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TRAFFIC CONGESTION CHARGING AND IMPLEMENTATION ISSUES

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Abstract

Congestion charging can be an effective traffic management tool for reducing traffic congestion. The paper discussed the review of the congestion charging concept, systems, methods and implementation issues. The learning experiences from the congestion charging program are discussed with the case studies. The key factors affecting the congestion charging such as cost efficiency, fairness, loss of privacy, political risks, awareness, equity, end-use of revenue and other relevant associated issues, are also addressed and concluded. These key issues need to be effectively addressed for the success of the scheme. The measures for effective mitigation of the congestion charging implementation risk are also systematically researched and presented. The study also highlights the measures like efficient public transport, allied facilities for improving traffic capacity, effective program management required for success, effectivity and acceptance of the congestion charging program.

Key words: traffic congestion, congestion charging, factors affecting congestion charging, risk mitigation.

1. INTRODUCTION

Congestion charging is a traffic management measure for reducing traffic congestion. Congestion charging is a type of road pricing with greater charges during peak hours of congestion as a way to reduce traffic volumes to optimum levels [1]. Traffic congestion is a major problem considering the lost income, time, environmental pollution and cost of associated hazards. [2]. The objective is to charge vehicles at places and at times where and when they caused congestion. A congestion pricing rate may be adjusted for reducing usage. Ideally, the charging system should be flexible over time and location, with the highest charges during the peak times of congestion, with incentives to users to shift from the peak to off-peak shoulder periods [3]. The congestion charging scheme aims to discourage the use of private vehicles, reduce congestion, and support improvements in the public transport system.

2. LITERATURE REVIEW

The published literature indicates the various aspects of congestion charging issues and their mitigation. The congestion charge needs should be planned to deter traffic congestion but at the same time not to lead the system under-utilized leading to a financial loss [4]. There are several specific ways to implement congestion charging which can be adapted to suit the specific location and charging objectives [2], [5].

Congestion charging leads to an impact on several aspects of area use, users' preferences, traffic conditions etc. The impacts need to be understood and mitigated for the successful implementation of the program. [6]. The traffic spillover due to diverted traffic in the adjoining uncharged areas may increase the traffic congestion. [7]. Congestion charging schemes will unavoidably have impacts upon the geographical areas and economic sectors of the charged area [8]. However, congestion pricing allows high-value activities over low-value activities with an overall advantage. [3]. There are several challenges in the implementation of the congestion charging program. The lack of political will is the main challenge for implementing congestion charging schemes [4] [9]. The public acceptance of congestion charging can be promoted by addressing privacy, complexity, and equity through public education and awareness [10]. Net revenues from Congestion pricing can be used for the costs of expanded roadway facilities, public transit, toll discounts or credits for low-income individuals [11].

The present study discusses the most relevant key issues like optimizing congestion pricing, the methods of charging, impact on associated elements, the challenges to implementation, public entitlement, utilisation of revenues, experiences from previously executed systems. These various aspects of congestion charging are systematically addressed.

3. ELEMENTAL THEORY OF TRAFFIC CONGESTION CHARGING

There are several specific ways to implement congestion charging which can be adapted to suit the specific location and charging objectives. According to Gomez-Ibanez, the congestion charging applicable may be classified into different types [2],[5]. Cordon ring charges need to be paid when a vehicle enters a cordoned area, generally only during traffic peak hours. Cordon ring charges may be for, Area, Corridor or Network charges (e.g. national motorways). These methods of congestion charging can be suitably classified into the subtypes such as Point pricing, Cordon pricing, Zone pricing, Distance-based charging, Time-based charging, Time- and distance-based charging and Location-based charging.

Collection of congestion charging may be invariable form. The charge collection may be adapted to suit the available implementation infrastructure and initial investment option. The charging system can be gradually shifted from manual to automatic based on the availability of funds.

i. The manual method of congestion charging

ii. Semi-automatic method

- Barcode scanning technique (Automatic or Semi-Automatic Scanners)
- Radio Frequency Identification Technique (RFID)
- Magnetic card Technique

iii. Automatic systems of congestion charging

- Automatic number plate recognition technique (video camera technique) system may be of various types based on the method of vehicle identification and may include Automatic license-plate recognition (ALPR), Automatic vehicle identification (AVI), Car plate recognition (CPR), License-plate recognition (LPR) etc. The vehicle identified will be charged as per the existing method of congestion charging.
- The electronic road pricing (ERP) system allow a precise solution for congestion charging by identifying the specific congested locations and varying the charge with existing traffic conditions. The charges will be flexible according to the traffic demand. The ERP system helps to regulate private vehicles for optimum usage of the road network by providing alternatives to the users. These may include using an alternative way to destinations, using off-peak hours, public transport system, car-pooling etc.

