Advances in Economics and Business Management (AEBM)
p-ISSN: 2394-1545; e-ISSN: 2394-1553; Volume 6, Issue 1; January-March, 2019, pp. 63-67

http://www.krishisanskriti.org/Publication.html

Congestion Pricing: A Stated Preference Study in Bengaluru

Abhinanda Mallick[1] and Dr. Varadurga Bhat[2]

[1]*Department of Economics, CHRIST (Deemed) University, Bengaluru*
[2]*Assistant Professor, Department of Economics CHRIST (Deemed) University, Bengaluru*
E-mail: [1]abhinanda.mallick@gmail.com, [2]varadurga.bhat@christuniversity.in

Abstract—*Traffic congestion is commonly cited as one of the biggest problems faced by people in Metropolitan cities. Studies show that chronic traffic congestion has a negative impact on the physical and mental health of commuters. Congestion Pricing is a dynamic pricing strategy suggested by Economists, to reduce congestion. The concept of congestion charge, although relatively unknown in India, has been effectively implemented in cities like London and Singapore. Levying of this charge would mean that private vehicles driving into congested areas of a city would have to pay an entry fee during peak hours. To avoid this charge, people might shift to public transport and fewer cars might come on that road.*

This paper aims to investigate the effects of congestion pricing on transport mode choice behavior (i.e. shift to public transport) of car commuters in Bengaluru. A stated preference approach has been used, since this policy is not in effect in India and direct observation of behavior is not possible. An orthogonal experimental design was used for creating the choice sets, provided to respondents. For the research, two variables were selected for car commuters, Travel time and Congestion cost. For public transport three variables were selected Travel time, Fare and Accessibility and Comfort. Logistic Regression has been used to understand the importance of each variable in commuter preference.

Keywords*: Traffic Congestion, Congestion Pricing, Stated preference, Mode choice behavior.*

1. INTRODUCTION

Bengaluru, the Silicon Valley of India is a rapidly growing city that houses more than two million IT workers. It is the hub of the $150 billion information technology sector that contributes nearly 10% to India's GDP.

The pitfall of this increasing urbanization and migration of workers into Bengaluru has led to a 6000% increase in the number of vehicles on the streets since 1990. Although population might seem like the problem but comparatively more densely populated cities have better traffic conditions. A basic problem in city planning is the star shaped road pattern instead of a grid pattern. Grid pattern has an inherent benefit, that to go from point A to point B, there are multiple paths and the traffic gets distributed. Whereas, in the Star pattern there is almost always just one (or two) main ways to go from point A to point B which congregates the traffic coming from sub-streets onto one main road (UX Design, 2018). Further, common office and school timings, excessive usage of cars and inefficient public transport further cements the problem.

Congestion pricing is a measure that can effectively deal with some of these problems and regulate congestion. In fact, it was considered by the Ministry of urban development (India). It is already in effect in some of the major cities in the world like Singapore (1975), Rome (2001), London (2003), Stockholm (2006), Milan (2008), etc. Levying of this charge would mean that vehicles driving into congested areas of a city would have to pay an entry fee during peak hours (say, 7-10 AM and 6-8 PM). In order to avoid congestion charge, people might shift to public transport and fewer cars would be on the roads during peak hours

How it works: A smartcard is inserted into a unit fitted into the car, money is debited from the smartcard every time the car passes the charging point. Alternative method is an ANPR System (Automatic number plate recognition is a technology used to read vehicle registration plates). Every time the car passes the charging point, the vehicle number is noted via ANPR and connected to state databases. A bill is sent to the owner of the car at the end of the month.

After successful implementation of this scheme, Singapore found a 50% drop in traffic entering the charged area of the city. 20% increase in average speed. Moreover, a rise in public transport usage from the previous 33% to 67%. Other cities like London and Stockholm also experienced various levels of success.

From the international experience regarding congestion pricing, it is evident that this regulatory measure has a good potential to be an effective solution to the chronic congestion problem in Bengaluru. But one of the main reasons behind this policy's success is the shift of car commuters to public transport. Empirical analysis is divided on its success to induce modal shift. It is the question under investigation, whether only levying congestion charges can sufficiently induce commuters to change their mode of transport in Bengaluru.

This paper attempts to understand the effect of congestion pricing on mode choice behavior. The responses to congestion charging have been captured through Stated Preference (SP) Surveys. In these surveys, users have been presented with hypothetical choice scenarios involving varying amounts of congestion charges and travel time savings along with improved public transport options and have been asked to choose between car and public transport given each scenario. (Choudhary, 2017). Discrete choice models have been developed using the collected data.

