Full Benefits and Costs of Transportation: Review and Prospects

T.R. Lakshmanan,1 Peter Nijkamp,2 and Erik Verhoef2

1 Director, Bureau of Transportation Statistics, U.S. Department of Transportation, Washington, DC, USA
2 Department of Spatial Economics, Free University, Amsterdam, The Netherlands

1 Introduction and Overview

Since transportation is a part of every good and service produced in the economy, the transportation system in an affluent and highly industrialized economy is a very large enterprise. In the U.S., the transportation system accounts for over 4 trillion passenger miles of travel and almost 4 trillion miles of freight, generated by over 260 million people, 6 million business establishments, and 80,000 units of government. Every tenth American worker is engaged in moving people or goods, fabricating, selling, or servicing transport vehicles and infrastructure, or providing other crucial services supporting the transportation system. Indeed, transportation accounts for about 11% of the U.S. gross domestic product—a contribution roughly comparable to major functional sectors such as food (12%), health (14%), and education (7%).

Transportation has indeed more far-reaching and pervasive effects on society than the above statistics indicate. The speed and cost attributes of transport technologies greatly influence the location and density of economic activity, and thus the evolution of the geography of production and settlement patterns. Low-cost and speedy transport has greatly facilitated the extensive and low-density settlement of metropolitan peripheries in these countries, supporting the growing independence of home and workplace.

The highly valued mobility and other benefits of transportation arrive with a variety of significant undesired consequences. In 1994, transportation accounted for 43,750 deaths, over 3.2 million injuries, and total economic costs to U.S. society over the lifetimes of persons killed and injured in 1990 of $135 billion. Total economic losses from traffic congestion and delays were estimated in the 50 largest U.S. cities in 1991 at over 45 billion (Schrank et al, 1994). Between a third and four-fifths of the major components of urban air pollution derive from motor vehicles. Transport-related energy use dominates American oil consumption (accounting for two-thirds of total), thereby leading to high levels of oil import
dependence, and a major contribution (about a third) to American production of greenhouse gases, that under current trends may potentially modify the global climate. Similar research in other OECD countries report estimates of aggregate external costs of land transport at levels ranging up to 5% of GDP (see Table 1.1; see also Verhoef, 1994).

Table 1.1. Estimates of External Costs of Transport in OECD Countries (expressed as percent of GDP)

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Air Pollution</td>
<td>0.4%</td>
</tr>
<tr>
<td>Noise</td>
<td>0.2%</td>
</tr>
<tr>
<td>Accidents</td>
<td>1.5%</td>
</tr>
<tr>
<td>Congestion</td>
<td>2.0%</td>
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</tbody>
</table>

*excluding global warming*

Source: European Commission, 1995

Given the vital role and enormous size of transportation, such undesired consequences have become the focus of private and public discussion and policy action in the last quarter century. To what extent are these undesired effects of transportation considered and dealt with by the two major institutions—the market and the state—which are engaged in the provision of transport? What changes in the incentive structures (pricing, taxes, etc.), and organizational environment are needed in order that market decisions will appropriately take into account these undesired consequences of transportation? Given the government sector’s role (albeit constantly evolving) in the provision of transport infrastructure and selected transport services, and the regulation of the transport sector as well as of public safety and the environment, what public policy approaches and instruments are called for in order to deal with the social costs of the transportation system? A prerequisite to addressing such issues is the ability to measure the full social costs and benefits of transportation.

This paper has four objectives: first, it differentiates and clarifies the motivations, theoretical approaches, measurement methods, and the results of the various researchers in North America, Europe, and Asia—exemplified by this book’s authors—who have sought to measure the total costs and benefits of transportation. Four different motivations appear to animate the researchers in their measurement projects, with consequent differences in theoretical expressions, measurement, and results. Second, the paper conveys briefly the salient aspects of our current knowledge of the full social costs and benefits of transportation. Since the relevant literature is driven by different purposes (e.g., transport performance
monitoring, efficiency, equity, etc.), it poses many complex issues and conflicts. This brief review attempts to identify what is known, what remains to be known, and—where there is debate—the terms of debate and the contingent inferences possible. A major inference that can be drawn from this survey is that the conference and indeed the broader literature on full social costs exhibits two glaring areas of neglect—areas that, while very crucial, have attracted little research attention and measurement efforts. Third, this paper explores briefly these two neglected aspects. The first is the issue of external benefits of transportation investments. Since transportation investments have dynamic impacts on spatial competition, market organization, spatial structure, and the long-run organization of production and consumption activities, it is appropriate to consider (and indeed shortsighted to overlook) such broad benefits of transportation. The second neglected area is that of equity and fairness issues. Since the application of full cost approaches in transportation public policy will likely have income distribution impacts, the neglect of equity and fairness concerns may threaten the feasibility of implementing efficient externality reduction policies in democratic societies. In democratic societies, inattention to equity aspects will make the development of a political consensus around efficiency-promoting policies difficult. Fourth, this paper describes some next steps—theory, methods, and measurement—for the field in general and the Bureau of Transportation Statistics (BTS) in particular.

