The Social Cost of Transport

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Transport and Sustainable Development .................................................. 2
Market failures in the transport sector ...................................................... 4
The benefits and the costs of vehicle use .................................................. 4
  External Costs .......................................................................................... 5
  External Benefits (?) .............................................................................. 6
  Classification of the external costs of transport ...................................... 7
Applying policy instruments to transport problems .................................... 8
  Command and Control vs. Market Based Incentives ......................... 8
  Box – Estimating the Marginal External Cost of Congestion ............... 9
  Road pricing and equity ........................................................................ 10
  The alternatives to road pricing ............................................................ 11
Final remarks ......................................................................................... 13
References .............................................................................................. 15

1 I am grateful to John A. Dixon for useful comments and suggestions.
Transport is undoubtedly a leading factor in economic development. New roads lower costs of goods and services, facilitate the development of new areas, create new job opportunities and allow the development of urban areas where people and ideas meet and interact.

Transport is essential in developing countries, where the potential for growth is often constrained by the lack of infrastructures and the high costs of transaction impede the development of new businesses. Some stylized facts, obtained from World Bank (1996) are:

- Value added by transport is estimated to account for 3 to 5 percent of GDP.
- Public investment in transport typically accounts for between 2.0 and 2.5 percent of GDP and may rise as high as 3.5 percent in countries modernizing outdated transport infrastructure or building new transport infrastructure.
- Transport likewise commonly accounts for 5 to 8 percent of total paid employment.
- Demand for freight and passenger transport in most developing and transition countries is growing 1.5 to 2.0 times faster than GDP—the bulk of this increase is for road transport.
- Although demand for freight transport in industrialized countries grows less rapidly than GDP, in developing and transition countries the growth rate is closer to that for passenger transport.
- In 1994 foreign aid accounted for 12 percent of total infrastructure financing in developing countries (including transport), while private financing of infrastructure accounted for 7 percent and was rising. In 1996 private sector lending to emerging markets peaked at $196 billion. Since then it has fallen sharply and estimates for 1999 were just over $17 billion.

Macroeconomic cross-country evidence show that investment in the transport sector promotes growth by increasing the returns to private investment. The estimated economic rate of return of projects in the transport sector is 22 percent, 50% higher than the Bank average (figure 1).

There are few doubts about the benefits of transport. However there are also a series of related costs which should be considered in assessing relative advantages. Such costs are usually external to those who make use of transport and are often unaccounted for.
Growing road congestion generates external costs at the local, regional and global level. Within cities, transport congestion generates pollution and increases road accidents. About 500,000 persons per annum are killed in road accidents in the Bank’s developing member countries and about 70 percent of these fatalities are pedestrians (figure 2). In recent years in India only 5 percent of those killed were in vehicles; the rest were pedestrians and cyclists. Moreover, automotive CO\textsubscript{2} emissions are growing fast in developing countries, contributing to the accumulation of GHGs in the atmosphere.

Given the intrinsic benefits and effects on growth, use of motor vehicles is expected to increase in the future. Population growth, urbanization, as well as growing incomes will
boost demand for both freight and passenger transport in developing countries. Figure 3 shows the estimated relative growth of population, car ownership and car use in developing countries between 1960 and 2010.

The previous considerations highlight the challenges for the transport sector. Choices made on the basis of the benefits of transport can eventually lead to alterations of the environment that are likely to be very important. The public good nature of air quality, road space and environmental landscapes makes difficult to take into account environmental values into current decisions. Analyzing such external costs is an integral part of the new tasks of planners. The following session describes how market failures take place in the case of transport.

**Figure 3** – Growth of population, car ownership and usage


Graph taken from World Bank (1996)

**MARKET FAILURES IN THE TRANSPORT SECTOR**

**The benefits and the costs of vehicle use**

Consider the case of urban transport. Motor vehicle use conveys important benefits, such as ease of communication, time saving, comfort and privacy. A simple graph will allow us to set the stage. On the horizontal axis of figure 4 we measure the number of vehicles at a certain hour in an urban area, a variable we call ‘mobility’. On the vertical axis we measure marginal benefits and costs\(^2\) of mobility. The graph represents a demand and

\(^2\) These are measured in monetary terms, US Dollars for example. The costs include the amount necessary to operate and maintain a vehicle, the congestion costs and the other external costs of traffic congestion (i.e. air pollution, noise). Valuation techniques exist to measure the external costs, such as hedonic pricing, contingent valuation and household production function approaches.
supply framework. The marginal benefits curve is indeed a demand curve for mobility. Given a certain number of vehicles, it gives the maximum price the marginal road user is willing to pay for driving. The marginal benefits curve is decreasing assuming that different individuals receive different level of utility from driving. For a very high price of transport, only those individuals with a high marginal benefit will drive, but as the cost of transport decreases, the number of individuals finding it worthwhile to drive will presumably increase.