4. EXPERIENCE WITH CONGESTION CHARGING SYSTEMS

Several countries have tried with congestion charging systems which can be viewed as learning examples for implementation of the program. These learning experiences of case studies are presented in Tables 1-2.

TABLE 1. Successful Case Studies

Parameters	Singapore [12]	London [13]	Stockholm [14]	Norway [15]
Objective	• Area Licensing Scheme (ALS) - To control traffic congestion during peak hours.	• To reduce traffic congestion and revenue generation for self-sufficiency.	• To reduce traffic congestion and improve the environmental quality.	• To reduce traffic congestion, in Oslo, Bergen and Trondheim and revenue generation.
Scheme Details	• ALS, in 1975 and Electronic Road pricing ERP in 1998 • Electronic (ERP) Road pricing as per actual vehicle use.	• The scheme covers central London (21 Km2), bounded by the Inner Ring Road. (2003)	• Charging was implemented in August 2007 after a trial period of 7 months in 2006.	• Charging was implemented in Bergen (1989), Oslo (1990) and Trondheim (1991).
Output	• 31-44% reduction in traffic volume	• 30% reduction in traffic congestion and	• 6% shift in the mode of transportation.	• Reduction in Traffic congestion by

	for restricted zone • 0.85% reduction in carbon emission • An increase in public transport usage by 12%-20% during peak hours. • Average traffic speed increase by 10-15kmph	number of cars reduced by 20% • 40%-70% reduction in accidents for the charging zone, • Raised reliability of public transport • In 2005-06, the net revenues collected about £122 million	The number of cars in the park-and-ride facilities increases up to 23%. • Decreased particulate matter and carbon emissions by 14% in the city area. • Decrease in average journey times and reduction in queuing times by a third for the peak hours.	about. 5-10% • Annual Revenue generated over US$ 118.4 million.
Limitation/ Advantage	• The charging system was labour oriented & not equitable to motorists	• The same charge for all the vehicles • More than 40% of vehicles are not paying the charge • The ANPR system is inefficient and costly to maintain	• Major routes in the network serving as the only means of connectivity with the city centre were kept free of charge, increasing traffic congestion.	• Functioning efficiently for inner roads, thus fulfilling the charging objectives • Users show more acceptance of tolls.

TABLE 2. Unsuccessful Case Studies [16]

Parameters	**Hong Kong**	**Edinburg**
Background	• Gradual implementation of automatic charging system from 1980-1985	• Two cordon congestion zones were implemented in 2005 after the referendum. • Revenues generated were used for the improvement of the public transport system
Status	• The trials during the early stages of a power transfer from the British colonial government. • Fear of misuse of electronic monitoring system (Privacy) by the government for supervision and	• Citizens rejected the charging referendum by over 74 % of negative votes and rejecting the charging. • Not implemented.

	doubtful functionality	
Concerns	• Suspicion about the beneficial use of revenues generated	• Citizens were unconvinced about the reduction in congestion and improvement in the public transport system.

5. IDENTIFICATION OF KEY ISSUES

Congestion charging for selected locations has an impact on several aspects of area use, users' preferences, traffic conditions etc. The charging can affect either positively or otherwise. The impacts need to be understood and mitigated for successful implementation. The first step is to review and identify critical key recurrent issues to be addressed by the experts and scheme implementers. [6]

5.1 Amount of Congestion Charging

The congestion charge needs to be planned carefully to deter traffic congestion but at the same time not to lead the system under-utilized leading to a financial loss. Net revenues from the charges must be sufficient to bear the operational expenses, as well as to generate revenue to support public transportation improvements. These considerations need detailed economic studies to calculate the optimum charging structure.

