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FORTIFYING A DEVELOPING PUBLIC TRANSPORT SYSTEM: A PURSUIT FOR THE OPTIMAL PRICE IN THE PHILIPPINE LIGHT RAIL TRANSIT

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Abstract: The Light Rail Transit (LRT) serves as mass transport system where it is assumed to be priced optimally and efficiently. However, its financial statements had been continually reporting massive losses from its operations such that it failed to recover its investments during the allotted time and hindered it from fully expanding its services. Using a 25-year consolidated annual data, we used a time series regression to estimate the demand, cost and production function, where we arrived at the optimal fare price using the Ramsey pricing theory. This study then enabled us to identify the different price levels, which would cover the operating costs and the additional amount for the debt payment. We then examined our proposed price against the reported price set by the LRTA, where we justified the price hike for the LRT fares. This study can contribute to a more transparent reasoning for the price hike, where commuters can distinguish the components for the drastic price increase.

Keywords: Rail Transit; Ramsey Price; Time Series Regression; Philippines

1. INTRODUCTION

Background of the Study

The LRT is an electric-based mass public transportation system that was established in 1980 to decrease the congestion in the roads of Metro Manila; particularly for the cities of Manila, Quezon, Pasig, San Juan, Pasay, Caloocan, and Marikina. It was set to provide an affordable public transport system and not serve as a profit-center business. 27 years since it started its operations, the government had continually provided subsidies to cover the costs not reflected in the prevailing fares. The increasing operational costs did not correspond with the fares as it had only implemented six price hikes since its establishment. From the year 2003 up to the present, the LRT ticket is priced at PHP 15.00, and this reflected a 10% drop in passenger traffic from the previous rate of PHP 10.00.

Research Problem and Objectives

Based from the aforementioned information on the rail transit, we ask, what is the optimal price for the LRT fares? As the government seeks to improve LRT's operational efficiency, it needs to consider the methods as to how commuters are charged for its public transport services. In line with this, the following are the objectives of the study:

- ❖ To determine and examine the production structure of the LRT in terms of passenger count with respect to labor and fixed cost.
- ❖ To examine the total cost of the operations of the LRT and trace the changes in the price of the LRT tickets.
- ❖ To estimate an optimal price per passenger that would be able to compensate for its operating costs.
- ❖ To analyze the sensitivity of the passenger volume with respect to changes in price.
- ❖ To provide a policy recommendation on how LRT can improve its pricing mechanism and services.

Cost Estimation Method

Cost estimation is necessary in order to get the optimal price since it serves as the basis for most pricing

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methods. Several studies have shown different techniques in estimating the cost function. Such are the accounting method of estimation, the econometric method of estimation, and the engineering method of estimation. For our study, the most applicable method of cost estimation is the econometric method. According to a study by Ben-Akiva (2008), in order to estimate the cost function, a regression will be performed to arrive at a Cobb Douglas production function which is useful in deriving the cost function.

Rail Pricing

According to a study conducted by Daniel Van Duuren (2002) about optimal pricing in Netherlands rail transit and his main objective is to be able to establish the relationship or connection between the optimal pricing theory, price elasticity of demand and marginal cost estimates. The study incorporated the Ramsey pricing methodology where the firm will want to maximize its profits. He used two methods in measuring the optimal price, the profit maximizing and the second best optimal pricing which is also called as the Ramsey pricing. After conducting the required processes, there were three main conclusions that were highlighted. First, the second best pricing is more appropriate than the alternate. Second, the profit maximization is a better method to implement for the off-peak hours. Lastly, imposing tariffs on different distance according to the track will allow the firm to realize more profit while improving the total welfare of the consumers.