2 Motivations and Perspectives

Since transportation is such a large economic sector with pervasive consequences, investigators of the social costs and benefits of transportation, as exemplified by some authors in this volume and others in the field, approach their task from different purposes and motivations. While they all note the significant mismatch between the charges the users pay and the costs they impose on other transport users and society and believe in bridging this gap by internalizing the external costs, many have different points of departure—motivated broadly by considerations such as efficiency or equity or institutional change in the provision of transport, or monitoring the performance of transportation, etc. Indeed, the literature on this subject reflects a broad confluence of a multiplicity of such motivations and points of departure which in turn lead to differences in theoretical perspectives, methods, measurement, and the results.

One group of researchers is interested in improvement of the performance of transport markets. Some seek appropriate policies for pricing of transport services—with some contending that transportation users pay all costs including a levy for environmental external costs. Some in this group even question the prevalent policy position that transport infrastructure is provided as social overhead capital by the public sector at less than full costs, and welcome an institutional change in the way transport infrastructure services are delivered, financed, managed, and priced. These analysts, interested in harnessing private initiatives in
the provision of infrastructure services (while protecting the public interest), have an interest in the design of pricing and other incentives (in the context of market competition and some regulatory oversight) and unbundling of public infrastructure services—with privatization, franchising of transport, etc. (Mody, 1996). Indeed, such a reliance on markets (to varying degrees) for determining transportation pricing and investment levels is becoming evident in many developing countries and selected OECD countries (Hümpelnick, 1996).

A second group’s interest in this area stems from its aims to reduce the adverse environmental and human health effects of transport. While full marginal external cost-based levies would generate the appropriate incentives for environmental quality, this group, in the context of persistent transport growth trends, appears to have broader objectives. Indeed, it seeks to reduce long-term threats to the environment through approaches which will reduce the absolute levels of environmental threat—by lowering the level of transport demand, of changing transport modal composition, and the like.

A third group has a major interest in equity and fairness issues. While there are many notions of equity, most would suggest that users should tender fair payment for the services they receive—including the costs of damages they impose on others. While such an equity notion of fair payment, including external costs, appears to be intuitively analogous to the efficiency approach of levying charges for external damages to correct for market failure, the criteria for guiding social equity and economic efficiency do not coincide. Unlike the fairness criterion of full payment noted above, economic efficiency suggests that users pay the marginal cost for every unit of damage. More generally, equity and fairness issues involve more than the computation of social costs and benefits; they involve a determination of who pays for transportation, and who benefits—this requiring a knowledge of the incidence of costs and benefits in relation to a prior income distribution. Thus, the information requirements of an equity-oriented approach are vasty than those for aggregate social benefit-cost estimation. Further, the very application of efficient externality-reducing pricing or charges may generate equity problems. Congestion pricing is an example of such a regressive effect on users; its unpopularity with the travelers, in spite of many proposals for rebates or subsidies and revenue-neutral sets of prices is puzzling, however, when one notices that the public seems to accept differential pricing in areas such as air travel, movie houses, and some utilities. This area of efficiency–equity conflict in policy implementation needs further inquiry. We pursue this issue in section 5 of this paper.

A fourth group of researchers, typified by an agency such as the BTS, is interested in monitoring the state and performance of the transportation system: Is the transportation system in the U.S. getting better or worse? By what indicators do you tell? Measures of full social costs and benefits of transportation should provide such information: What is the status and trends in the problem areas such as air quality or congestion? Are benefits improving and in what areas? Further such information will be helpful in assessing the relative sizes of the problem areas and benefits of the transportation system in general. Moreover, information on full
social costs and benefits of transportation, which are in the form of outcome indicators, could provide valuable inputs in an emerging process of government-wide assessment of public programs. As an accountability revolution is underway in the public sector (with the Congressional passage of the Government Performance and Results Act (GPRA)), measures of full costs and benefits of transportation can play a key role in the determination of the contribution of public policies to the efficient operation of the transportation system. Finally, information on the distribution of benefits and costs of transportation among the various groups within the society can be a useful input to broad transport policy determination.

Since each of these different motivations and perspectives brings with it some differences in points of departure, theoretical approach, methods and measurements, the results consequently will also vary to some degree, as illustrated in the next section where the current state of our knowledge in the field is briefly reviewed. It is, however, too simplistic to suggest that researchers in each of the four groups noted here hold one and only one viewpoint. Indeed, some analysts often view the issues from different perspectives. A major source of confusion in the field appears to be the unconscious mixing of efficiency of equity perspectives.