2. LITERATURE REVIEW

Literature on congestion pricing is extensive. Congestion charge as a concept belongs to the field of transport economics, road engineering and transport policy. There is no universally applicable congestion charge model or approach that suits every large city as all cities are unique in some way. However, in general, there are three clear goals of congestion charge that all cities share, namely; to collect revenue, to reduce traffic congestion and to invest in infrastructural projects (Niskanen & Nash, 2008; Eliasson, 2010).

An adjustment in commuter behavior due to traffic congestion charge takes place when the road users change mode of transportation, from car to public transport, and/or time and destination of the trip to evade charges (Karlström & Franklin, 2008; Keuleers, Thorpe, Timmermans & Wets, 2005; Keuleers et al. 2005). Hu and Saleh´s (2005) study investigated the likely effect of a preliminary congestion charge in Edinburg and suggested that a change in the driver's behavior would occur, as they would drive less or change their destination after the introduction of the congestion charge. However, it has also been shown in several cases that these changes in travel pattern is part of the adaption process and could be seen as a short-term strategy for dealing with the congestion charge and the new circumstances, and that the behavioral change will diminish over time (Keuleers et al. 2005; Bonsall et al. 2006).

However, for this paper we have chosen to assume short-term behavior mirrors long-term choices of people. One research gap that emerges from the literature is the lack of studies with respect to congestion pricing in India.

3. SURVEY DESIGN

The survey was conducted on a sample of 100 white collar workers who use cars for their daily commute to work. Convenience sampling was used due to time and cost constraints. As this policy has not been implemented in Bengaluru, direct observation of behavior is not possible. Two primary advantages of using Stated preference approach include: (i) Creating sufficient variation needed for estimation of underlying preference parameters; (ii) For new products (as in this study) that do not exist in the current market, providing a scientific alternative to gauge consumers' responses and preferences. Therefore, a Stated Preference Questionnaire was designed to investigate commuter response to various hypothetical scenarios and the mode of transport they prefer. (Figure 1 shows example of a choice scenario)

Scenario 1

Mode	Travel Time	Access to public transport and Comfort	Congestion Cost	Fare
Travel by Car	Decrease by 30%	-	Rs.240	-
Travel by Public Transport	Decrease by 20%	Good		Decrease by 30%

Given this scenario, which mode of transport would you prefer to use for your daily commute?

- ☐ Car
- ☐ Public Transport

Figure 1: Stated Preference Example

To maintain simplicity and readability (thus reliability of the SP data), only four features of a congestion charge system were considered in the SP experiments: the amount of congestion charge, travel time reduction, public transport fair decrease and comfort and accessibility of public transport. To make these SP experiments more realistic, the survey instructed respondents in the following way: -

"Compare the conditions described below to your most recent trip. If these scenarios were to actually occur, what would you most likely do, to deal with the situation. Examine each scenario and choose the response that best describes your actual behavior."

Respondents were asked to treat other factors that are not considered in the SP scenarios as unchanged. An orthogonal fractional factorial Design using SPSS was generated, consisting of 8 SP tasks in total.

In each SP experiment, two transport modes (i.e., car and Public transport) with specific attribute levels were available. Respondents were asked to choose between the two modes of transport. Two attributes for car were considered (Note that the numbers in parentheses are attribute levels): Travel Time percentage reduction compared with their most recent trip (-10%, -20%, -30%), and congestion charge (Rs.160, Rs200, Rs.240); Three attributes for public transport were considered: percentage of fare reduction compared with their most recent trip (-10%, -20, -30%), reduction in travel time (Unchanged, -10%, 20%) ; Comfort and Accessibility (Good, Average, Bad)

The values for the attribute levels have been considered keeping in mind real world effects of this policy. Congestion cost is based on a study on congestion cost in Delhi (Rawat,2018)

The questionnaire also contained socio-demographic questions (like gender, age, income, education).

4. METHODOLOGY

Binary Choice Model

Two alternatives are compared, and the one that yields the highest level of utility is chosen by an individual.

Binary Choice model is concerned with the estimation of utility (V_i)

V_i is often referred to as the "representative component of utility," because it is where the set of attributes that are observed and measured (for a representative individual *q*) reside. Their residency is accompanied by a set of weights that establish the relative contribution of each attribute to the observed sources of relative utility. In its simplest form, we can define the representative component of utility as a linear expression in which each attribute is weighted by a unique weight (called a parameter or coefficient) to account for that attribute's marginal utility input. Formally, we can write this out as (4.1), using *f* as a generalized notation for functional form, but recognizing that the functional form can be different for each attribute:

$$\boldsymbol{V_i} = \beta_{0i} + \beta_{1i}\, f\,(X_{1i}) + \beta_{2i}\, f\,(X_{2i}) + \beta_{3i}\, f\,(X_{3i}) + \cdots + \beta_{Ki}\, f\,(X_{Ki}) \quad (4.1)$$

Where,

β_{1i} is the weight (or parameter) associated with attribute X_1 and alternative *i*

β_{0i} is a parameter not associated with any of the observed and measured attributes, called the *alternative-specific constant*, which represents on average the role of all the unobserved sources of utility.

