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Benefits and costs of transport

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Abstract. This article aims to bring together insights from a broad body of recent literature concerned with the nature, the measurement and policy implications of benefits and costs of transport. It is argued that, for various reasons, transport cannot be treated as an 'ordinary' economic sector, and the policy implications of a number of the sector's peculiarities are addressed. Explicit attention is given to spatial aspects and network elements, internal and external benefits and costs, and efficiency aspects and equity considerations in policy making.

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1 Introduction

Transport undoubtedly belongs to the most complicated, and therewith fascinating economic sectors. The transport sector exhibits a number of specific features that renders common economic wisdom of only limited use in the assessment of the sectors' costs and benefits. Nevertheless, such an assessment is an important input for the design of transport policies based on solid economic principles. A number of these peculiarities of transport will be addressed in the present article. The article aims at providing a broad overview of the issues surrounding the benefits and costs of transport, and their policy implications.

A first important characteristic is that transport demand is usually a 'derived demand', serving to satisfy spatial mismatches between demand and supply on various markets: goods markets for freight transport; labour and housing markets for peak-hour commuters' traffic, etc. Therefore, the benefits of, for instance, infrastructure supply cannot be seen in isolation of its interaction with the entire economic system, nor in isolation of its spatial structure, and – since infrastructure usually lasts for decades – nor in disregard of the dynamic behaviour of these two.

Secondly, the costs and benefits of the entire transport system arise both through the supply and existence of infrastructure, and 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 as '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.

Thirdly, 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 (CO_2), which can have a local (noise) or a global (CO_2) impact, and so forth. Hence, it is unlikely that an unregulated transport market will be efficient in terms of accomplishing optimality in terms of, for instance, total mobility generated, the modal split, or the spatial and temporal (peak versus off-peak) distribution.

Of course, more peculiarities of transport can be mentioned – the fact that it takes place in a network environment, the mutually causal relationship with spatial economic development, the quasi-public character of infrastructure – but it will be clear that the assessment of the costs and benefits of transport provides an area of slippery ice. Nevertheless, we wish to tread upon it, and we will discuss a number of issues that complicate the assessment of transport's benefits and costs, and may therefore complicate the design of transport policies. In the next section, we will discuss issues related to the benefits of transport. Apart from considering the benefits *per se*, we will also pay attention to the distribution of benefits and related questions of equity. Section 3 is concerned with the cost side of transport, and we will pay attention to issues of equity and the related question concerning the social feasibility of transport policies. Section 4 offers some concluding remarks.

2 Benefits in transport systems

The benefits a society derives from a transport system arise through the usage of a (number of) transport network(s). Usually, the decisions of whether (1) to supply the infrastructure, and (2) to use it are taken by different actors. The latter decision is usually taken by individual agents (with, in case of public transport, the operator acting as an intermediate, offering certain services depending on the availability of infrastructure and the individual agents' demand). Although the possibility of private supply and exploitation of infrastructure increasingly gains interest (Nijkamp and Rienstra 1995), central, regional or local governments are normally responsible for the first decision. An economic rationale for the public provision is that transport infrastructure, especially when used at levels below which congestion sets in, exhibits non-rivalry in consumption, and, on the basis of cost considerations, non-excludability (especially for roads). These are the two standard criteria distinguishing public goods from private goods (Varian 1992). However, since these two criteria only apply with limited validity, most analysts agree that transport infrastructure actually is a 'quasi-collective' good.

Clearly, the benefits of infrastructure supply and usage are narrowly related: without usage, there are no benefits of infrastructure supply (apart, perhaps, from an 'option value'), and the total benefits of infrastructure can thus be seen as the total net benefits of the usage (net of the costs of usage) over the life of the infrastructure. We therefore start this section by discussing the benefits of transport.

2.1 Benefits and the derived demand for transport

In 'ordinary' goods markets, the benefits derived from consumption can quite accurately be described by consumers' surpluses, derived from Marshallian demand curves (although from a strictly theoretical perspective, Hicksian measures may deserve preference; see Varian 1992). For the benefits of transport, it is in this respect important to recognize the derived character of the demand. Often, it is not the consumption of transport services itself that yields benefits, but rather the possibility to demand or supply certain goods (for freight transport) or services (for passenger transport) at different locations. In such cases, the benefits of transport are actually to be found in the increase of consumers' and/or producers' surpluses in these markets. This means that for a given infrastructure, the benefits of its usage often arise in other markets, and cannot be seen in isolation of the factors that determine the demand for transport.