The marginal private costs (MPC) curve is the equivalent of a supply curve. Using a vehicle to commute at a certain time involve costs; first of all the necessary expenses to operate (gasoline, oil, etc.) and to maintain the vehicle. If these were the only costs of using a vehicle, the marginal cost curve would be practically horizontal: any additional user would spend on average the same to use a certain road at a certain time. As the number of vehicles increase, however, the time to commute increases. Road space is a resource common to road users and is limited in amount. As road use increases, congestion costs will be the same, but as the number of vehicles turns to be very high, the cost experienced by each new road user will be higher than the cost privately incurred by those before her. This is why the marginal cost curve is shown to be increasing.

External Costs

It has been noticed that road space is commonly used by the drivers. As mobility increases, not only each new driver pays a higher congestion cost compared to previously present drivers, but she also reduces the road space available to other drivers. This cost is external to the marginal driver. The marginal social cost (MSC) of mobility is thus represented as an increasing curve above the marginal private cost of mobility, to take into account the congestion externality.
Microeconomic analysis suggests that the optimal mobility level should be determined by the intersection of the marginal benefit curve and the marginal social cost curve. In practice, individual users will disregard the cost imposed on others and will be using the road space beyond point M* in figure 4, until the level at which the marginal private cost curve intersects the marginal benefit curve. A policy that allows to reduce mobility from M’ to M* would increase social welfare. This change is represented by area A in figure 4. For levels of car use higher than M*, marginal social costs are higher than marginal benefits and car use beyond M* causes a net welfare loss to society.

We may also account for the costs that road used causes to the non-driving urban population, i.e. noise, air pollution, health threats and risk of accidents. Adding this external costs leads to a ‘total’ marginal social cost curve (TMSC) which implies an optimal level of mobility even lower. When environmental external costs are taken into account, the social costs avoided by reducing mobility to the new optimal level M** is represented by area A+B in figure 4.

External Benefits (?)

So far we have considered only negative externalities. What about positive externalities? Transport lobbyists and groups with obvious interests in the development of the transport sector, have repeatedly argued that the external benefits of transport balance for its external costs, so no intervention on the level of vehicle use would be justified.

Often cited benefits from transportation include, among other, the lower prices in goods and services, the increase in job opportunities, the growth in prosperity and the increase in leisure time. The crucial question from the economic point of view is whether benefits from transport are actually external. In this was the case, government intervention would be needed to restore efficiency.

There seem to be evidence that ‘external’ benefit are very unlikely to take place. In order to be external, a benefit should be disregarded by the agent taking the decision regarding vehicle use. Assume that increased and faster transport has the potential to lower the cost of food storage. A transport company will easily realize such potential and make the necessary actions to increase its transport fleet. In other words, the marginal private cost curve will reflect such decision. As long as markets exist for cheaper food and better paid jobs, the benefits from transport will be internalized by such markets and there will be no need of government intervention in order to guarantee efficiency.

In conclusion, there seem to be very few identifiable cases of external benefits. One can think perhaps of the ‘external’ benefits of car, train, plane-spotters. In this case, no market usually exist to charge the benefit deriving from the enjoyment of seeing a car passing by, and an externality results. On the contrary, external costs are well documented in nature (even if they may be difficult to measure). As a consequence, the case for government intervention to control vehicle use is much more strong.
Classification of the external costs of transport

Verhoef (1996) classifies the external costs of transport along two dimensions (see figure 5). On one dimension (vertical axis) externalities are classified according to who is affected by the external costs. Three cases are possible: *intra-sectoral effects*, where users impose costs upon each other, *effects on social environment*, in which affected groups are not necessarily vehicle users, and *effects on ecological environment*. On the other dimension, externalities can be classified according to the type of source: externalities resulting from actual *vehicle use*, from the *vehicles when these are not in motion*, and from the mere *existence of the road infrastructure*.

The classification in figure 5 helps the analysis of environmental problems as it identifies the relevant stakeholders involved. It moreover facilitates the definition of appropriate policy instruments. Take *congestion* as an example. The external cost is in this case imposed by a group of car users upon themselves. A parallel can be made with the overcrowding of natural resources, as in fisheries. In this case, one could think about the advantages and disadvantages of limiting access, a policy implemented in many downtown areas in Europe. Alternatively one could think about the creation of a market for road space, via the introduction of tradable permits for circulating in certain areas.

