Formulation of a Methodology for Land Transport Costing and Pricing

Pavithra KUMARI\textsuperscript{a}, Amal S. KUMARAGE\textsuperscript{b}

\textsuperscript{a, b}Dept. of Transport and Logistics Management, University of Moratuwa, Moratuwa, Sri Lanka
\textsuperscript{a}E-mail: paviitrakumari@gmail.com
\textsuperscript{b}E-mail: amalk@uom.lk

Abstract: The land transport sector has direct cost inputs as well as intangible costs arising from traffic congestion, delays and etc. In addition most governments’ tax transport inputs and provide subsidies for some operations. Such interventions also affect pricing and encourages development of one mode of transport over another. Better understanding of transport pricing functionalities can lead to improved policies of taxation and subsidies.

This research identifies different transport input costs, types of taxes and subsidies commonly observed in transport pricing. It also identified the tangible and intangible costs and discusses how they can be included in the estimation of overall cost of mobility. The methodology allows the computation of overall cost of mobility of any given community as well as the cost for each mode of transport which will enable policy makers to influence the supply of the respective modes of transport towards reaching a lower overall cost of mobility.

Keywords: internal costs, external costs, cost bearers, pricing policy instruments, total costs of transportation, transport taxes, transport subsidies

1. INTRODUCTION

Transportation is the physical movement of an entity from its origin to the destination over time. The land transport sector is complex and desired mobility levels are often not achieved, resulting in external costs such as time loss, waste of resources, accidents and environmental degradation. In most cities especially in developing countries, the average vehicle speed is decreasing, door to door travel times increasing with the growth of the private vehicle population and the inability to keep up the provision of road space.

Demand and supply of transportation is governed by the price. Different countries adopt different transport pricing policies based on their level of understanding on how the transport sectors works, fiscal issues and other issues such as encouraging private provision of transport supply, environment and affordability. Transport price setting mainly depends on a threefold criteria; cost, competition and demand. Based on above as a single criterion or as a combination of criterion taxes and subsidies are used to manipulate the price setting to provide relief as a measure of social welfare or to encourage private investment. The most widely found pricing policies can be categorized as shown in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Widely used Transport Pricing Policies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost based pricing</td>
</tr>
</tbody>
</table>
Demand based pricing - is based on the demand and the price that is offered by the consumer.

Competition based pricing - is where the price is fixed based on competitors’ prices

Other types
- is where a subsidy is included to achieve welfare based objectives
- is where taxes over and above costs are levied in order to gather revenue to government or to influence a change in use.

Pricing policies would determine how the mobility costs of the movement of an entity such as a passenger or freight is met. The total cost may be met by different stakeholders. In the most general terms it is split between direct users and non-users. The latter being those who are affected by the travel or travel choice of another. This includes different external costs imposed by a user on a non-user. It also includes subsidies. In the case where a Government may impose taxes on transport, a user may be required to contribute towards other road users where cross subsidies may be imposed or to the Treasury for general expenditure. Identification of the party bearing such cost is very important in order to establish the amount and equitability of the system.

Currently, only few attempts have been made to estimate the total costs of land transportation. In most instances different cost components such as cost of congestion, cost of investment, cost of subsidies, operating cost, cost of accidents etc may be estimated from time to time. A comprehensive analysis on pricing policies is a yet unfilled space and a methodology for computing such costs will be a foundation for future research to develop detailed cost models and equations for different contexts.

The objective of the research includes identifying (a) the transport related cost components, (b) the different pricing policy instruments applied for transport and (c) the different parties who bear different components of the transport costs. The identification is based on the study of the land transport sector in Sri Lanka. It does not study sub sectors such as urban, rural or semi-urban.

2. LITERATURE REVIEW

Transport cost is a primary parameter in most transport related decision making processes since transport pricing follows transport costs (Baqueri et al., 2016). Transport pricing can be defined as instruments of compensating for the cost of usage of the transport system and its infrastructure. Transport pricing policies can be expected to have three main objectives to attain; (i) cost recovery (ii) reduce external costs and (iii) ensure equitability of bearing such costs.