Computation of marginal congestion cost for study area can be calculated considering present traffic volume (PCU) data, traffic speed and Value of Time (VOT) [17],[18] using Microscopic Simulation Methods [19]. Considering factors such as congestion cost, travel time, parking and corresponding shift to public transport different traffic situations can be tested. These scenarios can be checked with orthogonal array and Fractional Factorial Array creating combinations of factor levels for public transport and personal vehicles. The variable for car commuters/personal vehicles (Travel time, Congestion cost and Parking cost) and public transport (time and travel cost) etc. can be considered for determining the sequence and levels of the attributes needed. Binary Choice Model Analysis can be adopted to check the preferred choice between car or public transport with estimated utility levels. The binary Logit model will check which attribute (Congestion Cost, Parking Cost and Travel time) influences people's choice of mode. With the tested scenario's the Congestion charge leading to the maximum number of shifts of mode from private vehicles to public transport can be obtained [20]. The time costs and delays are imposed by the additional traffic entering the charged area. The charge can be increased with an increase in congestion levels i.e. the cost to users increases with the traffic volume. The Pigouvian taxation concept [21] can be applied to check the optimal toll variation with the degree of congestion and even the vehicle type as it can differently affect infrastructure costs.

The charging system should offer reasonable pricing efficiency. The simplest system with fixed charges is without any incentive to optimize driving. This system is relatively fast easy to implement and simple. A more advanced system allows planning for variable charges. The rational variable charging reflecting the vehicle class, time, and distance of travel within the charged area can also be adopted. It most accurately reflects the costs imposed by usage and provides users with an incentive to optimise their usage, by shifting from peak to off-

peak hours, or by minimizing their driving. The charging system should be accurate. The design of a congestion charging scheme must ensure that the users are unable to evade the charge. At the same time for Congestion Charging implementation false positives (vehicles wrongly ticketed) should be minimum. The charging must provide cost-efficiency. The basic congestion charging implementation costs may be substantial. Though the congestion charging program has fairly low operating costs a high initial investment is required for the congestion pricing system [4]. A major portion of revenues earned may be lost on the project overhead costs. Though Critics may claim that implementation costs may exceed total benefits, the intangible benefits are more and with experience more cost-effective pricing programs may be developed.

5.2 Traffic Effects

The charging zone will reduce a large quantum of traffic. This will make the area more pedestrian free and walkability may improve. The reduction in traffic will make the residents of the area more liveable.

The empirical evidence on traffic effects due to adjoining road network issues such as spillover, capacity reductions etc. is indigenous and localised. The London case study [7] indicates 67,000 fewer car trips per day into the charging zone among which around 17,000 were diverted around the zone on arterial routes close to tolled motorways. The Singapore, area licensing system [22] indicates a 73% reduction in traffic entering into charging zone.

The residents and motorists in border areas will experience traffic spillover impacts. The traffic spillover in congestion charging areas due to diverted traffic may increase congestion on adjoining free roads. The traffic spillover case studies have indicated that although some traffic diversion occurred, the effect is too small and may be addressed by expanding the priced area and charging more variable fees (Higher rates in the centre and lower rates in outer zones). Although there may be more traffic on the peripheral roads, traffic signal systems on these roads have to be adjusted in anticipation of these traffic shifts to have optimum journey times.

5.3 Land Use Effects:

Congestion charging schemes will inevitably have impacts upon the geographical areas and economic sectors that they interface with. There are objections to the loss to local property prices and businesses. According to Herve Commeignes [8], other factors influences the economy more predominantly compared to congestion pricing.

The London scheme [7] evidence that 71% of businesses feel there is no appreciable effect of congestion charging on business or commercial activities. The congestion charging has impacted land usage. The conventional under-pricing of roadways encouraged urban sprawl and the fair congestion pricing would encourage dense development around urban centres. Congestion pricing would facilitate de-centralization as it would reduce the importance of an area with pricing particularly if other competing areas are un-priced".

Some businesses like bulk good retailers rely on customers who drive private vehicles. May get affected. However, other economic activities may benefit due to improved access by other modes, reduced delay for high-value vehicle trips, and improved environmental conditions. A shift in the location of bulk retailing may not be always harmful to the regional economy. These city centre locations can be used for other productive business activities. The congestion pricing increases overall business activity by allowing high-value activities over low-value activities with an overall advantage. [3].

5.4 Costs and Benefits:

Social cost-benefit analysis of schemes considers benefits of congestion reduction and environmental improvements; whereas commercial business case analysis purely

deals with financial gains. However, it is essential to study exact the year-by-year cash flows to know financial cost analysis.
The public is unlikely to accept a scheme justified purely based on economic cost-benefit analysis unless the generated revenue presents direct tangible benefits. If the risks are not managed efficiently the operating costs of the scheme can outweigh the resulting benefits resulting, in failure.