Regulatory Pricing

Being a public good, LRT should be priced at a level where the people are willing to pay. With that, the government has imposed certain laws that regulate the price of the LRT rides. According to Ronda (2011), an increase in the fare rates will give the public social unrest. Hence, the government, in favoring its constituents with socially beneficial services, did not withdraw the eight billion pesos worth of subsidies to the LRT. According to a study of Philippine Institute for Development Studies (PIDS) (2010), the government should invest in giving the lowest subsidy possible in such a way that they investigate the consumers' level of willingness to pay. They should be able to propose the right fare level to the consumers, where it is deemed appropriate such that people will accept it and not affect their ridership. Also, the subsidies given should always advocate the improvement of LRT's services and infrastructure. Thus, in the Philippines' rail system, the prices should be regulated but not heavily subsidized. However, the large amount of subsidy might decrease the efficiency of the LRT, so that it is absolutely necessary for the budget to be spent responsibly, honestly, wisely, properly, and not be squandered.

2. METHODOLOGY

In order to construct the final production function, the variables Labor, Capital, Fare Prices, and Passenger Count as a basis for our study. But before regressing, the data were expressed at real terms where the variables Labor, Capital, and Fare Prices are divided by the consumer price index at 2000 base price. Afterwards, there will be regression of two 25-year time series data from years 1985 to 2010. The first regression is intended to get the price elasticity of demand where the log-log model will be utilized. The regression model used is:

$$\ln X = \ln dx (Px) \tag{Eq. 1}$$

where:

- X = passenger count
- P_x = fare prices

But before regressing, we will first look at the time series plot, conduct the Augmented Dickey-Fuller stationary tests, and then regress at the level of differenced while considering the robustness test. The coefficient that we will obtain from the regression serves as the value for the price elasticity of demand. After obtaining the

elasticity component, we then got the marginal cost component where we first derive the Cobb Douglas production function which is:

$$Q = AL^\alpha K^\beta \quad (\text{Eq. 2})$$

where:

Q	=	passenger count
L	=	labor component
K	=	capital component
A, α	=	parameters representing the factor share of inputs

In order to obtain the parameters, we will regress a log-log model which converted our equation as such:

$$\ln Q = A + \alpha \ln L + \beta \ln K \quad (\text{Eq. 3})$$

The coefficients that will be obtained from running the regression of the above model will serve as the parameters for A, α and in the Cobb Douglas production function. By the duality theory, we will obtain the cost function by substituting the derived production function in the Lagrangian function as shown below:

$$\mathcal{L} = wL + rK + \lambda(Q - AL^\alpha K^\beta) \quad (\text{Eq. 4})$$

From the Lagrangian function, we take the first order condition (FOC) to arrive with the labor (L) and capital (K) functions in terms of passenger count (Q), which will then be substituted into equation 4.8.

FOC:

$$\frac{\partial \mathcal{L}}{\partial L} = w + \lambda [-A\alpha L^{\alpha-1} K^\beta] = 0 \quad (\text{Eq. 5})$$

$$\frac{\partial \mathcal{L}}{\partial K} = r + \lambda [-A\beta L^\alpha K^{\beta-1}] = 0 \quad (\text{Eq. 6})$$

$$\frac{\partial \mathcal{L}}{\partial \lambda} = Q - AL^\alpha K^\beta = 0 \quad (\text{Eq. 7})$$

The Lagrangian function will allow us to determine the coefficients of capital and labor as a function of passenger Q where both will be substituted to the linear cost function:

$$C = wL(Q) + rK(Q) \quad (\text{Eq. 8})$$

After substituting, we may obtain the marginal cost (MC) by taking the derivative of the cost function in terms of Q . To show,

$$MC = \frac{\partial C(Q)}{\partial Q} \quad (\text{Eq. 9})$$

Finally, the Ramsey price can be computed below:

$$P = MC \left(1 + \frac{1}{\epsilon_p} \right)^{-1} \quad (\text{Eq. 10})$$

Since we now have the values for the price elasticity of demand, and the marginal cost, we now plug those



values in the equation, and through that, we have obtained the Ramsey price which is also the socially optimal price.

3. RESULTS AND DISCUSSION

For the past 25 years of operation of the LRT, the passenger count, capital and labor inputs significantly increased over time. It is important to note that, LRT's number of commuters drastically increased by 86 million in 25 years from a base level of 70 million in 1985 to a booming 156 million in 2010. This shows that over the years, people in the metro have relied heavily on public transport. In fact, in 2010, the LRT carries approximately 32,000 passengers per hour.