Another example is the *pollution caused by the disposal of used vehicles*. In such case, it is not the vehicle use which is damaging, but rather the act of disposing of it. Moreover, the victims are not easily identifiable: human health can be threatened as a consequence of resulting pollution, the effects on ecosystems can also concern future generations and foreign citizens. Can the reader think of an appropriate policy instrument in this case?
The following session will analyze the policy solutions more closely.

Applying policy instruments to transport problems

It has been observed that the externalities originated in the transport sector can be logically classified according to the ‘cause’ or origin of the externality (i.e. car use, car parking, infrastructure construction) and according to the geographical level of their effects (local, regional, global). Given the number and complexity of the issues involved, we will focus on the problems of traffic congestion. Following the classification adopted, this means that particular attention will be given to the externality caused by vehicle usage and that mainly affects the urban population (infra-sectoral and local effects). It is worth noting that the framework can be easily generalized to include other types of externalities. Moreover, instruments suited for a particular kind of problem, may help attacking other externalities at the same time.

Command and Control vs. Market Based Incentives

The previous analysis suggests that mobility should be reduced to the level M* in order to equalize marginal social costs and benefits. A first obvious way of doing so would be to impose limits in vehicle usage, for example by restricting access to a certain urban area. This policy has been in fact put in place in several European downtown areas, limiting the access to local residents. These policies have been intended to preserve historical buildings and sites from the corrosive effects of vehicle emissions. Others have advocated for the use of technical measures to directly limit contamination. In the case of pollution, the problem is in fact not the use of a motor vehicle, but the emissions this causes. Economic theory suggests that a first best policy should aim at reducing emissions rather than car usage. The former (emissions) is in fact a ‘bad’, while the latter (car usage) is a ‘good’! The case of congestion is different, as the external costs are directly linked to the number of vehicles and the policy should aim at controlling such number.

Command and control measures, such as limiting traffic in certain areas, usually disregard the difference between individual users. It might be the case that drivers that are ruled out from the restricted area, would be willing to pay a price higher than the marginal social cost. On the other side, drivers allowed to enter the restricted area may have marginal benefits below the marginal costs of using it. Swapping these two types of individuals would certainly increase social welfare. Command and control measures are not suited for such a swapping.

If we could define property rights on the limited access and if individuals could trade their permits to drive, drivers with higher marginal benefits would be willing to buy the right to enter the restricted areas and individuals with very low marginal benefits would
be willing to sell such rights. The trade would eventually end equalizing the marginal cost of driving across road users and social welfare would be maximized.

Another means of obtaining the same result would be to impose a **tax on road usage** equal to the marginal external cost (MEC) of congestion, measured in monetary units per vehicle km$^3$. The Box below shows the analytical procedure to calculate the MEC and displays some estimates from the UK.

With the tax on road use, drivers would then face the marginal social cost of mobility and take it into account in their decisions. Social welfare would be maximized, as there would be no individual with positive net marginal benefits of driving that would be unable to drive, and social congestion costs would be at their optimal level.

Road pricing, seem to offer an optimal solution. Compared to the definition of property rights it would have the advantage of avoiding the necessary transaction costs of creating a market on ‘mobility rights’. 80 years have passed since Pigou suggested the use of road pricing, but evidence shows that its implementation is not as wide as one would expect. Why are policy makers around the world reluctant to do what is obviously welfare improving?

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**Box – Estimating the Marginal External Cost of Congestion**

Attempts to measure the external cost of congestion suffer from the complexity of the relationships linking level of mobility with speed and this with time costs. Here we present a simple analytical representation. Consider a representative road user. Establish the following relationship, linking Marginal Private Cost (MPC) of transport to speed (s) and value of a unit of time (b):

$$MPC = ASC = a + \frac{b}{s}$$  \hspace{1cm} (1)

where $a$ is the fixed cost of a car trip. Equation (1) is a simple sum of cost elements: fixed cost of a trip (fuel, car maintenance, etc.) plus time cost of the trip, which depends on the value of time (hourly earning may be used as a proxie) divided by speed. Notice that Marginal Private Cost (MPC) is equal to the Average Social Cost (ASC). This is so because the marginal user incurs a cost equal to the cost each driver is paying before he enters.

