Estimating Welfare Changes from Efficient Pricing in Public Bus Transit in India

Kaushik Deb[1]

TERI University, Plot No. 10 Institutional Area, Vasant Kunj, New Delhi, India.

Massimo Filippini

Department of Management, Technology and Economics, ETH Zurich, Zürichbergstrasse 18, CH-8032 Zürich Switzerland. mfilippini@ethz.ch and

Economics department, Università della Svizzera Italiana, Lugano, Switzerland,

Abstract

Three different and feasible pricing strategies for public bus transport in India are developed in a partial equilibrium framework with the objective of improving economic efficiency and ensuring revenue adequacy, namely, average cost pricing, marginal cost pricing, and two–part tariffs. These are assessed not only in terms of gains in economic efficiency, but also in changes in travel demand and consumer surplus. The estimated partial equilibrium price is higher in all three pricing regimes when compared to the current price. As a result, consumer surplus falls in all three cases. The price increase is much larger with average cost pricing compared to marginal cost pricing or two–part tariffs, and hence a larger fall in demand and consumer surplus occurs due to average cost pricing. While there is a gain in economic efficiency from marginal cost pricing and two–part tariffs, this improvement comes at the expense of reduced public bus transit demand and consumer surplus, given the price inelastic public bus transit demand estimated for India. Given the mobility needs and the developmental concerns of a growing economy such as India, the challenge for policy makers

[1] Corresponding author: email: kdeb@teriuniversity.ac.in

Ph 0091 11 2612 2222

Fax: 0091 11 2612 2874

is to balance the gains in economic efficiency in the public bus transit sector against other social, political, and developmental goals.

1. Introduction

Rapid economic growth in India has resulted in a sharp increase in the demand for transport services. Sustaining this increased economic productivity is contingent on optimally utilizing existing infrastructure. In particular, an efficient and extensive public transport system is a key element of any strategy that seeks to optimally meet the mobility demand that arises from rapid economic growth (Justus (1998); Gowda (1999)). Additionally, increasing the share of public transport is important for reducing emissions from the sector, and improving social cohesion.

Unfortunately, public bus companies in India have been plagued by severe financial constraints and are hard pressed to even meet their fleet replenishment needs, let alone augment fleets to cater to growing demand or introduce efficiency improving technologies (Kadam (1999)). In the post–liberalization era, it would be difficult for governments to continue to provide financial support to cover the deficits of the bus companies, especially with the growing emphasis on fiscal discipline. Existing financial constraints, and the inability to raise resources for investments, is also caused in part by uneconomical operations to meet the universal service obligation with tariffs that do not reflect the cost of service delivery (Maunder (1984)). Thus, optimal pricing of public transport services to ensure economic efficiency and cost recovery is critical for ensuring a sustainable public transportation system.

Though fare increases are considered necessary to ensure financial viability, they are constrained by two factors: meeting the universal service obligation and the threat of reduced ridership due to a shift away from public transport. Thus, the sector is faced with a unique challenge: increase capacity while improving service quality in terms of access to transport, comfort, frequency, and reducing travel time. It is necessary to review the functioning of public bus transport firms in India to improve revenue collection and hence the tariff regime (Cervero (1990); Planning Commission (2002)).

In addition, access to transport services is considered critical for addressing equity concerns by facilitating access to primary education and employment generation facilities. Transport infrastructure is also important for integrating rural communities in the socioeconomic structure of the nation. Hence, any increase in bus fares, and the consequent fall in demand would have consequences beyond economic efficiency in the public bus transit sector. This is particularly important in a country such as India where access to public transport is not universal. There is therefore a tradeoff between economic efficiency and achieving universal coverage in service delivery.

Given this focus on pricing of public bus transport in India, this research assesses the impact of the introduction of three hypothetical pricing policies on bus fares, deficit of the companies, demand and consumer surplus. In particular, bus fares based on marginal cost pricing, average cost pricing, and a two part pricing policy are designed and evaluated. This research is, therefore, in the tradition of most research on public transit pricing, focused on the analysis of economic efficiency of bus fares. The pricing strategies that are assessed focus on both economic efficiency and revenue adequacy. Finally, the change in demand and consumer surplus that would come about from efficient pricing is also reported to indicate the potential social and political impact

While a study of the entire transport sector including all modes would be of great value, data to carry out such a detailed analysis is unfortunately not available. In addition, given the restrictive assumptions for first best pricing and the difficulties in estimating the welfare impact of the financing of the deficit of the companies using public revenues, this research only indicates the direction of change in case of policy reforms that focus on bus fares. Nevertheless, this study provides for the first time an economic analysis of public bus transit pricing in India focusing on economic efficiency, and its impact on transit demand and consumer surplus. As Nash (2003) points out, even if the limiting regime implied by first best marginal cost pricing and similar regimes is unrealistic, these still provide a starting point for the design of appropriate and feasible pricing regimes.

The following section describes various pricing strategies with a focus on network industries, and highlights their key features and issues in estimation and implementation. Following that, in section 3 and 4, the three tariff regimes for single product monopolies feasible given the industry in India, are estimated. These are average cost pricing, marginal cost pricing, and a second best two–part tariff. While average cost pricing and the two–part tariff ensure complete cost recovery, marginal cost pricing could lead to losses in the presence of Economies of Scale, as is also observed in our case. Finally, section 5 concludes.

2. Pricing transport services

Public bus transit in India is overwhelmingly provided by the government, and prices are directly set by it. Revenue streams for bus operators often comprise of both fare-box collections and some form of subsidy from the government.

Optimal or first best pricing of public bus transit services implies that fares should be fixed such that they equate the marginal social costs. Marginal cost pricing, however, would lead to losses given the significant Scale Economies that exist in the public bus transit in India (Deb (2008)). To address concerns arising from losses in public transport, pricing regimes need to ensure revenue adequacy. Pricing regimes that systematically diverge from uniform marginal cost pricing to ensure revenue adequacy are classified as second best pricing regimes. These include simple linear tariffs as in the case of average cost pricing, and more complex non–linear pricing regimes including two–part tariffs, Ramsey Pricing, and Peak Load pricing. Ramsey Pricing and Peak Load pricing are examples of price discrimination regimes where different customers are charged different prices to obtain revenues larger than those obtained from a single price for all consumers. These are relevant to public bus transit where demand varies temporally. Thus, demand in the peak period is often significantly higher than that in the off–peak period. Demand patterns also vary across different consumer categories. For instance, demand elasticities for educational trips by students would be different from work related trips. In principle, if it were possible to distinguish between demand elasticities of different consumer groups and over time, differential pricing regimes could be applied.