5.5 Public Entitlement:

There is a general unwillingness of the public to pay usage charges for the road as a commodity. As per some opinion, additional road pricing is unfair as it is "dual taxation,". Since motorists already pay registration and fuel taxes and are unfair to lower-income people who must drive. Special exemptions can be granted to the low-income category, disabled persons and for the people residing within the priced area. The people think that it is a forced payment of tax under the name of a congestion charge. They are not ready to pay such tax. Moreover, this amount may not show improvements in the existing facilities. The congestion charging scheme should base on revenue neutrality rather than revenue hypothecation with due consideration to pay back the capital, operating costs with a fair profit margin.

5.6 Privacy:

For automated system video surveillance and vehicles tracking system and violation enforcement, billing, in general, will involve privacy issues particularly when third parties have access to a person's mobility or usage information. However, the use of generic internal accounts linked with electronic toll collection (ETC) transponders can assure a driver's identity and prevent access to information.

5.7 Political Risk:

The majority of references cite political risk as a reason for a scheme According to Deloitte Consulting [9] the lack of political support was the major challenge to implementing congestion charging. Goh [23] also cites that 'political nervousness' caused the failure of the Hong Kong road pricing schemes.

5.8 Utilization of Revenue:

The revenue from congestion charging should be utilized for public facilities and welfare. The scheme should be transparent to gain public trust about promised revenue allocation [10]. The net revenue generated after managing operational expenses should be used for creating roadway facilities, improvements in public transport, toll discounts or credits for low-income groups, or to reduce other vehicle taxes, cycles for hire, accident prevention etc. [11].
The tangible benefits of congestion charging revenue have increased the public acceptance of the scheme [24] [25]. A promise to utilise revenues portion in the terms of benefits increased support to the London' scheme by around 7%. [25]

5.9 Awareness:

Congestion charging can be successful only if people are benefited from the project. The people should be educated properly for the same. Hence, creating awareness for the project is a must. It is thus of utmost importance to convey to people who reside in the area, the people who have businesses established or work in the area and people who pass through the area often the objectives and benefits of charging. Awareness campaigns should also aim to communicate benefits, different payment options etc. It should educate the people about new regulations or changes to the traffic regulation system. Thus, the campaign aims to attract people to support the project. In a broader sense, it should make people realize how better the area would be if it is congestion relief. This would help to have a greater average speed. Also, the time taken for the journey will be less for the same distance. As the total traffic volume will reduce the pollution problems of air, the sound will also be lessened. There will be fuel saving. Another important part of the campaign would be to educate the

people on how the revenue collected from the charging generated would be utilized. This will include the betterment of public transport, footpaths etc. however, it is slightly more difficult to convince the public of the environmental ill effects [26].

Hensher and Li [10] proposed a three-step approach for promoting the public acceptance of congestion charging. These include aspects of privacy, complexity, and equity through public education in the attempt of raising public confidence. According to Litman [27], the quality of public transport can influence the public reaction to the congestion pricing schemes. The Mass Transit can ensure the success of congestion charging. Also, integrated efforts are required for facilitating pedestrians and non-motorized vehicles [28].

6. CONCLUSION

i. The Congestion charging system can be effective in managing traffic congestion and improvements in traffic conditions. The traffic flow associate pollution is expected to be improved to a greater extent as a result of charging and spreading out the peak demand.

ii. Congestion charging trials need to be conducted to address the uncertainty issue such as the pricing efficiency, system accuracy and illegal loss, technical feasibility, enforcement and user's response.

iii. Although the program is a potential solution for the traffic congestion, there are certain issues related to the congestion charging program which needs to be addressed effectively. All the key elements such as traffic spillover, public entitlement and equity, privacy, political risk, utilization of revenue, public awareness etc. need to be identified and mitigated through public participation and effective governance.

iv. The priority to public transport will increase productivity and efficiency substantially. However, the system should be supplemented with other proactive measures such as vehicle ownership control measures, upgrading the existing public transport, encouraging users to shift to public transport, developing allied facilities for improving traffic capacity and management through the funds generated in the program.

v. The use of exempted non-motorized vehicles can be increased. The pedestrian facilities are expected to be efficient and improved.

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