There are $k = 1, 2 \ldots . K$ attributes in (4.1). This expression has included subscripts on every element to recognize that the weights, the attribute levels, and the constant are specific to the i^{th} alternative. (Hensher, 2005)

5. DATA ANALYSIS

Socio – demographic characteristics of the data

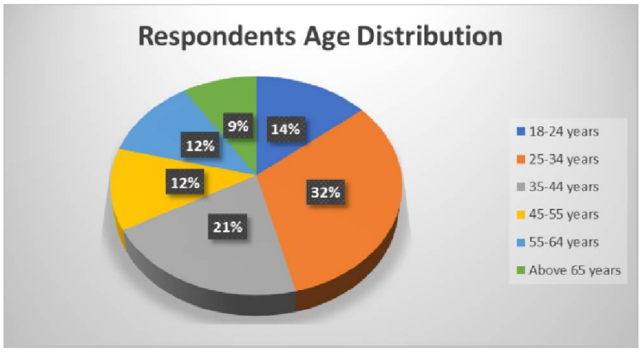

Figure 2: Age distribution of Respondents

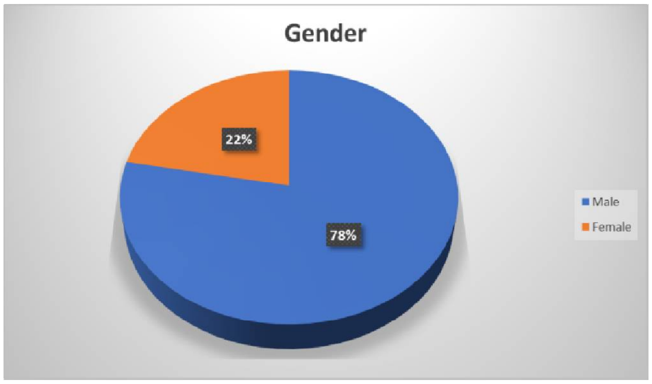

Figure 3: Gender of Respondents

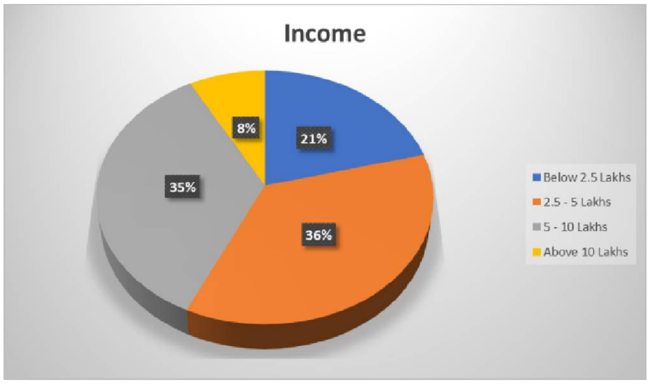

Figure 4: Income distribution of Respondents

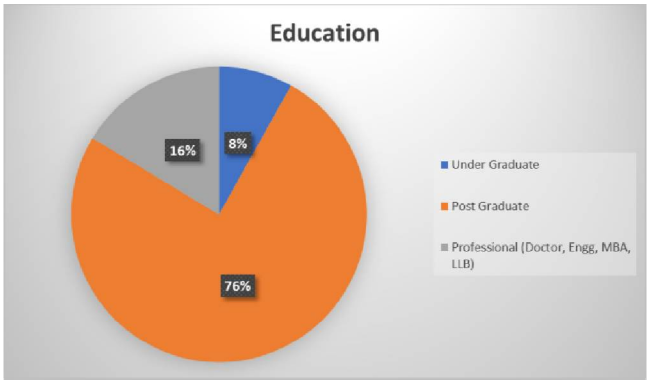

Figure 5: Educational qualification of Respondents

Mode Choice Analysis

Table 1: Variables and their parameter estimates (results from the binary logistic regression analysis)

Attributes	B	SE	Wald	df	P value	Exp(B)
Travel Time			145.54	3		
Travel Time Reduced (-10%)	1.03	0.60	0.57	1	.000	86.407
Travel Time Reduced (-20%)	4.45	0.15	24.25	1	.000	3.012
Congestion Cost (Rs.200)	-0.6	0.2	11.53	1	.024	0.543
C	-3.4	.696	668.51	1	0.008	1.049

B=logistic coefficient, df=degrees of freedom, Exp(B)=change in odds ratio, SE=standard error, Wald=Wald statistic

Table 1, is estimating the influence attributes on model choice behavior. After, fitting various models, only the significant attributes at various levels is shown here. The results show the individual influence of each attribute (Travel Time and congestion cost) on utility derived from choosing car as an Alternative.