Unfortunately, sufficient data is not available for different consumer categories to be able to estimate aggregate demand functions differentiated temporally or by each consumer category. Hence, differential pricing rules are not applied in this paper. In addition, there may be legal issues that prevent charging different prices to different consumers or consumer groups (Braeutigam (1979)).

This paper compares the first best marginal cost pricing outcomes with two pricing regimes that are designed to ensure full cost recovery, average cost pricing, and a budget constrained two part tariff. It is noted, however, that the welfare effects of marginal cost pricing cannot be directly compared with average cost pricing and two part tariffs, since marginal cost pricing leaves the problem of financing the deficits to the general public budget, while second-best approaches integrate this issue within the pricing rule. Data for such comprehensive economy wide welfare changes due to financing deficits is not available for this analysis and such changes are thus ignored. Hence, these changes should be considered only indicative, and considered in light of the assumptions discussed below. Moreover, this paper does not deal with the institutional and organizational changes that would be necessary to implement these pricing regimes.

2.1.First best pricing

First best pricing is derived from maximizing net social benefits, that is, the difference between the willingness of consumers to pay for the services and the cost of producing them (Gómez-Ibáñez (1999)) or the sum of consumer and producer surplus' (Braeutigam (1989)).

The optimal price can then be obtained from maximizing net social benefits with respect to output. Here, optimal prices equal the marginal costs of providing transit services. The optimal fare can be split into two parts, the first being the average cost of serving each passenger, and the second being the change in the cost from serving each additional passenger (Gómez-Ibáñez (1999)). Charging consumers a price equal to the marginal costs would ensure that consumers demand an extra unit of the product only if the value of the additional unit is larger than the additional cost of producing it.

This regime is premised on several crucial assumptions, which makes its effectiveness uncertain (Gómez-Ibáñez (1999)). In particular, marginal cost pricing assumes that there are no externalities in production and consumption. In the presence of externalities not addressed explicitly through taxes or subsidies, the social costs of production would diverge from the firms' costs and lead to inefficient outcomes. For example, the price of using a personal vehicle usually comprises the actual cost of use without accounting for external costs such as pollution or congestion. Hence, unless the use of personal vehicles is taxed such that the tax rate equals the marginal external costs of using personal vehicles, fixing bus fares equal to marginal cost of providing public transit services will not maximize the net social benefit. Of course, the external costs due to emissions from buses need to be accounted for in the fixing of bus fares as well.

With marginal cost pricing, concerns also arise in network industries since these are usually observed to have Economies of Scale. In particular, for a single output firm, the presence of Economies of Scale imply that marginal costs are lower than average costs and that average costs observed to be falling (Kahn (1970)). That is,

$$\frac{dAC(y)}{dy} < 0 \tag{1}$$

In that case, equating the fare to marginal costs means that average costs exceed the price. In terms of the formulation above,

$$p^*(y) < AC(y) \tag{2}$$

or $\pi = \left[p^*(y) - AC(y) \right] y < 0$ (3)

Hence, providing transit services with marginal cost pricing will imply a loss in the presence of Economies of Scale (Braeutigam (1989); Gómez-Ibáñez (1999))[2] . This loss then needs to be recovered, usually from government budgetary resources. Financing the deficit using the general budget creates two problems. First, public revenues to finance such losses should be raised using a lump sum tax [3] such that no other distortions are created in the market. Second, the financing of the deficit using the general public budget has equity and distributional issues between consumers who use public transit and other citizens of the economy. In addition, Lipsey and Lancaster (1956) point out that marginal cost pricing is a first best, if and only if, all other prices in the economy are also at their marginal cost levels. As Baumol and Bradford (1970) show, when all prices are not at their optimal level, marginal cost pricing in just one market may lead to significant sub–optimality. In effect, if the price of even one close complement or substitute is not equal to its marginal cost, marginal cost pricing of transit services will not be optimal.

In summary, the following assumptions are necessary for marginal cost pricing to lead to a first best outcome (Rothengatter (2003)):

- All costs, direct indirect, and external, need to be accounted in the calculation of marginal costs. In the transport sector, this would imply including 'operating costs, costs of the wear and tear of infrastructure, congestion and scarcity costs, ecological costs and accident costs'.
- Full cost recovery requires transport technology to be convex.

---

[2] In the empirical analysis of this paper, we provide evidence of the presence of economies of scale in the Indian bus sector.

[3] A lump-sum tax is a fixed sum that a person pays independent of that person's income. The advantage of this tax is not creating an excess burden of taxation, a loss in economic efficiency that results from the fact that taxes can reduce incentives for efficiency decisions in consumption and production. Generally, a lump-sum taxes are also considered inequitable. For this reasons, this type of a tax is rarely adopted by governments.

- Investments should be perfectly divisible to allow for growth in service delivery and area coverage.
- All other markets should be perfectly competitive.
- Perfect information and foresight is necessary.

2.2.Second best pricing rules

As described above, marginal cost pricing in the presence of Economies of Scale implies losses for a transit firm. Sustaining operations, especially over the long term, implies that subsidies or financial support is necessary, usually from the government. A lump sum transfer, to cover the difference between costs and revenues with marginal cost pricing in an industry characterized by increasing returns to scale, clearly Pareto–dominates a scenario with prices higher than marginal costs (Kahn (1970); Willig (1978)).

Governments are generally averse to providing direct subsidies to cover the difference between total costs and fare box collections (Kahn (1970)). This reluctance can be, at least in part, traced to the political economy of deficit budgeting. In particular, with increasing focus on fiscal responsibility and financial viability, direct transfers to public transit firms are unlikely. Such arguments are strengthened by arguing that the lack of a budget constraint implies that firms do not have incentives for minimizing costs (Garcia and Reynaud (2004)). Importantly, such revenue transfers have to be lump sum so that there are no new distortions created in the economy. This is because of the possibility of financing such transfers using new tax measures, which in turn may be distortional.

In addition, for regulated industries, the regulatory agencies may not have access to fiscal resources to provide subsidies. Hence, regulatory strategies are constrained by the revenue adequacy of the firms. If prices are above the marginal costs, this would imply a reduction in demand from the socially optimal level, resulting from a reduction in the consumer surplus (Braeutigam (1989)). This loss of efficiency is referred to as the deadweight loss.