3 Current State of Knowledge: Highlights

The conference participants noted that the benefits of transportation appear to be receiving scant attention in the literature on the social costs and benefits of transportation, and for that matter were not adequately addressed at this conference either. They urged that a future meeting should allocate far more time to the consideration of the full social benefits of transportation. For those investigators whose concern was with economic efficiency and the improved performance of transport markets, the focus of discussion was on whether and which benefits were external or not. As Blum notes in his paper in this book, functioning markets have a built-in propensity to capture external benefits unless institutional barriers come in the way. He argues that the failure to capture such benefits by the market imply the following: (a) whenever economic activities require transportation the relevant external benefits of these goods’ markets may also be related to the transport sector—e.g., where true supply costs are lower than individual firm supply costs due to technological externalities, or where social demand is higher than private demand because social utility exceeds private utility; (b) what are identified as external benefits are long-term effects that cannot be captured immediately, and are really potentials which can be exploited in the long-run through a spontaneous reorganization of the social and economic system. Furthermore, for groups like the BTS, which is concerned with measuring the status and performance of transportation or assessment of infrastructure investments, the full range of benefits, external or not, ought to be measured.

For analysts interested in equity and fairness issues, the concern will be on the distribution of benefits; the Anderson-Mohring paper in this volume, notes that
road pricing in the Twin Cities area will produce efficiency gains. However, it will make most drivers worse off (especially low-income travelers), unless toll revenue is carefully distributed. Optimal pricing of all congested roads will push up total travel costs by 18% to 42% (depending on demand elasticity for travel). With unit-elastic demand, such pricing would increase travel costs for the lowest and highest income groups by 31% and 5% respectively.

Next, the costs and benefits of the entire transport system arise both through the supply and existence of infrastructure, as well as through its usage. Although it is evident that these two elements are closely connected, the distinction is important as it may have important consequences for the specification of policies. For instance, the public benefits of infrastructure in terms of accessibility are often mistaken for external benefits of transport, thus casting doubt on the necessity of regulating transport’s external costs (such as environmental impacts). These benefits of accessibility, in turn, are realized (and revealed) only through the usage of infrastructure. This means that, whereas a large share of the costs of infrastructure provision are often concentrated in time (i.e., the construction phase), the benefits are to be reaped over a much longer, future period implying an imbalance in the timing of the costs and benefits of transport infrastructure.

While most people agree that external benefits created by the additional use of the transportation system are insignificant (e.g., Button and Nijkamp, 1994), there are significant external benefits attributable to roads, ports, airports, railroads and transport infrastructure. Such transportation improvements, by lowering the costs of moving goods and people stimulate demand, thereby promoting economic growth. Both users and nonusers are alike benefited by transport improvements in this fashion. Transportation improvements confer other less direct but significant benefits. For example, increased competition among firms in locations, whose access have been improved by the transport improvements would lower prices and raise economic efficiency. Further, such improvements, in the context of recent logistical developments such as “just-in-time,” have effects on production and firm organization, promoting more efficient production practices. Improved transportation technology and infrastructure can also promote a transformation of production and consumption.

Transport activities themselves often give rise to a variety of costs, which can be internal (fuel, time) or external (inter-sectoral: pollution, noise, accidents; and intra-sectoral: accidents, congestion) in nature; which can be variable (fuel) or fixed (purchase of cars, vehicle taxes) for individual trips; which can be instantaneous (congestion) or cumulative (CO₂), which can have a local (noise) or a global (CO₂) impact, and so forth. Hence, it is unlikely that an unregulated transport market will efficiently accomplish optimality in terms of, for instance, total mobility generated, the modal split, or the spatial and temporal (e.g., peak versus off-peak) distribution of activity.

There have been a few recent efforts to clarify, organize, and quantify these various types of social costs of transportation. Mark Delucchi, in an earlier part of this book, computes the total social cost of the motor vehicle as the sum of: explicitly priced private-sector costs, bundled private-sector costs, personal non-
monetary costs, public sector costs, and external costs—specifically the annualized social cost of motor vehicle use in the U.S. based on 1990-1991 cost levels. Delucchi warns us against several common misuses of his or other estimates of the total social costs, e.g., the temptation of adding up all the unpriced costs, and come up with a gasoline tax per gallon of gasoline—given the complexity of deriving an optimal strategy in the context of so many sources of inefficiency. Professor Emile Quinet provides a general overview of a number of European studies, some of which focus on environmental costs or infrastructure costs, while others as in U.K. and France take into account all kinds of costs.