The total cost of transportation is a combination of both internal and external costs. The internal transport costs are those borne by the user and generally include the costs for labour, taxes, energy fees or tolls for the usage of the transport network, insurance, cost for owning the vehicles and its repair and maintenance costs. External costs are the costs imposed on society and the environment such as air pollution, congestion, noise pollution and traffic accidents where the consequential costs are borne by the entire community or society. As such external costs are those that are borne by a party other than which makes the decision of travelling and usually not taken into account when making such decisions (Fridstrøm & Østli, 2017).
According to (Forkenbrock, 1999) external costs associated with freight trucking transportation between US cities has risen to 13.2% of private operating costs even after using conservative values as external costs. It has been estimated that hidden transport costs in European countries were $975B in 1995 and for the USA to be around $600B in 1989. According to (Mayeres, 2003), the total global transport linked external costs was $1280B in the late 90s (Jakob, Craig, & Fisher, 2006).

Taxes and subsidies and infrastructure investment policies are considered as pricing instruments by which governments mitigate the transport related complications and achieve a best combination of a communities’ economic, social and environmental objectives. By establishing a transport tax system a government expects mainly three prime objectives to be achieved (a) recovery of cost of providing public infrastructure or services, (b) tax revenue earning especially from higher priced vehicles and (c) recovery of costs for mitigating external costs.

Transport subsidies are adopted as a strategy to encourage (i) sustainable transportation, (ii) effect equitable distributions also known as social welfare and (iii) reduce external economic costs. Social welfare could include subsidy for disabled people, senior citizens, soldiers, students and the economically disadvantaged. These have been studied in detail by (Hao, Zhou, Huang, & Guan, 2009).

Kumarage, Storm et al (1999) have developed equations for costing different cost components including (a) vehicle operating cost, (b) time costs, (c) accident costs, (iv) emission costs etc. It also identifies quantifiable and unquantifiable costs. The latter referring to costs which still cannot be scientifically quantified or valued.

This paper fills an important gap in the scientific estimation of transport cost by the development of a unified single formula for capturing the total cost of land transportation combining all cost items identified in earlier research for all modes of land transport. It proceeds further to provide an estimate of such total cost in Sri Lanka based on the computation of the cost of different cost components for the different modes of transport.

3. METHODOLOGY

3.1 Identification of Transport Costs

The land transport costs components summarized in Table 2 were identified using a comprehensive literature review.

<table>
<thead>
<tr>
<th>Cost Components</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal costs</td>
<td>(Janic, 2007)</td>
</tr>
<tr>
<td>Vehicle operating costs</td>
<td>(Berthelot et al, 1997), (Profile, 2018)</td>
</tr>
<tr>
<td>Cost Recovery through Fares</td>
<td>(Kumarage, 2002)</td>
</tr>
<tr>
<td>Accident costs</td>
<td>(Forkenbrock, 1999), (Forkenbrock, 2001), (Eriksen, 1999), (Kumarage, Gunaruwan, Storm, Ranawana, &amp; D, 2001)</td>
</tr>
<tr>
<td>Emissions costs. Noise costs</td>
<td>(Forkenbrock, 1999), (Forkenbrock, 2001), (Eriksen, 1999), (Janić, 1999)</td>
</tr>
<tr>
<td>Congestion costs</td>
<td>(Eriksen, 1999), (Janić, 1999)</td>
</tr>
<tr>
<td>Cost of maintenance of</td>
<td>((Forkenbrock, 2001), (Eriksen, 1999)</td>
</tr>
</tbody>
</table>
3.2 Computation of Total Transport Cost

The total cost of land transport (TTC) in a given area could be expressed by Equation (1)

\[ TTC = VOC + PIO + PIC + UTC + NCC + EC + ADT + AC + OT \]  \hspace{1cm} (1)

where,

- **VOC**: vehicle operating costs including cost for fuel, oil, registration, fares & tolls, vehicle purchase costs, vehicle registration fees, parking fees, insurance costs, maintenance & repair, depreciation costs and financing costs, carbon taxes, inclusive of all taxes and subsidies.
- **PIO**: public infrastructure operating and maintenance costs including roads, bridges, stations, terminals,
- **PIC**: public infrastructure capital cost for road ways, railways, terminals, stations etc.
- **UTC**: user time costs
- **NCC**: congestion cost borne by the non-user, including costs of schedule delay, and increase in vehicle operating costs due to delays and speed reductions
- **ADT**: administrative cost for transport management, police traffic management, utility services, vehicle registration traffic courts
- **AC**: accident costs, property damage, medical costs, police cost, insurance costs, congestion costs due to accidents, output loss, pain & grief
- **EC**: environmental costs, including cost of air emissions, noise pollution, water pollution, severance etc
- **OT**: other costs