2.2.1. Average cost pricing

The simplest pricing strategy followed by most utilities for ensuring that all costs are met is setting the price equal to the average cost. This strategy is also called the revenue–recovery principle (Garcia and Reynaud (2004)). Following White (1981),

$$p(y) = C(y)/y \tag{4}$$

where $C(y)$ is total cost of providing y .

In the transit sector, this translates into dividing the total cost by the number of passengers to obtain the average cost per passenger and setting the fare equal to that. This is the simplest case of charging a flat fare to cover all costs of operation. In this case, the output y is defined in terms of the number of passengers. Hence, the average cost price obtained is a flat fare per trip.

However, often transit services are priced according to the distance covered. To incorporate a distance dimension to average cost pricing, the total cost is divided by the passenger kilometers. The result here is a fare per kilometer that is charged to each passenger. Other characteristics of average cost pricing could include temporally differentiated prices, by different types of services provided, etc.

The most significant criticism of this scheme is that such prices do not signal scarcity as they would in neoclassical economics (Garcia and Reynaud (2004)) and therefore create a deadweight loss. As a result, there is a loss in economic efficiency that comes about from prices that do not reflect marginal costs and demand, and hence a loss in net social benefit.

2.2.2. Budget constrained two–part tariff

Most early analysis of costs and benefits did not explicitly recognize deficit between revenues and costs in the social objective function, instead focusing on only the consumer surplus and cost of production (Obeng (1983))[4]. However, as discussed earlier, in industries characterized by increasing returns to scale, this implies that firms are unable to recover costs and hence cease production over time.

That is, $p < AC\left(y\right) \Rightarrow py - C\left(y\right) = \pi < 0$ if $p = MC$ (5)

Welfare maximization in such a scenario could take into account a revenue adequacy constraint by charging an entry fee or fixed price in addition to the variable price. The fixed fee is set to extract just enough of the consumer surplus to cover the deficit arising from marginal cost pricing. The entry fee in this case is a payment for the privilege of being able to consume the service and the variable price is the payment for consuming each additional unit of the service. This leads to non–linear pricing since total payment for consuming the service falls with each additional unit consumed.

Following Ng and Weisser (1974) and Berg and Tschirhart (1988), the problem can then be set up as follows:

$$\max \psi\left(x\right) \text{subject to } \pi = p_v Y + p_F I - C\left(y\right) \geq 0 \quad (6)$$

where $\psi\left(\cdot\right) = \int_0^I V\left(p_v, p_F, w\left(I\right), I\right) f\left(I\right) dI$ is a measure of consumer welfare and $f\left(I\right)$ is the density function of consumers[5]. $Y = \int_0^I y_i f\left(I\right) dI$ is the total demand of I consumers, p_v and p_F are the variable and fixed price components, respectively. $C\left(\cdot\right)$ is the total cost of producing, and π is the profit. Solving the above system gives a variable part that equals

[4] This analysis does not account for different elasticities of demand with respect to the fixed and the variable parts, and different levels therein, as also variations in elasticity across consumers due to lack of data. By accounting for such a variation in elasticities, a number of combinations of fixed and variable pricing parts can be obtained.

[5] The expression for consumer welfare here ignores any normative weighting that a social planner may assign to different consumers. In addition, income effects are ignored while aggregating welfare across consumers.

marginal costs, and fixed price equals the difference between cost and the revenue from the variable price divided between all customers[6].

Hence,

$$p_v = \frac{dC(y)}{dy} = MC(y) \tag{7}$$

and $$p_F = \frac{C(y) - p_v y}{I} \tag{8}$$

where p_v is the variable price component, p_F is the fixed price component, and I is the total number of consumers.

Such a two–part tariff regime would lead to the same output equilibrium as marginal cost pricing. The analysis here is contingent on the fixed price being charged, analogous to a lump sum tax, and hence not influencing consumption at the margin similar to the approach suggested by Loeb and Magat (1979) in their model of monopoly regulation. This is important when demand is sensitive to income effects, then such access charges would lead to a change in the demand from the optimal level.

3. Efficient transit pricing in India

The estimation of an efficient pricing regime requires estimates of marginal costs and demand elasticities. The subsidy and equity considerations are then described by comparing the prices to marginal costs, and evaluating the impact on public bus transit demand, consumer surplus, and profits (Naughton (1986)). In the present research, estimates for user costs and external costs are not available and only production costs for firms that have been estimated. Therefore, in this research, marginal social costs comprise only production costs. As noted earlier, the focus of the pricing regimes in this section is on the public bus transit firms in a partial equilibrium framework following Naughton (1986) and Garcia and Reynaud

[6] Refer to Berg and Tschirhart (1988) for a detailed derivation.

(2004) and not the entire transit sector, as is the case in the PETS project (European Commission (2000)).

In all the literature that is available for review, this is the only study that looks at efficient transit pricing in India. A comprehensive analysis has been attempted, including the estimation of a cost function for all public transit firms in the country. In addition, the specification used for estimation in both cases has included significant variables to capture heterogeneity in the operating environment of the firms. The pricing strategies that are assessed focus on both economic efficiency as well as revenue adequacy.

3.1. Specification and estimation of a total cost function

Cost specifications traditionally assume cost as a function of output and input prices (capital, labor and energy price). However, several authors go beyond this specification and identify other exogenous variables, which can further explain cost differences among the observations. For example, several studies recognize output heterogeneity by adding a series of output characteristics such as the length of the network, the number of stops and the frequency to the cost function specification [7]. Following this literature, we specify the following cost function[8]:

$$C = f\left(y, P_l, P_f, P_k, LF, NL, AR_i, MG_i, t\right) \tag{9}$$

We assume the total cost of a bus transit company C to be a function of the output, y, and of the factor prices, P_l, P_f, P_k. Labour costs include all expenditures related to personnel costs for all categories of staff. Energy costs include only expenditures on diesel. Capital costs are

[7] See for instance Filippini and Prioni (2003) and Farsi, Fetz et al. (2007).

[8] It should also be noted that bus companies might have other objectives in addition to cost minimization implied in function (9), in which case functions based on cost optimization can still be used as a 'behavioral' cost functions and can be helpful in studying the firms' behavior rather than their production technological characteristics (Bos (1986)).

obtained as a residual from total costs after excluding personnel and energy expenditures. This category includes interest, depreciation, taxes, expenditure on tires, lubricants, batteries etc., payment for private operations, and other undefined expenditures.