This can be illustrated, for the case of freight transport, with the aid of a simple spatial price equilibrium (SPE) model, first presented in a seminal paper by Samuelson (1952) and later on extensively studied and further developed by Takayama and others (see Takayama and Judge 1971; and Takayama and Labys 1986). Figure 1 gives the diagrammatic representation of SPE in a back-to-back diagram. Two nodes A and B are distinguished (by subscripts), and the local demand (D) and supply (S) curves can be used to derive equilibrium prices and quantities supplied (Q) and demanded (Y), in autarky (superscript A) and with trade (T). To derive the latter, for both nodes R an excess demand/supply curves $X_R(E_R)$ is constructed by horizontal subtraction of the supply curve from the demand curve, where E gives the net export. Using that in equilibrium, the price difference between the regions should be equal to the transport costs t, the after-trade equilibrium can be found where $E_A = -E_B$ and $|P_A^T - P_B^T| = t$.

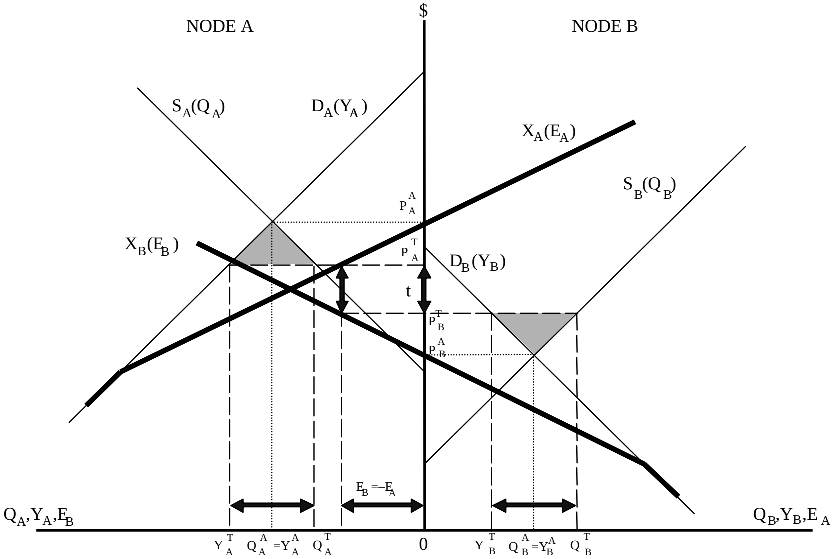


Fig. 1. The benefits of transport in an SPE model

In Fig. 1, we find $P_A^T - P_B^T = t$, and $Q_B^T - Y_B^T = E_B = -E_A = Y_A^T - Q_A^T$: node B is the net exporter. The two shaded areas give the net benefits of transport, which are made up from changes in consumers' and producers' surpluses. Both nodes gain, as they should with voluntary trade. However, it can be noted that in node A the consumers benefit whereas the producers lose, while the opposite occurs in node B. It is relatively easy to see that for this system, the demand for transport can be found by vertical subtraction of X_B from X_A. The relevant range lies between the vertical axis and the intersection of the two curves. Hence, although the demand is derived, the principle that the area under the demand curve for transport gives total benefits still applies.

The benefits of transport can thus often be thought of as the benefits of the increased local specialization it enables. Although it is of course hard to imagine what our contemporary societies would look like in absolute absence of transport in order to determine the 'total benefits of transport' (note also that transport is very broadly defined in Fig. 1, including all possible modes of movement of goods and persons), the above principle can also be used to assess the benefits of marginal changes in the transportation system. The above SPE model is probably the most simple spatio-economic system with transport that one could think of, but nevertheless, it already demonstrates a number of important complications that are associated with the evaluation of transport infrastructure investments (which could be represented by a reduction in transport costs t).