We see that individuals are time sensitive. And there is an inverse relationship between choosing mode of transport and travel time. Say, if travel time increases commuter's preference for car as a mode of transport will reduce.

Congestion cost also shows inverse relationship with choice of transport. As congestion cost increases, people will tend to choose car as an alternative less.

Wald statistic is significant for all the attributes.

Table 2: Estimating shift to Public Transport

	Congestion Cost	TravelTime	Utility	Exponential	% shift to Public Transport
Scenario 1	Rs. 160	30 min	-(0.746)	0.474259803	12%
Scenario 2	Rs. 200	30 min	-(0.426)	0.653116342	16%
Scenario 3	Rs.240	30 min	-(0.016)	0.899424862	23%

In Table 2, the utility from the above three scenarios are estimated against the utility derived from a trip of 30 minutes and no congestion cost. It is evident that congestion cost of Rs. 240 would lead to maximum number of shifts to public transport. Clearly, people are cost sensitive.

6. CONCLUSION

The potential response to implementation of congestion charging in Bengaluru has been explored in this research. The study has several limitations though. In particular, the data sizes are relatively small and isolated to few parts of Bengaluru. Similar studies need to be repeated in other parts of the city to get more representative results.

Moreover, in order to keep the choice task simple, only two alternatives have been provided. Also, levels of service for the non-car alternative has been fixed in this research. Varying the levels of services of those alternatives can help to improve the statistical significance of the parameter.

The research, though limited in extent, provides important behavioral insights that need to be considered to implement congestion charging successfully in Bengaluru. The key policy implications are listed below.

It can be inferred from the analysis that congestion pricing can play an effective role in shifting commuters from cars when they are provided with the option to use public transport. However, in this analysis the congestion charges are quite high. Thus, it can be said that the congestion charge needs to be sufficiently high to induce a shift.

Moreover, the quality of public transport needs to be improved. Congestion pricing in isolation is not sufficient. This is in line with the feedback commuters provided regarding reasons for using car over public transport. Therefore, proper emphasis must be given in improving levels of service of public transport before congestion charging is implemented.

Part of this investment can be recovered later by the revenue generated from the congestion charge.

The modelling results revealed that travelers have significant sensitivity to cost increases which is also a promising indication about the potential effectiveness of congestion pricing in the city. However, this study did not collect data from commuters with high level of income disparity. Choudhary (2017) has shown highest income group (who have the highest usage rates of cars and have higher average trip lengths were found to be less sensitive to the congestion charges. This needs to be accounted for in the detailed feasibility study so that the reduction in traffic is not overestimated.

REFERENCES

[1] Choudhury S, "Modelling the Behavioural Response to Congestion Pricing in Dhaka, Bangladesh", *Transp. in Dev. Econ.*, 2017 pp. 3-23

[2] Rawat M., "Congestion Pricing: A Case of Delhi", Urban Mobility in India Conference & Expo, 2016.

[3] Zheng L., David H., "Congestion charging and car use: A review of stated preference and opinion studies and market monitoring evidence ", Transport Policy 20, 2012, pp. 47–61

[4] Kriendler G., "The Welfare Effect of Road Congestion Pricing: Experimental Evidence and Equilibrium Implications", retrieved from http://economics.mit.edu/grad/gek

[5] Zeng et. al, "Understanding public response to a congestion charge: A random-effects ordered logit approach" Transportation Research Part A: Policy and Practice, 70, pp. 117-134

[6] Hensher, D. A., Rose, J. M., Greene, W. H. (2005). Applied choice analysis: A primer. Cambridge University Press.

[7] Gärling, T., Jakobsson, C., Loukopoulos, P., Fujii, S. (2008). Acceptability of road pricing. In: Verhoef, E., Bliemer, E., Steg, L., Van Wee, B. (Eds.), Pricing in Road Transport: Multidisciplinary Perspectives. Edward Elgar, Cheltenham.

[8] How Can Design Help Solve Bangalore's Traffic Problem? Kunal- Kunal retrieved from https://uxdesign.cc/bangalore-traffic-short-case-study-7206b53ccc40

[9] Hammar E., Loewe C "Consumer behavior and public acceptance to the introduction of a congestion charge in Gothenburg." Jönköping, 2013

[10] Ben-Elia, E. Ettema D. "Rewarding rush-hour avoidance: A study of commuters’ travel behavior", Transportation Research Part A 45, 2011 pp. 567–582.