Network length $\left(NL\right)$, average load factor (LF), two dummy variables for the area of operation (AR_i) and three dummy variables for the management structure (MG_i) have been included as output characteristics. Finally, the variable t captures the effect of technical change occurring over the years.

In terms of the functional form, this study estimates the commonly used Translog specification, a second–order approximation of an unknown cost function (or technology) around a specified point. Most studies of bus transit have used the Transcendental or Trans Logarithmic (Translog) cost function first introduced by Christensen, Jorgenson et al. (1973). Using a translog function, the expression in (9) can be approximated by the following total cost function[9].

$$\begin{aligned}
\mathrm{Ln}\frac{C}{P_k} &= \alpha_0 + \alpha_y \mathrm{Ln}y + \alpha_l \mathrm{Ln}\frac{P_l}{P_k} + \alpha_f \mathrm{Ln}\frac{P_f}{P_k} + \frac{1}{2}\alpha_{yy}\mathrm{Ln}y^2 + \frac{1}{2}\alpha_{ll}\mathrm{Ln}\frac{P_l}{P_k}^2 + \frac{1}{2}\alpha_{ff}\mathrm{Ln}\frac{P_f}{P_k}^2 \\
&+ \alpha_{yl}\mathrm{Ln}y\cdot\mathrm{Ln}\frac{P_l}{P_k} + \alpha_{yf}\mathrm{Ln}y\cdot\mathrm{Ln}\frac{P_f}{P_k} + \alpha_{lf}\mathrm{Ln}\frac{P_l}{P_k}\cdot\mathrm{Ln}\frac{P_f}{P_k} + \alpha_t t \\
&+ \alpha_{LF}\mathrm{Ln}LF + \frac{1}{2}\alpha_{LFLF}\mathrm{Ln}LF^2 + \alpha_{yLF}\mathrm{Ln}y\cdot\mathrm{Ln}LF + \alpha_{LFl}\mathrm{Ln}LF\cdot\mathrm{Ln}\frac{P_l}{P_k} + \alpha_{LFf}\mathrm{Ln}LF\cdot\mathrm{Ln}\frac{P_f}{P_k} \\
&+ \alpha_{NL}\mathrm{Ln}NL + \frac{1}{2}\alpha_{NLNL}\mathrm{Ln}NL^2 + \alpha_{yNL}\mathrm{Ln}y\cdot\mathrm{Ln}NL + \alpha_{NLl}\mathrm{Ln}NL\cdot\mathrm{Ln}\frac{P_l}{P_k} + \alpha_{NLf}\mathrm{Ln}NL\cdot\mathrm{Ln}\frac{P_f}{P_k} + \alpha_{NLLF}\mathrm{Ln}NL\cdot\mathrm{Ln}LF \\
&+ \alpha_{AR1}AR1 + \alpha_{AR2}AR2 + \alpha_{AR4}AR4 + \alpha_{MG1}MG1 + \alpha_{MG2}MG2 + \alpha_{MG3}MG3
\end{aligned} \tag{10}$$

By normalizing total cost and input prices by one of the input prices (here the price of capital), the cost function becomes linearly homogeneous in input prices.

---

[9] A translog function requires the approximation of the underlying cost function to be made at a local point, which in our case is taken at the median point of all variables. Thus, all independent variables are normalized at their median points.

The estimation of a cost function enables us to derive some important characteristics of bus supply technology such as economies of scale, marginal and average costs. These technology characteristics are particularly interesting in a translog framework, as this functional form does not require restrictive a priori assumptions, allowing these measures to vary with the firm's output.

For the estimation of the translog function (10), we used an unbalanced panel of 51 public bus companies operating in India between 1996/97 and 2003/04 (CIRT (Various years)). This is not a balanced dataset as data for all firms is not available for all years due to mergers, unbundling, and closures. In addition, data for all bus companies is not available for any year in the dataset. In total, 211 observations were available.

Transit output is usually defined in the literature in terms of a measure that reflects transit demand (passengers carried), or one that reflects supply (bus–kilometers or bus–hours operated), or a hybrid of the two (passenger kilometers). Data on bus–kilometers is easily available and this measure is highly correlated with cost items. However, supply measures do not reflect the motivation for providing bus services, namely carrying passengers. Demand related measures such as passenger–trips or passenger kilometers are based on actual market transactions and allow more comprehensive economic analyses (Costa (1998)). However, input costs may not systematically vary with demand–related output measures. In this research, the objective is to estimate efficient price levels, and hence the definition of output needs to reflect actual market transactions while characterizing the firms' technology. Hence, passenger kilometers (y) are taken as the output measure. The two measures of output, passenger kilometers and bus–kilometers, show a very high level of correlation in our dataset.

All cost variables have been deflated to take into account inflation. The deflators were calculated from the appropriate inflation indices reported by Government of India (2005):

- Labour costs have been deflated by the Consumer Price Index for Industrial Workers.

- Energy costs have been deflated using the Wholesale Price Index for Fuel, Power, Light, and Lubricants.
- Capital costs were deflated using the Wholesale Price Index for Machinery and Machine Tools.
- Total costs were deflated using the Wholesale Price Index for All Commodities.

The price variables are estimated from the total expenditure for each input divided by the input quantity consumed (Braeutigam (1984)). For instance, energy price is the total expenditure on diesel divided by the total diesel consumed. Following Obeng (2000), Filippini and Prioni (2003), and Farsi, Filippini et al. (2006), capital price is defined as the residual cost divided by average number of buses in use in a year.

A summary of the data used for estimating the cost function is presented in Table 1.

Table 1 here

With regard to the estimation technique, it should be noted that in the econometric literature we find various types of models focusing on cross-sectional variation, that is, heterogeneity across units. The two most widely used approaches are: the fixed-effects model (FE) and the random effects model (RE)[10]. The main advantage of these two estimators for panel data is that they are able to account for unobserved heterogeneity[11]. In this paper, we estimated the cost function (10) using the random effects estimators (RE)[12] .

---

[10] For a detailed presentation of the econometric methods that have been used to analyze panel data, see Greene (2003) and Baltagi (2002).

