motor User		Mode change User		Public Transport		Toll free road			
			High income	Low income	High income	Low income	High income	Low income	High income	Low income	High income	Low income	High income	Low income	High income	Low income	High income	Low income		
Road User Benefits	Pricing		- FF 10/trip		No change in fares		No change in fares		No charge		- FF 10/trip		No change in fares		No change in fares		No charge		+ FF 16 X No.of trips	**0**
	Perceived benefits (Eqiuity)	Spatial	++	++	+	+	+	+	+	+	-	-	-	-	-	-	-	-		-
		Horizontal	-	-	+ 2.39		+ 2.99		-	-	-	-	+ 2.39		+ 2.99		-	-		-
		Vertical	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-		-
Operating cost/Implementation cost																			- FF 6000 million (FF324 million/Year)	-
TOTAL			- Direct and perceived benefits are lesser than the toll paid.		+ **2.39** Gains are very small as compared to over all consumer surplus		+ **2.99** Gains are very small as compared to over all consumer surplus		- Loss due to capacity restrictions on parallel roads		- Direct and perceived benefits are lesser than the toll paid		+ **2.39** Gains are very small as compared to over all consumer surplus		+ **2.99** Gains are very small as compared to over all consumer surplus		- Loss due to capacity restrictions on parallel roads		+ Start up stage authority got good revenues, but due to pubic opposition it is rejected, later	- Though there are some gains in mode change from Individual to PT and PT, these gains are very small compared to the loss of consumer surplus of Individual users who continue to use, it is in the order of FF **272.85 million.** Gains in excess consumer surplus are not compensated in the form newly provided facility and these are transformed additional use of buses to gain this led to agitation to stop the project.
			Over all consumer surplus loss who continue to use the Car/Motor is at the order of FF 272.84 million																	

Table 5. BIT of Urban Road Pricing –Lyon(Operation under BPNL form June 2000)

Sector		Road Users										Road Corporation (BPNL)	Total (FF million)
		North Zone Users					***Other Zone Users***						
		Car/Motor User		Mode change from Car/Motor to PT	Public Transport	Toll free road	Individual Mode		Mode change from Car/Motor to PT	Public Transport	Toll free road		
		High income	Low income				High income	Low income					
Road User Benefits	Pricing	- FF 10/trip	- FF 10/trip	No change	No change	No charge	- FF 10/trip	- FF 10/trip	No change	No change	No charge	+ FF 10 X No.of trips	**0**
	Direct and Perceived benefits **(Spatial Equity-accessibility)**	+++ 1 Accessibility Increased, 2.Increase in Travel time savings	++ 1.Accessibility Increased, 2. Small Increase in Travel time savings	+ Small gains	+ Moderate gains	+ Increase in accessibility relatively, Congestion observed during peak hours	++ Increase in accessibility relatively lesser	+ Increase in accessibility is relatively lesser	+ Moderate	+ Moderate	+/- Small gains, Congestion observed during peak hours		+
Operating cost/Implementation cost												- FF 6000 million (FF324 million/Yr)	-
TOTAL		+ Gains in (accessibility) Spatial equity Horizontal and Vertical equity	+ Gains in accessibility, Horizontal equity and gains Vertical equity are less	+ Due to lesser change in mode, gains are moderate	+ Gains are moderate	+ Moderate	+ Gains are relatively low compared to North zones, but improved under BPNL	+ Gains are relatively low, but improved under BPNL, Vertical Equity is less	+ Improved over previous situation	+ Moderate	+/- Moderate	+ Due to reduce toll rates, the revenue is at lower side	+/- Gains for the North zones are increased relatively; vertical equity for the low-income groups is less. Though there are gains for the car/motor users, from economic efficiency point of view, it is still sub-optimal, because these gains are still at the detriment of tax payers money and are not distributed evenly among zones and all income classes..

the form of reduced toll rates and perceived benefits put together gained more benefits as against toll charge they paid. Regarding the vertical equity among the low-income groups which are under losses from previous case are gained to some extent, further other travel options are also available to change travel decisions so as maximize the gains and also higher income groups gained even further in addition to the previous case.

Finally though the situation is improved among the individual mode (car/motor) user to a great extent gaining maximum consumer surplus, the improved situation is as a effect of reduced toll rates and only part of the project length is charged while lifting the capacity restrictions on parallel roads. This is only deteriorated equilibrium of economic efficiency further even less than sub-optimal as compared to TEO. However these benefits are at the detriment of the taxpayer money paid their part of earnings in the form of tax payment. There may be tendency that user groups are also well organized to change their travel behavior to maximum their gains unlike taxpayers. This is as good as public road project under tolling. This we have discussed here to show how the decisions of implementation and equity (spatial, horizontal and vertical) among the various sectors will influence on road pricing acceptance under different road pricing conditions.

7. Conclusions

Table 6 comparison of road pricing schemes, indicates the performance, equity, economic efficiency and acceptance levels of four pricing schemes. Though the nature of pricing is different for each scheme we have given here to show broad understanding among them. From Table 6, 91 express lanes and I-15 Fas Trak schemes are operating with good benefit cost ratios. Where as London pricing scheme is at lower side, because of more diverted traffic from the charging zone than the expected and mainly targeting at initial stage of implementation to have least resistance from the public by giving more subsidies. With respect to ratio of revenue to cost, , London congestion pricing ,91 Express lanes and I-15 Fas Trak are healthy in performance. However, in case of London congestion pricing due to the huge initial start up costs, publicity costs, heavy administration costs and heavy subsidy etc., are resulted a high operational costs in the beginning. These results are very encouraging to show the success of the road pricing/toll pricing schemes.