3.3 Total Cost Equation

Consequently each cost parameter can be derived from the summation of its cost components;

\[ VOC = \sum_{k=0}^{n} C_{1k} \] \hspace{1cm} (2)

\[ PIO = \sum_{k=0}^{n} C_{2k} \] \hspace{1cm} (3)

Where,

\[ C_{1k} = \text{is the cost component of the travel of passenger 1 on mode k} \]

Annual passenger kilometer is the multiplication of annual vehicle kilometers into average vehicle occupancy for each mode.

\[ pkt = vkt \times u \] \hspace{1cm} (4)

Where,

\begin{align*}
\text{pkt} & = \text{annual passenger kilometer} \\
\text{vkt} & = \text{annual vehicle kilometer} \\
\text{u} & = \text{average vehicle occupancy}
\end{align*}
Transport costs per passenger kilometer is derived by dividing the total transport costs from the annual passenger kilometers.

\[
TC_{pkt} = \frac{TTC_{pkt}}{pkt}
\]  

Where,

- \( TC_{pkt} \) = transport costs per passenger kilometer
- \( TTC_{pkt} \) = total transport costs

Furthermore, this model can be used to anticipate the costs for different transport modes. In advance

\[
Costs\ proportion\ to\ the\ modal\ share = \frac{TC}{\sum_{j=1}^{n} pkt_j} \times pkt_j
\]

where,

- \( J \) = different mode 1, 2, 3 ………….n.

### 4. FINDINGS AND DISCUSSION

The estimation of Total Travel Costs (TTC) best estimates for the different cost components of the passenger transport sector in Sri Lanka for the year 2018 is shown in Table 3.

<table>
<thead>
<tr>
<th>Cost Type</th>
<th>Rs bn</th>
<th>PV</th>
<th>Bus</th>
<th>Rail</th>
<th>Total Pax</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOT</td>
<td>682.0</td>
<td>120.8</td>
<td>8.5</td>
<td>811.3</td>
<td></td>
</tr>
<tr>
<td>PIO</td>
<td>16.4</td>
<td>3.5</td>
<td>5.6</td>
<td>25.5</td>
<td></td>
</tr>
<tr>
<td>PIC</td>
<td>129.8</td>
<td>27.8</td>
<td>15.2</td>
<td>172.8</td>
<td></td>
</tr>
<tr>
<td>UTC</td>
<td>518.3</td>
<td>173.5</td>
<td>23.8</td>
<td>715.6</td>
<td></td>
</tr>
<tr>
<td>NCC</td>
<td>43.4</td>
<td>27.3</td>
<td>3.8</td>
<td>74.5</td>
<td></td>
</tr>
<tr>
<td>ADT</td>
<td>7.6</td>
<td>1.6</td>
<td>2.8</td>
<td>12.0</td>
<td></td>
</tr>
<tr>
<td>EC</td>
<td>1.9</td>
<td>0.2</td>
<td>0.1</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>56.3</td>
<td>12.1</td>
<td>1.7</td>
<td>70.1</td>
<td></td>
</tr>
<tr>
<td>OC</td>
<td>-</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TTC</td>
<td>1,455.7</td>
<td>366.8</td>
<td>61.6</td>
<td>1,884.1</td>
<td></td>
</tr>
<tr>
<td>Pax km (bn)</td>
<td>62.0</td>
<td>59.7</td>
<td>8.2</td>
<td>9.2</td>
<td></td>
</tr>
<tr>
<td>Rs/Pax-km</td>
<td>23.5</td>
<td>6.1</td>
<td>7.5</td>
<td>204.8</td>
<td></td>
</tr>
<tr>
<td>Tangible Costs Rs bn</td>
<td>682.0</td>
<td>120.8</td>
<td>8.5</td>
<td>811.3</td>
<td></td>
</tr>
<tr>
<td>Tangible Cost %</td>
<td>47%</td>
<td>33%</td>
<td>14%</td>
<td>43%</td>
<td></td>
</tr>
<tr>
<td>Public Investment %</td>
<td>11%</td>
<td>9%</td>
<td>38%</td>
<td>11%</td>
<td></td>
</tr>
</tbody>
</table>

The table shows that the overall economic cost of passenger transport in Sri Lanka is Rs 1,884.1 bn, while the per km cost of mobility ranges from a high of Rs 23.5 for private vehicles to Rs 6.1 for buses, while the railway compares with buses at Rs 7.1 per passenger km carried. Even though buses have the lowest economic cost, the public investment percentage in the total cost at 9% is the lowest in buses. The direct cost percentage as expected is highest in private vehicles at 47% while the railways at 14% has the lowest direct cost mostly due to the low railway fares policy of the Government.
4.1 Identifying Transport Related Cost Components

Transport cost components can be divided into two parts: tangible and intangible. Tangible costs are the directly attributable costs while the intangible costs are the hidden costs of providing transportation. The iceberg principle (Figure 2) can be applied to illustrate the transport costing given the fact that only a small portion of transport cost are tangible or felt by the users while most are intangible and hidden to be paid through indirect means and usually not at the time of making a decision.