[11] A cost function model by definition includes a random error term that captures the idiosyncratic heterogeneity among different observations. In panel data where an individual firm is observed several times, the firm-specific unobserved variations can also be taken into account through fixed or random effects. This is an important practical advantage for our empirical analysis because in many cases the relevant environmental factors are location characteristics that vary among bus companies but are constant over time. For a discussion, see Farsi, Fetz et al. (2007).

Table 2 presents the parameter estimates and standard errors of the translog cost function. Dummy variables for operations only in urban areas (AR_1) and management structure within a government department (MG_1) are omitted to avoid singularity, and hence the coefficients for area of operation and management structure dummies are interpreted relative to these excluded values. The estimated function is well behaved**.** Most of the parameter estimates are statistically significant and carry the expected sign.

Table 2 here

Since total cost as well as most of the explanatory variables are in natural logarithms and have been normalized, the first order coefficients can be interpreted as cost elasticities evaluated at the sample median. Output elasticity is 0.650. This implies that a 1% increase in output will increase total cost by 0.65%. The cost elasticity of the network length is as expected positive (0.132) and significant.

The distinction between economies of density and economies of scale is very important in industries that provide their services over a network. In such cases, firm size is more closely tied to the size of the network than to the output provided over that network. For this reason, it is important to distinguish cost changes that occur because of output changes only and cost changes that occur because of a proportional network and output change.

Economies of density are defined as the increase in total cost resulting from an increase in output, holding all input prices and the network size fixed (Caves, Christensen et al. (1984):

---

[12] The fixed effects model has not been considered in this empirical analysis for two reasons. First, as pointed out by Cameron and Trivedi (2005), the low within Variation for several of the regressors could result in imprecise coefficients in the Fixed Effects model since it relies on Within Variation to carry out the estimation. Moreover, Random Effects estimates can be applied outside the sample for predictions, which is not appropriate for estimates obtained from the Fixed Effects models (Cameron and Trivedi (2005)). This is important in the context of the current research since the objective is to simulate several pricing strategies.

$$ED = \frac{1}{\frac{\partial \ln C}{\partial \ln y}} \qquad (11)$$

Economies of density exist if ED is greater than 1. For values of ED below 1, we identify diseconomies of density. The existence of economies of density implies that the average costs of a bus operator decrease as physical output increases, holding network size fixed. The estimated economies of density for the median bus operator calculated according to the formula specified in (11) is 1.47. This result confirms the presence of economies of density and suggests that franchised monopoly, rather than side-by-side competition, is the most efficient form of production organization in the bus transport industry.

Economies of scale are defined as the increase in total cost resulting from an increase in output and in the network size, holding the factor prices constant, According to this definition, ES can be written as:

$$ES = \frac{1}{\frac{\partial \ln C}{\partial \ln y} + \frac{\partial \ln C}{\partial \ln NL}} \qquad (12)$$

The estimated economies of scale for the median bus operator calculated according to the formula specified in (5) is 1.28. This result confirms the presence of economies of scale and suggests that the consolidation of adjacent bus companies is likely to reduce costs.

3.2.Demand elasticities

This study uses the results from the static Random Effects model reported by Deb and Filippini (2008). From the log linear demand function specified in Deb and Filippini (2008) and the estimation results there, and using median values to characterize a representative consumer, the demand function can be expressed as the following[13]:

---

[13] The static demand function estimated using a Random Effects GLS approach in Deb and Filippini (2010)is the following:

$$\text{Ln}y = d + \alpha_p \text{Ln}p \tag{13}$$

Then, the following is the inverse demand function for a representative consumer that can be used to evaluate the different pricing regimes[14].

$$p = \left(y \cdot e^{-d} \right)^{1/\alpha_p} \tag{14}$$

Finally, for estimating changes in consumer surplus, the use of the Marshallian demand curve is appropriate, if and only if income effects are absent (Braeutigam (1989)). However, in empirical analyses, it is difficult to estimate and use a compensated or Hicksian demand curve. In addition, Willig (1976) shows that consumer surplus measures estimated from either of the demand schedules are similar in magnitude. Hence, the Marshallian demand curve is used for analysis in this research.

Using the demand curve given above,

$$CS(p) = \int_{p_1}^{p_0} e^d p^{\alpha_p} = \left. \frac{e^d p^{\alpha_p + 1}}{\alpha_p + 1} \right|_{p_1}^{p_0} \tag{15}$$

where $CS(\cdot)$ is the consumer surplus, evaluated in the interval $\{p_1, p_0\}$.

4. Pricing regimes

The optimal prices have been estimated using the cost function and the inverse demand function given above. This is a pair of non–linear equations in p and y. The three tariff regimes for single product monopolies described in section 2 are estimated. These are

---

$\text{Ln}y = \alpha_o + \alpha_p \text{Ln}p + \alpha_w \text{Ln}w + \alpha_q \text{Ln}q + \alpha_s \text{Lns} + \alpha_{pop} \text{Ln}pop + \alpha_{work} work + \alpha_{lit} lit + \varepsilon_t$

Now if the representative consumer is characterized by the median values of all variables, then let, $d = \alpha_o + \alpha_w \text{Ln}\overline{w} + \alpha_q \text{Ln}\overline{q} + \alpha_s \text{Ln}\overline{s} + \alpha_{pop} \text{Ln}\,\overline{pop} + \alpha_{work} \overline{work} + \alpha_{lit} \overline{lit}$, where. $\overline{x} = median(x)$. Then, substituting in the demand function, we obtain (13).

[14] From $\text{Ln}y = d + \alpha_p \text{Ln}p \;\; \therefore\; y = e^{d + \alpha_p \text{Ln}p} = e^d p^{\alpha_p}$ Thus $p = \left(y \cdot e^{-d} \right)^{1/\alpha_p}$

average cost pricing, marginal cost pricing, and a second best two–part tariff. For average cost pricing, the estimated price and quantity is the solution of the following system of equations:

$$\begin{cases} p_a = AC(y_a) = y_a^{\alpha_y + \alpha_{yy} - 1} e^{\alpha_0} \\ y_a = e^d p_a^{\alpha_p} \end{cases} \qquad (16)$$

For marginal cost pricing, the estimated price and quantity is the solution of the following system:

$$\begin{cases} p_m = MC(y_m) = \left(\alpha_y + \alpha_{yy} \mathrm{Ln} y_m\right) y_m^{\alpha_y + \alpha_{yy} - 1} e^{\alpha_0} \\ y_m = e^d p_m^{\alpha_p} \end{cases} \qquad (17)$$

In the case of two part tariffs, the pricing system can be described as following[15]:

$$\begin{cases} p_v = MC(y_m) = \left(\alpha_y + \alpha_{yy} \mathrm{Ln} y_m\right) y_m^{\alpha_y + \alpha_{yy} - 1} e^{\alpha_0} \\ p_F = \dfrac{y_m^{\alpha_y + \alpha_{yy}} e^{\alpha_0} - p_v y_m}{\overline{pax}} \\ y_m = e^d p_v^{\alpha_p} \end{cases} \qquad (18)$$

where $\overline{pax}$ is the median value of the number of passengers.