Due to a number of peculiarities of transport such as the fact that it takes place in a network environment, the mutually causal relationship with spatial economic development, the quasi-public character of infrastructure, the heterogeneity among users, etc., it has become clear that the standard economic bench-mark of first best regulation of externalities is of only limited practical relevance. Instead, second-best policies will often be used, and it is in this respect important to stress that naive Pigouvian taxes, derived as if, apart from the externalities considered, first-best conditions apply in the transport system and in the spatio-economic system, will usually lead to an inferior outcome compared to second-best policy rules which do take account of additional market failures. The contributions by Professor Freeman and Professor Gillen in this book offer good examples of such analyses of second best issues in transportation, and we will not discuss these issues in great detail here (see also Verhoef, 1996; Verhoef, Nijkamp and Rietveld, 1995ab, 1996a).

4 Benefits of Transportation Investments

An important characteristic of transportation is that its demand is usually a derived demand, serving to satisfy spatial mismatches between demand and supply on various markets: goods markets for freight transport; labor and housing markets for peak-hour commuters' traffic, etc. Therefore, the benefits of, for instance, infrastructure supply cannot be seen in isolation from its interaction with the entire economic system, nor in isolation from its spatial structure (see also the contribution by Blum in this book), and since infrastructure usually lasts for decades, nor in disregard of the dynamic behavior of these two.

Due to the interrelations with other economic sectors, the estimation of benefits of infrastructure supply is, however, a complicated task. Nevertheless, a number of methodologies have been developed to assess these benefits, in particular in terms of the impact on regional and national growth (indeed, such models of infrastructure tend to focus on its use for firms). A distinction can here be made between studies at the firm level, measuring the reduction in (transport) costs that can be achieved through infrastructure improvements; and aggregate studies at the regional and national levels. The aggregate methods of benefit measurement at regional and national levels appear in two forms: (a) an aggregate production
function with transport capital as one of the production factors—with the computed output elasticities of transportation providing a measure of transport benefits; and (b) as aggregate cost functions which yield cost elasticities of public capital and private inputs. In the estimation of the production and cost functions, various analysts have used many functional forms, ranging from the Cobb-Douglas to newer flexible functional forms such as the translog and Generalized Quadratic. For the estimation of benefits in passenger transport, the value of time (see also the contribution by Hensher in this volume) is the most important input.

It would be too much of a distraction to discuss these methodologies in great detail here. There are many overviews of the recent literature on this subject (see for e.g., BTS, TSAR, 1995; Rietveld, 1989; Vickerman, 1991; Rietveld and Nijkamp, 1993). A clear majority of these studies conducted in North America conclude that highway capital reduces costs of transportation and production and makes a positive contribution to total economic output, although small relative to private labor and capital inputs. Similar studies carried out in European and Asian countries, some of them preceding the work done in the U.S., produce comparable results. Using various specifications of production and cost functions over different periods, in different countries, and with slightly different representations of several variables, researchers have usually inferred that transport infrastructure makes a positive contribution to productivity of the aggregate economy (see Table 4.1).

Table 4.1. Summary of Output and Cost Elasticities of Highway and Other Public Capital

<table>
<thead>
<tr>
<th>Country</th>
<th>Infrastructure Measure</th>
<th>Elasticity Range</th>
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<tbody>
<tr>
<td>United States</td>
<td>Highway capital</td>
<td>Output: 0.04 to 0.15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cost: -0.07</td>
</tr>
<tr>
<td>Japan</td>
<td>Transportation &amp; communication infrastructure</td>
<td>Output: 0.35 to 0.42</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Public Capital</td>
<td>Cost: negative, statistically significant</td>
</tr>
<tr>
<td>France</td>
<td>Public capital</td>
<td>Output: positive, statistically significant</td>
</tr>
<tr>
<td>Germany</td>
<td>Public capital, Highway capital</td>
<td>Cost: negative, statistically significant</td>
</tr>
<tr>
<td>India</td>
<td>Economic infrastructure: roads, rail, electric capacity</td>
<td>Cost: -0.01 to -0.47</td>
</tr>
</tbody>
</table>

The findings are, however, sufficiently varied to warrant further inquiry. Rietveld (1989), for example, asserts that the regional economic effects of the building of new infrastructure will be moderately positive (if infrastructure was initially lacking), neutral (if infrastructure already exists) or even negative (redistributive effects between regions). Furthermore, the impacts may vary quite strongly among economic sectors (Fukuchi, 1978; Blum, 1982) and between various transport modes (Blum, 1982; Andersson, Anderstig and Harsman, 1989).