![Image of an iceberg illustrating transport components](image)

**Figure 1.** Transport components illustrated by Iceberg theory

4.2 Recognize the Pricing Policy Instruments

Taxes and subsidies were identified as the main policy instruments in transport pricing applied to maintain the trade-off of financial flow between different parties who bear the transport costs as well as for distributional purposes and to recoup external costs. This is illustrated in Table 4. Subsidies granted for railway and bus fares act as an extra burden on the whole society while releasing the public transport users from the full cost. However car users will also get a subsidy if parking is allowed free of charge when roads are made from public funds. In contrast taxes are imposed in order to pull out an extra amount of money from the users’ pocket. Transport related taxes as well as other non-transport related taxes are also often used for transport sector expenditure. Vehicle purchase taxes, vehicle import taxes, vehicle license fee tax, fuel taxes, vehicle part taxes: tires, taxes on engines, lubricant, GST, carbon tax, non-transport related taxes and excise duties are some examples of identified transport taxes in the local context.
Table 4. Pricing Instruments

<table>
<thead>
<tr>
<th>Policy instruments</th>
<th>List of References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taxes</td>
<td>(Börjesson, Eliasson, Hugosson, &amp; Brundell-Freij, 2012), (Sterner, 2012)</td>
</tr>
<tr>
<td>Subsidy</td>
<td>(Ubbels &amp; Nijkamp, 2002), (DODGSON, 1986), (Hao et al., 2009), (YANG, QI, QIAN, XU, &amp; YANG, 2010), (Athukorala, 2010)</td>
</tr>
</tbody>
</table>

4.3 Identifying the Parties Bearing Social Cost of Transport

Figure 2. Stakeholders who bear socio economic cost of transport

Socio costs of transportation of a community can be considered as an accumulation of the costs borne by all the different stakeholders in a society both individually as well as a community in the pursuit of all mobility aspirations of that community. Vehicle operating expenditures, fares and loss of time are purely incurred and borne by the producer and referred to as individual costs. Environment pollution costs, administrative costs, infrastructure O&M costs, congestion costs, accident costs, infrastructure capital investment are the costs which are not born by the producer and referred to as social costs. It is vital to understand the individual bearers of the different cost elements to evaluate the equity perspective in terms of how the mobility costs are distributed between users and non-users.

As an example the components in total accident costs such as the property damage, insurance costs are paid by the user who is responsible for the accident. The medical costs, output losses, pain and grief are endured by the victims of that particular accident. Police and other administrative costs are borne by the government. Consequently, the transport costs will be borne in different proportions by the different parties. While some may pay more than the actual social cost, others may be subsidized, effectively paying a tax or receiving a subsidy creating many social inequities that may unintentional or even contravening explicit policy for transport. Table 5 identifies the cost bearing parties for Sri Lanka. This may change from country to country depending on transport policy especially tariff and taxation policies.
5. CONCLUSION

This study is a systematic analysis of existing pricing policies in land transport sector from different perspectives; identifying the different cost components, the different parties that bear such costs and the policy instruments that distributes such costs across the users and non-users.
The paper presents its findings in terms of key cost parameters that includes vehicle operating cost / fares & tolls, infrastructure O&M costs, infrastructure capital investment cost, time costs, congestion cost, administrative cost, accident costs and environmental costs. The total cost comprising above, irrespective of being tangible or intangible has to be fully borne by a society in which such transport activity is incurred. The paper identifies how the payment for such cost components are distributed across the users and non-users in Sri Lanka. It also presents a review of methods available for estimating such cost components.

The paper also shows a best estimate for passenger costs in Sri Lanka across three modes of transport. It computes the overall cost of mobility for carrying a passenger a distance of one km by each mode. It also shows the public investment as a percentage of the total cost as well as the direct or tangible cost paid by passengers. These indicators can be used for strategic planning in determining the public investment required to optimize the overall economic cost of mobility, or the level of taxes to reduce higher cost modes while offering subsidies for lower cost modes of transport.

6. REFERENCES