Factor inputs had also significantly increased over time. But it is rather obvious that the increase in capital is greater than the increase in labor. This is due to LRTA's investments on equipment for operations like trains, automated ticketing systems and infrastructures. The increase can also be attributed to the expansion projects and maintenance facilities that LRT had undertaken. Such projects include the extension of the Line 1 rail system and the construction of the Line 2 rail system.

The Ramsey Price

The first step in determining the LRT's Ramsey price was to find the elasticity component in the pricing model. It was pooled by conducting a regression between annual values of passenger count and price. The elasticity's computed value was -0.0295, which reflected an inelastic demand. This inelastic demand indicated that the consumers were not price sensitive. Thus, for every 1% increase in price, quantity decreased by 0.0295%. Though the demand was deemed inelastic, it is interesting to note that the elasticity represented a very a low value of -0.0295%. This means that the number of passenger traffic would not vary much, if the LRT would impose a change in its fares.

Another component of the Ramsey formula is the marginal cost. To arrive at this value, a Cobb Douglas production was estimated as shown below

$$Q = 4.4219 L^{0.3608} K^{0.0035} \quad (5.1)$$

By virtue of the duality theory, the production function was converted to a corresponding cost function expressed as

$$C = 0.0179 Q^{2.7450} r^{0.0096} w^{0.9904} \quad (5.2)$$

We take the derivative of this function to arrive at the marginal cost, and finally, this value was substituted together with the elasticity in the Ramsey price formula.

By this, we were able to get PHP 23.7857, which is the price per passenger per trip from Baclaran to Monumento. It is important to note that this price does not account for subsidy and debt. This means that this price solely covers the operational costs of the LRT. This price represents the base price that has to be charged to consumers. If not, the rail firm will incur losses as a price lower than this level will not be able to sufficiently cover for the operational costs of LRT.



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The PHP 24 price level reflects the socially optimal price for both the LRTA and the passengers. On one side, this price is acceptable to consumers because for approximately the same distance travelled, the price of LRT, buses and jeepneys are now comparable. This price is relatively higher than the ones charged by buses and jeepneys but this can be justified by the convenience and faster service provided by LRT. On the other end, the LRTA can also accept this price because it would enable the rail firm to sufficiently cover its operating costs

Ramsey Method vs. Arithmetic Method

As a basis of comparison, we used the arithmetic method to compute for a price that LRT can charge its passengers. The arithmetic method involves simple costing method where the average cost is set as the optimal price. In economics, pricing at average cost is called as break even pricing. This price is computed by getting the ratio of total cost to the total number of passengers. The computed breakeven price of LRT for the year 2010 was PHP 12.24 while the Ramsey price was PHP 23.79. Since the results were based on 2010 prices, we adjusted for inflation for 2011 and 2012, and we computed a price of PHP13.17. Essentially, the 2012 price is PHP14. If we compare the breakeven price to the Ramsey price, the breakeven price is more than half as much as the Ramsey price. This price is too small because it only considered total costs while the latter considered capital or fixed assets because it used the Cobb-Douglas production function. As a result of the comparison, we can say that the Ramsey price is a better measure compared to the breakeven price because the LRT relies heavily on fixed assets, which is why it is important to take into account the cost of capital. The cost of capital was considered in the Ramsey price as evidenced by the use of the Cobb-Douglas production in deriving the cost function.

We have also extended our study with the inclusion of debt in the fare prices. We used the 2010 borrowing rate of 3%, and the loan period of 40 years in amortizing their 2010 debt of PHP 62.8 Billion. We used a period of 40 years in order for the LRTA to have ample time to repay their debt given that huge amount. Given these assumptions, we used the annual payment as the measure of the cost of debt divided by the average number of passengers of LRT. Doing those steps allowed us to arrive at the computed cost of debt per passenger of PHP 18. Adding this to the computed Ramsey price of PHP 24 for 2012, we came up with the total price of PHP 42. Adjusting this price to inflation for 2011 and 2012, we arrive at a price of PHP 46. This price represents the LRT's operating costs, and cost of debt.