A recent study by Professor Nadiri on the contribution of highway capital to U.S. productivity and growth is more definitive (Nadiri and Mamuneas, 1996). It uses cost functions for 35 industry groups—using the symmetric generalized McFadden cost function introduced by Diewert and Wales (1987). This study is careful and rigorous with a variety of statistical tests including "causality tests," whose results suggest that aggregate highway capital can be considered as an exogenous variable in these industry cost functions. The cost elasticities in manufacturing industries range from -0.146 to -0.22 and for service industries from +0.02 to +0.06. Positive cost elasticities suggest that the demand for highway infrastructure services in these industries is less than the available supply at the price the industries are willing to pay. These industries demand highway capital services but face "excess capacity" in highway capital—alogous to the notion of excess capacity in private capital stock in a private firm. Since the entire highway capital stock enters the cost function of each industry, (regardless of changes in the demand for its product), the cost to the firm will rise.

Nadiri and Mamuneas make endogenous estimation of cost factors, and independent estimation of a demand function for each industry—developing output and cost elasticities for each industry. Further, they calculated rates of return for total highway investment in the U.S. by relating cost reduction benefits to the opportunity costs of public roads—these aggregated to a measure of social rate of return. The social rates of return on highway investment were significant and high in the 1950s and 1960s, when there was shortage of highway capital stock and the interstate network was being put in place. It slowed down later but still is comparable to returns on private capital (see Table 4.2 and Figure 4.1). Nadiri calculates that highway investment is the second most significant contributor to U.S. total factor productivity, after the exogenous demand for goods and services, and well ahead of changes in factor prices or autonomous technical change.

Table 4.2. Annual Rate of Return by Type of Investment

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<tbody>
<tr>
<td>Total Highway Capital</td>
<td>28%</td>
<td>35%</td>
<td>35%</td>
<td>16%</td>
<td>10%</td>
</tr>
<tr>
<td>Non-local Highway Capital</td>
<td>34%</td>
<td>48%</td>
<td>47%</td>
<td>24%</td>
<td>16%</td>
</tr>
<tr>
<td>Private Capital</td>
<td>13%</td>
<td>13%</td>
<td>14%</td>
<td>12%</td>
<td>11%</td>
</tr>
</tbody>
</table>

Source: Nadiri and Mamuneas 1996.
Fig. 4.1 Net Rate of Return of Highway Capital, Private Capital, and Private Interest Rate (1951-1989)
5 Efficiency and Equity Considerations in Transport Policies

As has become clear in this and the previous chapters, the correct estimation of full (and marginal) costs and benefits of transport is fraught with all sorts of difficulties. Nevertheless, should one succeed in producing reliable overall figures, even then will the results often only provide a first guideline for the design and evaluation of policies. The reason is that, although distributional impacts tend to be ignored by economists advocating Pareian principles in policy making, the public at large and, as a result, also the responsible policy makers often seem to be at least as interested in equity and distributional consequences of policies as in their efficiency. In other words, in reality, it is often not the sum of costs and benefits, but rather their distribution, that governs policy choices. In this section, we discuss this problem by concentrating on a given subset of policy measures, namely those directed to the regulation of external costs of road transport.

The external costs of transport can be subdivided according to a number of criteria. An important distinction is between "intra-sectoral externalities," which users impose upon one-another (e.g., congestion, part of the costs of accidents) and "inter-sectoral externalities," which are imposed upon society at large (environmental externalities, noise annoyance, another part of the external accident costs). From the viewpoint of economic efficiency, both are relevant for the regulation of transport (both should be accounted for in optimal Pigouvian taxes based on marginal external cost pricing; see Figure 4.1). From the viewpoint of equity, on the other hand, especially the latter are important, as these make up the "unpaid bill" that transport imposes upon society.

There appear to be large differences between viewing the taxation of transport externalities from the traditional perspective of economic efficiency, and from viewing it from an equity perspective. For instance, consider the well-known Polluter Pays Principle. There, the question of whether the polluter should pay the total external cost, which may seem justifiable from an equity perspective, or whether marginal tax rules should be used for reasons of efficiency, may often lead to different outcomes in terms of both allocative efficiency and equity—unless of course marginal external costs are constant and therefore equal to average external costs.

Given such tensions between efficiency and equity considerations, it is no surprise that the mixing up of equity and allocative efficiency arguments may often lead to rather fuzzy discussions about the policy implications of research findings on external costs of transport. Table 5.1 gives an overview of the most important characteristics and implications of taking these two perspectives for the case of road transport, demonstrating the absence of a direct mapping between the two and hence identifying some sources of confusion in the above mentioned discussions.