The results are presented in terms of equilibrium prices in rupees per passenger kilometers (rupees per passengers in the case of the fixed component of the two–part tariff), and quantities in terms of million passenger kilometers. For estimating the change in demand and consumer surplus, the current market price and quantity is required. However, the current market outcome is not a Walrasian equilibrium as defined by a market-clearing price such that public bus transit demand equals supply. In other words, the current market outcome can be described as a quantity constrained equilibrium where the market price and

[15] In case of the two–part tariff, the deficit of the firm is recovered by a lump sum transfer from the consumer to the firm, such that the reduction in consumer surplus is just enough to cover the losses of the firm.

quantity are exogenously given by the government. In our analysis, this market outcome is characterized by the median value for current output and the bus transit fare. Thus, the observed median values for output and the traffic revenue per passenger kilometer for the most recent year have been taken to reflect the current market outcome[16].

Finally, the reduction in loss is also presented. Efficiency gains from moving towards an efficient pricing regime are then obtained as a sum of the change in consumer surplus and the reduction in losses. All prices are presented in terms of 1989/90 rupees. As noted earlier, welfare changes due to financing using public revenues the current losses in public transport and those that would result in applying marginal cost pricing are ignored. Therefore, the welfare analysis only gives some directions of the potential changes.

Table 3 here.

Solving equations (16), (17), and (18), the equilibrium prices and quantities reported in Table 3 are obtained. From the regression results in Table 1, this industry is characterized by declining average costs and hence is a natural monopoly. Thus, the estimated equilibrium price is higher with average cost pricing than with marginal cost pricing. Average cost pricing calls for an increase in the public bus fares by more than 425% compared to the current median fare. The price increase required for marginal cost pricing is much more modest, about 72%. This is also reflected in the larger decrease in quantity that would come about from average cost pricing, compared to marginal cost pricing. It should be noted that this is the change with respect to the current supply level where the price and quantity are exogenously set. Nevertheless, with both average cost pricing and with marginal cost pricing, there is a significant decrease in quantity from the current levels. In the case of two–part tariffs, the equilibrium variable price and quantity is the same as in the case of marginal cost pricing. The fixed component is obtained in terms of rupees per passenger. Again, it is noted

[16] The median bus fare reported in 2004 was 0.135 rupees per passenger kilometer in 1989/90 prices. A low standard deviation of the bus fares in 2004 of only 0.040 indicates that this is quite representative of the bus fare charged by a representative firm.

here that the fixed price is similar to a lump sum tax, and does not influence consumption. Hence, a move towards efficient pricing would lead to a fall in public bus transit ridership, and this fall would likely lead to an increase in personal vehicles. This is clearly a cause for concern.

The change in consumer surplus also mirrors the change in prices. The much larger price increase required in the case of average cost pricing is reflected in the larger fall in the consumer surplus caused by the price increase. With public bus transit fares fixed such that all costs are recovered, the quantity consumed falls by more than 60% and the consumer surplus falls by nearly 35%. On the other hand, with marginal cost pricing, the fall in consumer surplus is just 7.5%. In general, the fall in consumer surplus is restrained by the inelastic demand for public bus transit in India where even a fall in demand of over 40% in the case of marginal cost pricing leads to only a 7.5% fall in consumer surplus. There is a substantial fall in the consumer surplus with the two–part tariff given the large transfer from consumers to the firms that is effected through the fixed price.

For the firms, average cost pricing and two–part tariffs lead to zero profits by design. Again, given the natural monopoly characteristics of the firms, marginal cost pricing leads to losses, due to falling average costs. Nevertheless, with efficient pricing, the change in profits is always positive. Since marginal cost pricing leads to some losses, the change in profits is greater in the case of average cost pricing and two–part tariffs.

Finally, summing the change in consumer surplus and losses gives the gains brought about by to efficient pricing. As is expected, these gains are positive in the case of marginal cost pricing and two–part tariffs based on marginal costs. Since average cost pricing is not motivated by efficiency and only by cost recovery, efficiency gains are negative here. This is in large measure due to the loss of consumer surplus from the large fare increase required in the case of average cost pricing. In addition, efficient pricing implies a fall in consumer surplus and a rise in profits. Thus, distributional issues arising from efficient pricing could be significant. Recalling that non–price attributes, such as access to public transport networks have a much larger impact on travel demand as reported in Deb and Filippini (2008), the role of efficient pricing in meeting policy objectives other than economic efficiency is limited. Hence, it is important to recognize the limitations of a pricing policy that focuses solely on economic efficiency, while addressing the mobility and other developmental concerns in a developing economy. Moreover, since the rise in bus fares would likely lead to a shift towards personal vehicles, these efficiency gains would need to be compared to the additional costs due to higher personal vehicle usage such as higher emissions and congestion.

5. Conclusions

This paper estimates three different pricing regimes for public bus transit in India in a partial equilibrium framework, and their impact in terms of changes in demand and consumer surplus. The pricing strategies focus on both economic efficiency as well as revenue adequacy. Three tariff regimes are estimated, namely average cost pricing, marginal cost pricing, and a second best two–part tariff. While average cost pricing and the two–part tariff ensure complete cost recovery, marginal cost pricing could lead to losses in the presence of Economies of Scale. In addition, this study provides empirical evidence of the presence of economies of scale in the Indian bus sector.

The price regimes have been estimated using the cost function obtained from the estimation in section 3.1 and the aggregate demand function estimated in Deb and Filippini (2008). This is a pair of non–linear equations in price and quantity. By solving these equations, equilibrium prices and quantities are obtained. With all three pricing regimes, there is a significant decrease in quantity from the current levels.