To draw further insights into the cost of debt and its effects on the rail fare price, we manipulated the loan period and investigated how price changes.

Table 5.2
Effect of Varying Loan Period on Prices

Loan Period in Years	Cost of Debt per Passenger*	Ramsey Price*	Total Price*	2011 Prices**	2012 Prices**
10	47	24	71	75	78
20	27	24	51	54	56
30	20	24	44	46	48
40	18	24	42	44	46

*in PHP; at 2010 constant prices

** Adjusted for inflation; : 2011 = 4.4%, 2012 = 3.1%

As shown in the results, as the loan period prolongs, the total price to be charged to a consumer increases at a decreasing rate. From an initial difference of PHP 22, it went down to PHP 8, until it reaches PHP 2. Hence, we assumed 40 years to be the optimal loan period since prolonging the years more will not have a significant decrease to the price of PHP 46. It is better to charge at this level and be able to pay earlier rather than prolonging it without having a drastic or relevant change in the price.

We also investigated how prices will change interest rates move from 3% to 1.5% with a 0.5% difference in each level. The results are summarized in the table below:

Table 5.3
Effects of Varying Interest Rates on Prices

Interest Rate	Cost of Debt*	Ramsey Price*	Total Price*	2011 Prices**	2012 Prices**
3.0%	18	24	42	44	46
2.5%	16	24	40	42	44
2.0%	15	24	39	41	43
1.5%	14	24	38	40	42

*in PHP; at 2010 constant prices

** Adjusted for inflation; : 2011 = 4.4%, 2012 = 3.1%

The results imply that as interest rates move up from 1.5% to 3%, the fare price per passenger also increases. This is intuitive since as the interest rate increases, interest payment also increases, the cost of debt per passenger increases, and therefore, the price per passenger also increases. This only shows that interest rates can significantly affect rail prices especially when the cost of debt is considered. By this, the LRTA should repay its loans, which have floating base rates, when interest rates are low.

4. CONCLUSIONS

Based on the objectives that were formulated at the start of this study, we can draw several conclusions.

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First, we have drawn a Cobb-Douglas production function for the LRT, which accounted for both labor and capital. Second, the Cobb Douglas function was used to estimate the total cost of the LRT. Given the cost function derived we determined that the increase in cost should correspond to an increase in prices. Third, after deriving the cost function we have estimated an optimal price per passenger, which is PHP24 for the LRT using the Ramsey pricing. The Ramsey pricing was used to determine the optimal price at breakeven while considering the price elasticity of demand and marginal cost. We also compared the Ramsey price formula to the arithmetic way of solving the breakeven price, which resulted to PHP14 only. We could say that Ramsey price is better because the model accounted for capital and price elasticity of demand. Fourth, we analyzed the sensitivity of the passengers against the changes in prices. We have seen that as number of passengers increased the price per passenger would increase to account for the cost it would incur because of the increase in passengers. Lastly, we recommended some policies for the LRT in order for them to improve services and pricing mechanism. We recommended that the LRT increase their fare prices to PHP 42 in order for them to pay total operating costs and to allot PHP 18 per passenger to pay off their debt in a span of 40 years. Another recommendation is that now that the subsidy would be lessened because they are charging a higher price, they could also allocate it in different avenues, which will be further discussed below.

LRT's fare is currently priced at PHP 15 per trip. This price proved that LRT operates at a loss and is dependent with the government subsidies. This is supported with the computed price of PHP 24 which only covers the operating cost and the current price of PHP 15 only shows that they are charging a price even below their minimum operating cost. With that in mind, our result is consistent with LRT's proposal of a price hike. But, without considering the debt and assuming that their proposed price covers the operating costs, LRT's proposed price hike is PHP 6 higher than our computed one. But, assuming that the proposed price of PHP 30 includes the debt payment and all the cost that LRT incurs, we will need to compare this with our computed price with debt. Including an amortized debt payment into the fare price, the estimated price would become PHP 46, where a decrease in debt level could ultimately lead to lower fare prices as it strives to improve its operations and costing. An incremental charge for the payment of debt would also benefit the transport system in the long run, as it would have a good credit rating, thus, the opportunity for expansion projects and improvement of its services. From the currently proposed price hike to PHP 30, it is evident that our recomputed price is higher by 53%, wherein the PHP 16 difference might be the current subsidy per passenger from the government. According to Montecillo (2012), Congress is expected to cut the budget for LRT subsidies which will take effect by the year 2013. In essence, the computed price and proposed price both move in the same direction which requires an increase in the price of services charged to the public. Given that our assumptions hold true, the proposed price hike is justified from the findings of our study.