7.1 Users Equity

Regarding the equity point of view, the spatial equity in case of urban link toll pricing scheme (Lyon) and cordon pricing (London) may be compromised at the initial stages of operation, but in the long run once the project spill over effects are in the form land rents, improved business and improvements in environmental quality, it will balanced in the system due to the migration mechanism. Hence spatial equity in long run will be attained. However in case of new priced lanes (91 Express lanes) and value added pricing (I-15 Fas Trak) as the lanes are coming up side by the existing freeways, the impact of these changes in spatial equity would be minimal. With respect to horizontal equity, it is a user pay principle for the damage he/she causes and pays for a "good". According to this, with a scale of (poor-fair-good-excellent) the London congestion pricing and I-15 Fas Trak pricing will be rated as good, because these schemes are funding the some part of revenues to the improvement of public transport and transit services apart from their own operating and maintenance cost from the revenue

Table 6. Comparison of Road Pricing Schemes

(all the values are in $ million)

Name of Road Pricing	*Nature of Pricing*	**Total Annual benefits (1)**	**Total Annual project cost (2)**	**Total Net benefits (B/C ratio) (3)**	**Total Toll revenue (4)**	**Ratio of Revenue/ cost (5)**	**Net users Net Benefits (6)=(1-4)**	**Equity**			*Economic efficiency*	**Acceptance level (Percentage)**
								Spatial	*Horizontal*	*Vertical*		
London Congestion pricing	Cordon pricing	340.46	189.42 (947.11, in 2003)	**151.50 (1.79)**	312.54	**1.65**	**27.92**	Initially it may be compromised but in long run it will be achieved	For the private car users it is a loss, for the public car users, it is gains, However, the part of revenue also funded from revenue, to some extent	Lower income groups are always looser because of more travel usage from higher income groups	Less than Sub optimal	90 (among the house holds in the charged zone)
91 Express lanes, Orange county (SR91)	New priced lanes	92.07	14.45 (135, in 1995)	**77.62 (6.37)**	26.56	**1.84**	**65.51**	Not much changes	Social welfare benefits will be created by reducing flows on GPLs, but these are not sufficient against the project revenue, hence it rated as fair from social welfare point of view, good from toll revenue point of view	Lower income groups are always looser because of more travel usage from higher income groups	Sub optimal	90
I-15 San Diego HOT lanes/Fas Track	Value added Pricing (HOV lanes to HOT lanes)	31.97	10.23 (10.23,in 1996)	**21.69 (3.13)**	2.2	**0.22**	**29.77**	Not much changes	Part of generated revenue is funded for improvements in public transport/transit services, hence this can be rated as good	Lower income groups are always looser because of more travel usage from higher income groups	Sub optimal	92
Urban Road Pricing -Lyon	Toll road pricing	NA	1195.64 (1997)	-	NA	-	-	Initially it may be compromised but in long run it will be achieved	Horizontal equity is improved some extent under BPNL,	Lower income groups are always looser because of more travel usage from higher income groups	Less than sub optimal	NA

generated. Where as in case of 91 express lanes it is only the user paying for the facility he/she gets, social welfare of the society or other general pool lanes users may be created by reducing the flow on general pool lanes as a effect, however it is not sufficient against the revenue it is generated. In case of Lyon it is improved under BPNL operation having a wide travel options to low income groups with the effect of lifting the capacity restrictions on parallel roads. Regarding vertical equity, impacts in all most all cases it will be in the order of fair, because of the distribution benefits are in order of income levels, higher the income levels higher road usage/higher travel demand and gains the more benefits. Hence relatively in case of vertical equity the low-income groups are always scapegoats relatively. Normally in road pricing/toll pricing achieving the equity at higher order is somewhat difficult due to the considerations of involvement of various public subsidies, use of public lands for the right of ways with subsidy and other social reasons etc. However these are on observations made about each scheme, it requires analysis to quantify the equity levels further.

7.2 Economic efficiency

With respect to the economic efficiency of the scheme/project, Though it is optimal when it is charged at the marginal cost pricing, due to some reasons it is some times may not be possible to implement this pricing. However in due course of time it may be possible to implement. In case of London congestion pricing and Lyon, it is a flat rate pricing with heavy subsidy resulting economic efficiency less than sub optimal. Where as incase of 91 express lanes and I-15 Fas Trak, pricing is dynamic time varying in nature hence it is operating at sub optimal level, further it may possible in these cases in future to operate at optimal level also.

7.3 Acceptance level

Regarding the acceptance level almost all the pricing schemes except in Lyon are at ninety percent level with increasing positive response form the users. Though in case of London the acceptance among producers it is some less however from the households point of view within the charging zone are around ninety percent, this very peculiar in spite of lesser net benefits, This is a good sign for the road pricing/toll toll pricing schemes and various stakeholders, further to take up projects, which are already under demonstration.

With the success in implementation and good results in evaluation of couple schemes have given positive outlook towards other road pricing schemes which are under implementation stage in United States of America, Europe, Australia and Asia etc. Recently in Japan the Construction and Transportation Ministry had decided to introduce “smart” car license plates with a integrated circuit chips on experimental basis from fiscal year 2006 to combat congestion and to enhance mobility and network performance with help of road pricing techniques in Aizu, Karuizawa, Kurashiki, Sendai, and Shimonoseki municipality areas (Yomiuri Daily). It is a good sign to look at towards these pricing schemes.

Finally, we have given quantification of welfare benefits in its post evaluation with help of BIT giving in detailed results about each scheme. Though the values given may vary slightly due to the estimations, at the outset these are true indicators, which give broad understanding of each sector. Some sectors like landusers and landowners are still remains to be accounted in quantitative way. At end we have given detailed comprehensive note about all the projects, which help immensely to know the details about each project very quickly and assess some future schemes to operate.

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