Space is lacking to discuss this table in great detail here (see Verhoeof, 1996), but with the aid of the footnotes added, the reader should be convinced that estimates of external costs of road transport do not lead to unambiguous policy implications unless a clear goal for regulation is formulated. From the viewpoint of environmental quality, this should be the goal of allocative efficiency. For this
Table 5.1. Characteristics and Implications of the Allocative Efficiency Versus the Equity Perspective for Studying External Costs of Road Transport

<table>
<thead>
<tr>
<th></th>
<th>Allocative Efficiency Perspective</th>
<th>Equity Perspective (&quot;Unpaid Bill&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goal of the analysis</td>
<td>Assessment of &quot;optimal road mobility&quot; and optimal regulatory taxes</td>
<td>Assessment of the total costs shifted to society at large</td>
</tr>
<tr>
<td>Relevant external cost measure</td>
<td>Marginal external cost given induced defensive outlays by receptors</td>
<td>Total external cost plus induced defensive outlays by receptors</td>
</tr>
<tr>
<td>Apt level of aggregation</td>
<td>Individual</td>
<td>Sectoral</td>
</tr>
<tr>
<td>Relevant external cost categories</td>
<td>Intra-sectoral and inter-sectoral external costs</td>
<td>Inter-sectoral external costs</td>
</tr>
<tr>
<td>Relevance of some existing financial transfers:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Defensive outlays by receptors</td>
<td>Should not be accounted for in optimal taxes</td>
<td>Should be added to &quot;unpaid bill&quot;</td>
</tr>
<tr>
<td>Insurance premiums</td>
<td>Very limited relevance</td>
<td>Limited relevance</td>
</tr>
<tr>
<td>Car ownership taxes</td>
<td>Very limited relevance</td>
<td>Relevant</td>
</tr>
<tr>
<td>Indirect taxes on fuel</td>
<td>Potential relevance</td>
<td>Potential relevance</td>
</tr>
</tbody>
</table>

a These transfers are usually fixed yearly payments, (largely) independent of total kilometers driven. Hence, they have no direct impact on road usage.
b A certain share of accident costs (including fatalities) are intra-sectoral, and hence should not play a role in the "unpaid bill" analysis. Neither should therefore a certain share of the insurance premiums. Moreover, from the perspective of the "unpaid bill," the relevant question is whether the payments from the insurance companies to society are enough to cover the costs posed on the rest of the society.
c These taxes are a relevant coverage for part of the "unpaid bill" only if they exceed government outlays on infrastructure (depreciation, maintenance, management, police, etc.).
d Taxes on fuel will act as a substitute for Pigouvian taxation only when the rate exceeds those of indirect taxes on other goods (forgetting here about the "optimal taxation" argument for the sake of simplicity).
e Also here, only any indirect taxes above average rates can be considered as relevant transfers from road users to society, compensating for part of the unpaid bill.
goal, one can safely state that additional Pigouvian taxation of road transport is necessary. However, interest groups representing road users tend to use arguments of an equity nature to point out that road users already pay a lot to society, and that additional economic regulation is "unfair." This brings us to the issue of the social feasibility of regulatory policies.

Although the principles of Pigouvian regulation of externalities and its attractive efficient properties have been known for some 75 years now, practical applications in regulatory policies in road transport, as well as in other sectors, remain scarce. Still, one of the basic lessons in environmental and transport economics courses is the first-best character of regulatory taxation according to marginal external cost rules.

Figure 5.1 demonstrates this for the case of road transport, where as a complicating factor, both intra-sectoral and inter-sectoral externalities are present. The market equilibrium $N^0$ is at the intersection of the demand curve, which is equal to the marginal private and social benefits ($D=MPB=MSB$), and the marginal private cost curve (MPC). With identical road users, MPC may be equated to average social cost (ASC); it is positively sloped because of intra-sectoral externalities such as congestion. Taking account of intra-sectoral externalities, MSC represents marginal social costs; when accounting for the marginal environmental external costs MEC, TMSC gives the total marginal social costs. Optimal road usage is therefore at $N^*$, where net social benefits, given by the area between the curves MPB and TMSC, is maximized, and the shifted welfare loss $hel$ is avoided. Although diagrams such as Figure 5.1 are usually taken to represent the situation on a certain road on a certain time of day, the figure can also be seen as an abstraction for the more general road transport issue.

The identification of $N^*$ as "optimal" is of course contingent on the application of the, among economists more or less commonly accepted, potential Pareto criterion. However, this criterion to a considerable extent bypasses issues of equity, and therewith also the narrowly related issue of "social feasibility" of regulation. Social feasibility is not so much dependent on the question of whether society at large benefits from regulation, but rather on the distribution of such a net welfare improvement expressed, for instance, in the numbers of winners and losers, combined with the intensities of individual welfare changes. For example, in a very simple democracy where all decisions are taken by referendum, a rule of thumb might be that at least half of the voting population should benefit from a certain policy (change); otherwise it would not be accepted. Of course, most democracies do not operate in such a simple manner. Nevertheless, comparable decision and policy mechanisms will apply. In general, there will be some limit to the freedom of a democratically elected government, aiming at being re-elected, in the choice of their regulatory policies.