Establish next a relationship linking speed ($s$) and the level of mobility ($M$). This relationship is usually assumed linear:

$$s = \alpha - \beta M$$  \hspace{1cm} (2)

Parameters for equation (2) can be estimated with a linear regression. Substituting (2) into (1) gives:

$$MPC = ASC = a + \frac{b}{\alpha - \beta M}$$  \hspace{1cm} (3)

Multiplying by $M$, we obtain an expression for the Total Social Cost (TSC) of Congestion. If we then differentiate with respect to $M$, we obtain the Marginal Social Cost (MSC) of congestion:

$$MSC = a + \frac{ab}{(\alpha - \beta M)^2}$$  \hspace{1cm} (4)

Equation (4) gives the cost that any new user causes on the others when there are already $M$ drivers on the road. The Marginal External Cost (MEC) is then obtained by subtracting MPC from MSC and multiplying by the number of drivers affected by the externality ($M$):

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3 This is an example of Pigouvian tax. It is worth to note that the spiritual father of the instrument, Arthur Pigou, made the very first formulation of this pricing instrument with reference to a road congestion example. The concept has then been applied widely in the theory of externalities and in Environmental Economics.
\[ MEC = (MSC - MPC)M \]  
(5)

The table below shows estimates for the MEC of congestion in the UK in 1990:

<table>
<thead>
<tr>
<th>Road type and time</th>
<th>Marginal external cost of congestion, pence per vehicle km</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motorway</td>
<td>0.26</td>
</tr>
<tr>
<td>Urban central peak</td>
<td>36.37</td>
</tr>
<tr>
<td>Urban central off-peak</td>
<td>29.23</td>
</tr>
<tr>
<td>Non-central peak</td>
<td>15.86</td>
</tr>
<tr>
<td>Non-central off-peak</td>
<td>8.74</td>
</tr>
<tr>
<td>Small town peak</td>
<td>6.89</td>
</tr>
<tr>
<td>Small town off-peak</td>
<td>4.20</td>
</tr>
<tr>
<td>Other urban</td>
<td>0.08</td>
</tr>
<tr>
<td>Rural dual carriageway</td>
<td>0.07</td>
</tr>
<tr>
<td>Other trunk and principal</td>
<td>0.19</td>
</tr>
<tr>
<td>Other rural</td>
<td>0.05</td>
</tr>
<tr>
<td>Weighted average</td>
<td>3.40</td>
</tr>
</tbody>
</table>

Note: this session draws on Maddison (1996)

**Road pricing and equity**

The question posed at the end of the previous paragraph points at the importance of understanding the policy decision making process. This can be done with the use of economic analysis. This session analyzes the equity effects of road pricing as a source of public opposition to road pricing.

Figure 6 represents the marginal benefits and costs curves introduced earlier. It moreover shows the welfare effects of road pricing. This helps us to identify potential losers and winners of road pricing. We identified three main stakeholders: (i) the drivers that use the road even after the policy, (ii) the mobility forgone, and (iii) the government (or in general the tax recipients. The drivers that continue using the roads will pay the newly introduced tax, which is equal to the area between the original marginal private cost curve (MPC) and the new curve after the tax (MPC‘). This is area B”+D. Moreover, continuing drivers will benefit from the reduced congestion costs, equal to a percentage k of the area A+C.

The ruled out drivers will lose the benefits of driving, while forego the private costs necessary to drive. The net effect is –C. Moreover, these drivers will save their share of the social cost of congestion they were paying in the status quo: +(1-k)(A+C).
Finally, the government is enjoying increased tax revenues equal to area $B''+D$. Summing up the three components, we obtain the net welfare gain to society, equal to area $A$. This confirms the fact that road pricing can actually increase social welfare when congestion externalities are present\(^4\). The analysis goes even further, by identifying net gains to different groups. It is graphically apparent, and it can be shown analytically, that both sub-groups of drivers incur welfare losses from the policy intervention, while the government gains. This explains the strong resistance that road pricing has encountered within road users and transport lobbies.

We have implicitly assumed that the tax revenue stays with the regulator. It is obviously very important the way in which the government redistributes these revenues. Improving public transportation can be an effective way to overcome the welfare loss of those ruled out from the streets and to improve welfare of non-drivers. Both sub-groups may represent considerable share of the poorest sectors of society. Figure 7 shows the composition of vehicle use in different Asian cities. It is evident that the use of non-motorized vehicles (NMV) can be very important as a share of total road usage, especially among the poorest sectors of society. Cycling for example may be a low cost way to reduce commuting times compared to walking. Congested roads however increase the risk of accidents for people using NMVs. Policies designed to reduce the level of traffic and to improve the services for non-drivers can have important distributional effects.

**The alternatives to road pricing**

\(^4\) For simplicity, we have not considered environmental externalities, such as air pollution and noise. Including these into the analysis would make necessary to define a fourth stakeholder: the victims of the environmental externalities, who would be certainly favored by the road-pricing instrument.
Road pricing constitutes an efficient way of internalizing the social cost of congestion and of controlling for the environmental external costs of transport. The equity effects of road pricing might have contributed to its slow adoption around the world. Alternative instruments have been used instead with mixed results. We proceed to identify some of these policy instruments and briefly describe the main weaknesses they present.