Since the industry is characterized as a natural monopoly, the estimated equilibrium price is higher with average cost pricing than with marginal cost pricing. Conversely, the fall in quantity that would come about from average cost pricing is larger compared to marginal cost pricing. Two–part tariffs lead to the same equilibrium quantity and variable price as in the case with marginal cost pricing. In addition, the change in consumer surplus also mirrors the change in prices with a much larger fall in the consumer surplus in average cost pricing compared to marginal cost pricing. For the firms, average cost pricing and two–part tariffs lead to zero profits by design. However, due to the natural monopoly characteristics of the firms, marginal cost pricing leads to losses due to falling average costs. Importantly, a significant efficiency gain is obtained from marginal cost pricing and two–part tariffs.

Hence, in the context of optimal pricing by a natural monopoly firm in the public bus transit industry in India, a move to efficient pricing has significant economic gains. However, as discussed earlier, an optimal pricing regime based on marginal costs of service delivery may not lead to socially optimal prices and outcomes. In particular, external and user costs in the transit sector need to be accounted for while estimating marginal social costs. In addition, prices of services that are substitutes or compliments to public bus transit should also be at their marginal cost levels. Moreover, the fall in public bus demand that results from price increases in the three regimes discussed above could lead to, a higher modal share of personal vehicles. In such a scenario, external costs due to higher emissions and increased congestion could become significant.

The pricing analysis in this paper demonstrates the impact that efficient pricing strategies would have on public bus transit demand in India. It also highlights the fall in demand and consumer surplus that would come about from such pricing policies. Given the mobility needs and the developmental concerns of a growing economy such as India, the challenge for policy makers is balance the gains in economic efficiency in the public bus transit sector against other social, political, and developmental goals. It may be noted, however, that the restrictive condition for first best pricing and issues in financing deficits of bus companies from the general budget imply that the welfare impacts estimated here only indicate the direction of change in case of policy reforms that focus on bus fares.

Finally, the pricing regimes estimated in this research are limited to a partial analysis for a representative firm in the public bus transport industry. A more comprehensive exercise based on total social costs of all modes of transport would reveal changes in prices and taxes required for all modes in the transport sector, such that net social benefits are maximized. In particular, with estimates of marginal social costs that include external and user costs for all passenger transport modes, optimal pricing could then take into account the possibility of price discrimination across modes and hence increase net social benefits. Further, enforcing optimal pricing could be done either through direct regulation of public bus transit fares or other regulatory approaches such as yardstick regulation or franchise auctions. The performance of these alternative regulatory strategies should be assessed to ensure that an appropriate regulatory framework is put in place.

6. References

Baltagi, B. H. (2002). Econometric Analysis of Panel Data. New York, John Wiley.

Baumol, W. J. and D. F. Bradford (1970). Optimal Departures from Marginal Cost Pricing. American Economic Review. **60 (3):** 265–83.

Berg, S. V. and a. J. Tschirhart (1988). Natural Monopoly Regulation: Principles and Practices. Cambridge, Cambridge University Press.

Berg, S. V. and J. Tschirhart (1988). Natural Monopoly Regulation: Principles and Practices. Cambridge, Cambridge University Press.

Bos, D. (1986). Public Enterprise Economics: Theory and Application. Amsterdam & New York, North-Holland.

Braeutigam, R. R. (1979). Optimal Pricing in the Intermodal Competition. American Economic Review. **69:** 38–49.

Braeutigam, R. R. (1984). "Socially Optimal Pricing with Rivalry and Economies of Scale." The RAND Journal of Economics **15**(1): 127-134.

Braeutigam, R. R. (1989). Optimal policies for natural monopolies. Handbook of Industrial Organization. R. Schmalensee and R. D. Willig, Elsevier**:** 1289-1346.

Cameron, A. C. and P. K. Trivedi (2005). Microeconometrics: Methods and Applications. New York, Cambridge University Press.

Caves, D. W., L. R. Christensen, et al. (1984). "Economies of Density versus Economies of Scale: Why Trunk and Local Service Airline Costs Differ." RAND Journal of Economics **15**(4): 471–489.

Cervero, R. (1990). "Transit pricing research: A review and synthesis." Transportation **17**(2): 117-139.

Christensen, L. R., D. W. Jorgenson, et al. (1973). "Transcendental Logarithmic Production Frontiers." The Review of Economics and Statistics **55**(1): 28–45.

CIRT (Various years). State Transport Undertakings: Profile and Performance. Pune, Central Institute of Road Transport.

Costa, A. (1998). Public Transport Efficiency and Effectiveness: Metro de Madrid. Transport Networks in Europe: Concepts, analysis and policies. K. Button, P. Nijkamp and H. Priemus, Edward Elgar**:** 248–263.

Deb, K. (2008). Efficiency, demand, and pricing of public bus transport in India. Department of Management, Technology, and Economics. Zurich, Eidgenössische Technische Hochschule. **D.Sc.:** 127.

Deb, K. and M. Filippini (2008). Public bus transport demand elasticities in India. Zurich, Centre for Energy Policy and Economics, ETH.