To illustrate this, consider two "textbook" instruments for achieving $N^*$ in Figure 5.1: a prohibition on mobility between $N^*$ and $N^0$, and the optimal effluent

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1Significant external benefits of road transport are not likely to exist; see Section 2. Hence, MPB and MSB are assumed to be identical in Figure 5.1.
fee $r^*$. The distributional impacts of these policies are given in Table 5.2. It is assumed for the moment that both policies succeed in achieving the Pareto optimum.

**Table 5.2.** The Welfare Effects of Optimal Physical Regulation and Optimal Fees

<table>
<thead>
<tr>
<th>Road users:</th>
<th>Road users:</th>
<th>Victims of the</th>
<th>Regulator</th>
<th>Social (total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0$ $N'$</td>
<td>$N'$ $N^0$</td>
<td>environmental externality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Optimal physical regulation</td>
<td>$abdc$</td>
<td>$beh$</td>
<td>$+beif abdc$</td>
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<tr>
<td>Optimal regulatory fees</td>
<td>$abdc abhg = cdfg$</td>
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Optimal regulatory taxation yields the same welfare effects as physical regulation for both policies for the mobility foregone, for the victims of the environmental externality, and for society at large. However, the remaining road
users are worse off, as total tax revenues *abhg* necessarily exceed the reduction in congestion costs *abcd*. These tax revenues of course accrue to the regulator, or more general, to the government. Therefore, in this stylized setting, where the two instruments are equally efficient in terms of accomplishing *N*′, they are certainly not equivalent in terms of social feasibility. The road users generating optimal mobility enjoy a welfare gain with physical regulation, whereas they are worse off with regulatory fees. Since the other groups are likely to be indifferent between both policies, physical regulation will be more socially feasible than regulatory taxation. If, in the case sketched above, the ratio of mobility and the number of road users is assumed to be constant along the horizontal axis, a majority of road users would even be in favor of physical measures, while all road users would be opposed to the fee. An important assumption here is that internal (time) costs do not differ among road users.

It is important to stress that the tax revenues are implicitly assumed to remain with the regulator, and that the various groups in society do not consider the possibility of benefiting from possible allocations of these financial means. Given the usual response to regulatory taxation ("the car as a cash-cow" or "yet another tax," instead of "more money for beneficial public projects"), governments should formulate convincing policy packages if such skepticism of taxpayers is to be overcome. In theory, it is by definition always possible to construct a lump-sum redistribution of means, including the tax revenues, such that everyone is better off after optimal regulation. This might, however, involve taxation of those benefiting from the reduced environmental externality.

Apart from differing in terms of social feasibility, regulatory instruments will usually also differ in terms of efficiency. In fact, the above assumption of both instruments achieving optimality is quite unrealistic. This particularly holds for physical regulation: it is hard to envisage a regulator applying "optimal" physical regulation by identifying and prohibiting the socially excessive mobility between *N*′ and *N*″. In reality, with physical regulation, the regulator runs the risk of also affecting mobility with relatively high economic benefits. In contrast to fees, which will naturally make the road users give up mobility between *N*′ and *N*″, where benefits fall short of the sum of the internal costs and the fee, a "quasi-optimal" physical measure might in the worst case affect mobility between 0 and *N*′ (with *N*′=*N*″=*N*′). Regulation may then even be inferior to non-intervention, like in the sketched case where the benefits foregone *∂N*′/*N* exceed the savings in social costs *N*″*N*′/*h*. Such adverse effects may for instance occur with a physical measure such as the "car-free Sunday;" temporarily applied in The Netherlands during the first oil crisis in 1973, and now again frequently mentioned in the public debate on transport and environment. It is very well possible that road users would much rather give up part of the mobility generated on week-days rather than on Sundays. If the benefits associated with some mobility generated on Sundays exceed those associated with some mobility generated on other days, such a measure is clearly not optimal from an efficiency perspective. In conclusion, with physical regulation, there is no guarantee that the remaining mobility represents the highest benefits. Between these two extremes, of course, various other types of second-best regulatory schemes will be available in practice, each with their own specific
features in terms of efficiency and social feasibility (see, for instance, Verhoef, Nijkamp and Rietveld, 1995ab, 1996ab).