**Figure 7 – Transport modes in selected Asian cities**

![Graph of transport modes in selected Asian cities](image)


Graph taken from World Bank (1996)

- **Parking charges** – the act of parking is a close complement of vehicle use, especially in the case of urban transport. Charging a toll for parking may be needed to cover the cost of the parking space, and to allocate existing space efficiently. Here we are talking of something beyond this: the idea of taxing vehicle use by taxing a close complement. The effect can be analytically represented by a shift to the left in the demand curve for vehicle use. The result would be a lower level of mobility. Among the main weaknesses of this policy is the fact that it penalizes ‘stopping’ traffic vs. ‘through’ traffic and shorter trips vs. longer ones. Even more importantly, it leaves open the problem of regulating privately owned parking facilities. It is often the case that companies offer their employees parking perks. This in fact constitutes a strong subsidy to driving, and leads to an inefficient use of motor vehicles. Eliminating such subsidies could have important effects, moreover it would presumably have positive redistribution effects.

- **Public transport subsidy** – symmetrical to taxing complement goods, is the subsidization of substitutes to privately owned vehicles, such as the public transport. The effect is again a shift in the marginal benefit curve to the left. It has however been observed that the demand for public transport might be very inelastic so as to require very strong subsidies. Other shortcomings include the difficulties in setting the optimal level of subsidy, the risk of mismanagement of

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5 In this session we refer to Button (1998). This list is not intended to be exhaustive.
funds and the rent seeking behavior. Moreover, compared to road pricing, this instrument would require an increase in fiscal revenues.

- **Taxing fuel** – there is a natural correlation between road congestion and fuel use. Higher congestion means lower speed and longer waiting times, implying higher fuel consumption. Taxing fuel has the effect of raising the marginal private cost of mobility. It has been observed that in practice, cost of fuel might have little effect on congestion, especially in the short run.

- **Vehicle license fees** – this constitute a way of increasing the fixed costs of vehicle use. It is not suitable to take into account when and where the vehicle is used and the external costs of congestion are higher. For the same reason, it might be less powerful compared to policies that increase the marginal costs of mobility.

- **Road building and land use planning** – the effect of developing new networks is to shift to the right both the MSC and the MPC curves. In this way it presumably diminishes the vertical distance between the two and help minimize the external costs of congestion. Many have observed that traffic may eventually expand to fill the road space available. Moreover, new developments around the new roads would cause an increase in the vehicle fleet and in the level of car use. Another way of tackling the problem is by spatially locating trips destinations in a way that optimizes road use. The historical configuration of many urban areas limits the scope of this solution. Moreover, land use and transport are linked by very complex relationships. In general, these constitute longer term solutions and are characterized by high level of inflexibility. The modification of the natural landscape could be irreversible and the cost of environmental degradation should be taken into account.

- **Encouraging alternatives to transport** – it has been advocated that the development of new communication technologies, such as telecommuting, teleshopping and videoconferencing may allow to limit vehicle use. This is analytically represented by a shift to the left of the marginal benefit curve. Concerns include the fact that the available time made possible by such technologies can be used for other (non-business) trips and that activities such as videoconferencing may generate additional travel as a complementary activity. The experience of the telephone as a substitute to the mail system constitute a precedent.

**FINAL REMARKS**

The links between transport and development are widely recognized. Projects related to transport development have shown very high rates of return. Evidence has also shown that transport may be cause of high externalities. We recognized the importance of taking into account the environmental external costs of transport in order to lay the ground for a more equitable and environmentally sustainable development.

Economic theory can help identifying the issues at stake and the source of inefficiencies. It is worth noting that tackling the external costs of transport need not to be against transport development. The idea is to create the conditions for leading such development
towards a more sustainable path. The present paper has laid out the basic elements needed to analyze transport problems in urban cities. We have mainly focused on urban congestion and environmental quality. Economic incentives have the advantage of attaining optimal outcomes at the lowest cost. They have been opposed by transport lobbies and other groups mainly given their redistribution characteristics. A political economy perspective could be helpful to identify main stakeholders and potential rent seeking behaviors and find solutions that can lead to a better priority setting in the transport sector.

The ultimate goal of a policy should be to use efficiently road space, a common resource facing the proverbial ‘tragedy’ of over use, and allow users to take into account the true cost of their decisions, so as to lead to a higher social welfare. The equity implication of such policy can be a powerful tool for poverty alleviation.
REFERENCES