Deb, K. and M. Filippini (2010). Public bus transport demand elasticities in India. Working Paper. Lugano, Quaderni della facoltà di Scienze economiche dell'Università di Lugano.
European Commission (2000). Pricing European Transport Systems. Brussels, European Commission.
Farsi, M., A. Fetz, et al. (2007). "Economies of scale and scope in local public transportation." Journal of Transport Economics and Policy **41**(3).
Farsi, M., M. Filippini, et al. (2006). "Cost Efficiency in Regional Bus Companies: An Application of Alternative Stochastic Frontier Models." Journal of Transport Economics and Policy **40**(1): 95–118.
Filippini, M. and P. Prioni (2003). "The influence of ownership on the cost of bus service provision in Switzerland–an empirical illustration." Applied Economics **35**(6): 683–690.
Garcia, S. and A. Reynaud (2004). Estimating the benefits of efficient water pricing in France. Resource and Energy Economics. **26:** 1–25.
Gómez-Ibáñez, J. A. (1999). Pricing. Essays in Transportation Economics and Policy: A Handbook in Honor of John R. Meyer. J. A. Gómez-Ibáñez, C. A. Winston and W. B. Tye. Washington, DC, The Brookings Institution Press**:** 99-136.
Government of India (2005). Economic Survey 2004/2005. New Delhi, Ministry of Finance, Government of India.
Gowda, J. M. (1999). "Implications of Concessional Travel Facility on the Commercial Viability of SRTCs in India." Indian Journal of Transport Management: 149-157.
Greene, W. H. (2003). Econometric Analysis. New Jersey, Prentice Hall.
Justus, E. R. (1998). "Operational Efficiency in Public Passenger Road Transport-A Criteria Analysis." Indian Journal of Transport Management: 573-577.
Kadam, V. A. (1999). "A Diagnostic Study of Viability of STUs." Indian Journal of Transport Management: 501-508.
Kahn, A. E. (1970). The Economics of Regulation: Principles and Institutions. Cambridge, MIT Press.
Lipsey, R. G. and K. Lancaster (1956). "The General Theory of Second Best." The Review of Economic Studies **24**(1): 11-32.
Loeb, M. and W. A. Magat (1979). "A Decentralized Method for Utility Regulation." Journal of Law and Economics **22**(2): 399-404.
Maunder, D. A. C. (1984). Trip rates and travel patterns in Delhi, India. Transport and Road Research Laboratory Research Report 1. Crowthorne, Transport and Road Research Laboratory**:** 24.
Nash, C. (2003). "Marginal cost and other pricing principles for user charging in transport: a comment." Transport Policy **10**(4): 345-348.
Naughton, M. C. (1986). The Efficiency and Equity Consequences of Two Part Tariffs in Electricity Pricing. Review of Economics and Statistics. **68:** 406–414.
Ng, Y.-K. and M. Weisser (1974). "Optimal Pricing with a Budget Constraint--The Case of the Two-part Tariff." The Review of Economic Studies **41**(3): 337-345.
Obeng, K. (1983). "Fare Subsidies to Achieve Pareto Optimality–A Benefit Cost Approach." Logistics and Transportation Review **19**(4): 367–84.
Obeng, K. (2000). "Expense preference behavior in public transit systems." Transportation Research Part E: Logistics and Transportation Review **36**(4): 249–265.
Planning Commission (2002). 10th Five Year Plan (2002-2007) - Volume II: Sectoral Policies and Programmes. New Delhi, Planning Commission, Government of India.
Rothengatter, W. (2003). "How good is first best? Marginal cost and other pricing principles for user charging in transport." Transport Policy **10**(2): 121-130.
White, P. R. (1981). "Recent Developments In the Pricing of Local Public Transportation Services." Transport Reviews **1**(2): 127-50.
Willig, R. D. (1976). "Consumer's Surplus Without Apology." The American Economic Review **66**(4): 589-597.
Willig, R. D. (1978). "Pareto-Superior Nonlinear Outlay Schedules." The Bell Journal of Economics **9**(1): 56-69.

Table 1. Variables in cost function estimation*

Definition	Units		Mean	Standard Deviation	Minimum	Maximum
Total Cost	10^5 Rupees per annum	overall	14,571.33	22,484.98	76.16	117,758.50
		between		20,363.89		
		within		4,256.39		
Passenger km (y)	10^5 km	overall	101,811.20	149,807.60	94.00	765,269.00
		between		137,439.30		
		within		21,244.03		
Labour price(Pl) = Labour cost / Total staff	10^5 Rupees per annum	overall	0.31	0.09	0.03	0.66
		between		0.07		
		within		0.06		
Energy price (Pf) = Diesel cost / Diesel consumed	10^5 Rupees per annum	overall	0.04	0.02	0.00	0.26
		between		0.02		
		within		0.01		
Capital price (Pk) = Residual cost / Average buses held	10^5 Rupees per annum	overall	2.32	0.92	0.17	6.60
		between		0.79		
		within		0.53		
		between		3,494.00		
		within		711.42		
Load Factor (LF) = Passenger km / Seat km	%	overall	68.62	12.61	16.55	128.57
		between		10.11		
		within		8.17		
Network Length (NL) = Total routes × Average route length	Kilometers	overall	179,727.00	363,351.70	100.08	2,719,122.00
		between		277,775.50		
		within		166,662.60		
		between		0.06		
		within		0.06		

* Area of operation (AR_i) and Management type (MG_i) are included as dummy variables

Table 2. Random Effects first order regression results

	Coefficient	Standard Error
Total cost		
Constant	–0.832	9.997
y	0.650***	0.030
Fuel price	0.182**	0.071
Labour price	0.574***	0.067
*y*y*	0.359***	0.029
Fuel price Fuel price*	–0.175	0.137
Labour price Labour price*	0.200	0.108
*y*Labour price*	–0.118*	0.048
*y*fuel price*	0.164	0.058
Labour price fuel price*	0.069	0.113
time	0.001	0.005
Load factor	–0.365**	0.121
Load factor Load factor*	0.300	0.629
y Load factor*	–0.558***	0.066
Labour price Load factor*	0.200	0.293
Fuel price Load factor*	–0.338	0.244
Network length	0.132***	0.030
Network length Network length*	0.037	0.013
*yf*Network length*	–0.106***	0.021
*Labour price*Network length*	0.112*	0.060
*Fuel price*Network length*	–0.101	0.044
*Load factor *Network length*	0.293***	0.060
Mixed (AR1)	–0.599***	0.145
Hilly(AR2)	–1.324***	0.216
Company(MG1)	0.612*	0.252
Municipal Undertaking(AR2)	0.626*	0.286
Corporation(MG3)	0.881***	0.245

*Variables significant at 95% confidence level, **Variables significant at 99% confidence level, ***Variables significant at 99.9% confidence level

Table 3. Pricing regimes for public bus transit in India#

Pricing regime	Price (Rs per pkm)		Quantity (10^5 pkm)	Change in demand	Change in Consumer Surplus	Reduction in Loss	Efficiency gain
Current market*	0.135		11,493.580	–	–	–	–
Average cost pricing	0.709		4,571.527	–60.23%	–33,017.406	27,982.136	–5,035.270
Marginal cost pricing	0.232		6,795.726	–40.87%	–7.164.625	9,571.812	2,407.180
Two–part tariff	Fixed	Variable	6,795.726	–40.87%	–25,578.880	27,982.136	2,407.180
	3.080	0.232					

#Price estimates were also obtained for varying network structures with network lengths at 25th and 75th percentile, apart from the results at the median network length reported above. These results were similar to the ones reported here in terms of the direction of change in consumer surplus, profits, and efficiency gains, and are hence not presented here.

* Median output and public bus fare.