This dilemma, and trade-off, between the efficiency of regulation on the one hand, and its social feasibility on the other, has come to the forefront as one of the major issues in contemporary transport policy debates (Verhoef, Nijkamp and Rietveld, 1996b). Most of the research into the social and political feasibility of transport policies concerns the issue of road pricing in the context of congestion regulation. Emmerink, Nijkamp and Rietveld (1995) provide an extensive literature survey; we will here only provide a brief discussion. A central element in the theory of the social feasibility of road pricing is that, with identical road users and under the assumption that the regulator keeps the tax revenues to himself, everybody except the regulator is worse off due to (optimal) congestion fees (see Verhoef, Nijkamp and Rietveld, 1997a), because the tax flow from road users to the regulator necessarily exceeds the monetary value of the time gains. This, of course, renders the policy a rather unattractive option for democratically elected politicians (everybody would vote “no”), notwithstanding its efficient properties. It has been observed that these redistributive effects of road pricing may dominate the efficiency gains (Evans, 1992).

A well established result from the literature, however, is that some road users may benefit from road pricing when heterogeneity of road users is allowed for. The typical case considered concerns income differences. A higher income implies, ceteris paribus, a lower marginal utility of money and hence a higher value of time (Verhoef, Nijkamp and Rietveld, 1997a). Therefore, starting with Richardson (1973), most authors conclude that road pricing is likely to be regressive (Layard, 1977; Arnott, De Palma and Lindsey, 1994). Clearly, stated this way, the non-intervention outcome is taken as a reference. Another way of looking at it is that higher income drivers suffer disproportionately from unregulated (excessive) congestion. From that perspective, it is of course questionable whether the progressive incidence of welfare losses due to unregulated congestion provides a sound basis for leaving this inefficiency in existence.

In general, externality pricing measures are likely to harm lower incomes more seriously, because of their ceteris paribus higher marginal utility of money, and their (consequently) lower willingness to pay to reduce externalities. However, Giuliano (1992) notes that such equity considerations may merely "present an apparently legitimate basis for opposition that is actually motivated by other reasons" (p. 349), and Small (1983, 1992) stresses at several places that road pricing may actually be progressive given certain redistributions of revenues. The same argument of course holds for other types of Pigouvian regulation.

A recent empirical study carried out by Verhoef, Nijkamp and Rietveld (1997a) confirmed both elements mentioned above: first, road pricing received more support from higher income groups; and secondly, the respondents' opinions on road pricing seemed to be very sensitive to the way that the tax revenues are to be allocated. Rienstra, Rietveld and Verhoef (1996) studied the social acceptability of a large set of transport policy instruments. They found strong support for safety related measures compared with congestion and environmental policy measures. Comparing various types of measures, it turns out that fiscal measures receive a
infrastructure policies are often unavoidable as they are for the regulation of externalities.

6 New Departures for Future Research

The positive (both pecuniary and technological) externalities of the transport sector comprise a wide range of phenomena. Even though the use of the system does not exhibit clearly demonstrable external benefits, the very existence of infrastructure may generate behavioral responses of various kind. Such a "bequest" value may have impacts on entrepreneurial perceptions of a region's accessibility and their future willingness to invest or locate, on the hedonic price of property values and recreational sites, on the degree of market contestability of new firms entering an isolated market, on complementary logistic improvements or informatics investments inside firms or transport operators, and so forth. So far scientific investigations have dealt with these issues only in a fragmented way, while there is certainly a need for more solid theoretical and applied research.

A second area of importance is the equity issue of transportation infrastructure, in relation to accessibility. This applies not only to peripheral areas characterized by low valued infrastructure provisions, but also for congested metropolitan areas characterized by traffic jams and environmental problems. The social support for new transport infrastructure depends in general on a complex array of social ramifications. It is a challenge for governments to find policies which ensure an efficient allocation of resources while guaranteeing both critical environmental quality levels and a sufficient infrastructure access to all groups involved.

Another field which deserves more attention in the future is the area of transport technology and transport systems dynamics. This puts the benefits issue in a dynamic perspective. Transport technology is not static, but may be actively stimulated in order to reap the benefits of improved pollution abatement. In this context, the main problem is the development of technology policies to influence the private sector where market risks may be high, as well as to encourage the adoption of new technologies among users who will derive primarily "public goods" benefits from such new technologies (see Nijkamp et al., 1996). Thus, the interface of transport systems technology and its social acceptance is a research issue of great social importance.

In the third place, there is need for more focused empirical indicators to support policy making. First of all, a clear typology of various kinds of benefits indicators would be necessary, with a particular view on the distribution of such benefit indicators among different social groups, regions, and sectors. A critical element here is that the spatial structure (or morphology) of a network is to a large extent responsible for geographically discriminating effects. This means that the spatial dimensions of such indicators ought to incorporate the network's structure. This is a largely under-researched area which needs to be explored more thoroughly. This will certainly include continued research on the estimation of the external costs of transport. But, measuring benefits, and the distribution of both are equally
context necessary to give transportation indicators precise meanings in the context of the complex role of transportation in society and in the environment, and to serve as a guide for their use in public and private decision making. This conference has taken a step toward those goals, but clearly much remains to be done.

7 References

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