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6. REFERENCES

- Ableson, P. (2001). *Pricing Public Services*. Retrieved from Applied Economics: http://www.applieconomics.com.au/pubs/papers/pa01_services.htm
- Association, A. U. (2007, November 30). *Towards a Light Rail Transit Program*. Retrieved from AUMA: http://www.auma.ca/live/digitalAssets/15/15563_12112007Light_Rail_Transit.pdf
- Alivelu, G. (2007). The estimation of Indian railway cost function. *Zagreb international review of economics and business*, 10(1), 11-32. Retrieved from <http://ideas.repec.org/a/zag/zirebs/v10y2007i1p11-32.html>



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- Analysis on Cost of Urban Rail Transit. (n.d.). *ScienceDirect*. Retrieved June 27, 2012, from www.sciencedirect.com/science/article/pii/S1570667211601906
- Besanko, D. And R. Braeutigam, *Microeconomics*, 3rd ed., NJ: John Wiley & Sons, 2007.
- Bitzan, J (2000). *Railroad Cost Conditions: Implications for policy* Paper prepared for the Federal Railroad Administration, US Dept of Transportation May 2000.
- Boncocan, Karen. "MRT, LRT fare hike is wrong says Solon | Inquirer News." *Inquirer News | Latest Philippine News for Filipinos*. N.p., 24 Aug. 2012. Web. 14 Nov. 2012. <<http://newsinfo.inquirer.net/257084/mrt-lrt-fare-hike-is-wrong-says-solon>>.
- Cost structure and productivity growth of the Taiwan Railway. (n.d.). *ScienceDirect*. Retrieved June 27, 2012, from www.sciencedirect.com/science/article/pii/S1366554505000104
- De Borger, Bruno, Inge Mayeres, Stef Proost, and Sandra Wouters. "Optimal Pricing of Urban Passenger Transport." *Transport Economics and Policy* 1 (1995): 31-33.
- De Villemeur, E. B. (2005). Optimal price and frequency on the railway. *IDEI & GREMAQ*, 1-23.
- Design of a rail transit line for profit maximization in a linear transportation corridor. (n.d.). *ScienceDirect*. Retrieved June 27, 2012, from www.sciencedirect.com/science/article/pii/S1366554511000627
- Graham, D., Couto, A., Adeney, W., & Glaister, S. (2003). Economies of scale and density in urban rail transport: effects on productivity. *Transportation Research , Part E*, 443-458. Retrieved June 22, 2012, from www.elsevier.com
- Goldman, S. (n.d.). *Economics 101 A Lecture Notes on The Profit Function*. Retrieved July 10, 2012, from Berkeley: <http://emlab.berkeley.edu/~goldman/101a/profit.pdf>
- Montecillo, Paolo G.. "MRT, LRT fare hike to take effect in 2013—DoTC | Inquirer Business." *Inquirer Business | Philippine News for Filipinos*. N.p., 19 Sept. 2012. Web. 14 Nov. 2012. <<http://business.inquirer.net/82878/mrt-lrt-fare-hike-to-take-effect-in-2013-dotc>>.
- O'Sullivan, A. (2007). *Urban Economics*. In *Mass Transit* (pp. 235-254). Singapore: McGraw-Hill International.
- Parry, I. W., & Small, K. A. (2007). *Should Urban Transit. Resources for the Future*, 7-38.
- Tae, Hoon Oum, and Michael W. Tretheway. "Ramsey Pricing in the Presence of Externality Cost." *Transport*