In the first place, an estimation of the benefits of such an investment often requires an estimation of its impact on other markets in the spatio-economic system considered. In particular, the benefits of such projects are likely to be spread out over various markets related to the transport market. However, this does not imply that the benefits are ‘external’; note in particular that for the attainment of the optimum in Fig. 1, market forces can be relied upon and no Pigouvian subsidization is required. Secondly, in contrast to many other types of public investments, where often only ‘winners’ and ‘non-affected’ are involved (leaving aside the question of tax raising and feelings of jealousy), transport infrastructure improvements are likely to cause some agents to be better off (consumers in A and producers in B), but also some to be worse off (producers in A and consumers in B). The incidence of gains and losses over different interest groups may thus vary over space. This means that equity considerations, and issues of social feasibility are likely to be important determinants for the viability of infrastructure policies.

2.2 Infrastructure and spatial dynamics

In this section we will focus on some main aspects of spatial dynamic consequences of infrastructure supply. Broader reviews can be found in Vickerman (1991), Rietveld and Nijkamp (1993) and Rietveld (1994). As shown in Table 1, transport infrastructure investments have both temporary and non-temporary effects on the economy. Infrastructure supply has a broad range of effects which are spatially differentiated. In the present section we will give a discussion of a number of them, including: (a) construction phase effects, (b) trade, (c) changes in distribution systems, (d) productivity, (e) housing and labour markets, (f) monopolistic price setting.

Table 1. Temporary and non-temporary effects of transport infrastructure investments

	Demand side	Supply side
Temporary effects	Construction effects crowding-out	–
Non-temporary effects	operations and maintenance	effect on productivity, trade, land use, etc.

2.2.1 Construction phase effects

A major temporary effect concerns the stimulation of employment and income during the construction phase via the demand side. A straightforward tool to use is input-output analysis. However, attention should be paid to the question how the infrastructure is financed. A tax increase or an increase in interest rates due to government borrowing on the capital market would have a negative impact on consumption or investments which would counter the initial demand stimulating effect of government spending. Such crowding-out effects are often ignored in regional or urban studies where the infrastructure project is considered ‘small’ compared with the size of the national economy. However, if local projects are financed by means of local financial resources (local taxes), one should of course take into account the impacts of these taxes on investment behaviour of firms in the area concerned.

In a spatial sense the construction phase is interesting, because the infrastructure project will be partly carried out by local construction sector workers. Depending on the level of sophistication of the work also a good part of non-local workers may be needed. In addition, spatial effects in the construction materials industry and other suppliers may take place in regions far away from the region.

2.2.2 Trade

The effects of transport infrastructure on trade have already been discussed by means of a simple two region model in Sect. 2.1. Of course this is a very partial model, since only one market was distinguished. Also for more complicated interregional trade models the main conclusion remains true that improvement of infrastructure, leading to lower transport costs, implies tendencies towards local specialization and larger trade flows. Much will depend on the extent to which factor markets are flexible and production factors are mobile. With highly mobile production factors responding to differences in factor payments substantial shifts in economic activity may occur.

Of special importance are economies of scale in production. When scale economies exist, regions with an initial advantage may benefit much more from a reduction in transport costs than other regions (Krugman 1991) leading to a process of 'cumulative causation' (Myrdal 1957).

2.2.3 Spatial organization of distribution

Above we noted that infrastructure improvement leads to a reduction in transport costs and hence affects trade flows. A closer look reveals that infrastructure investments may have various effects in the way production, transport and distribution are organized. Infrastructure provision may in principle affect choices concerning matters such as: route choice (including port choice), mode choice, location of distribution centres, number of levels in distribution structure, choice of logistical strategies, etc. McKinnon (1996) mentions three types of 'reorganizational benefits' of transport infrastructure supply that are of particular importance: market expansion, spatial concentration and tighter scheduling.

Market expansion may be quite important in less developed regions where the improvement of infrastructure makes the exploitation of natural resources feasible. It may also have large effects when island economies get fixed links. Note further that due to various factors (such as limits on driving hours of truck drivers, and the wish of business travellers to return home on the same day) in some cases even a modest improvement of infrastructure may induce a substantial reduction in transport costs, implying improved opportunities for reaching markets further away.

Spatial concentration is the result of an adjustment of the optimal plant size as a result of a trade-off between size dependent production costs and transport costs of inputs and outputs. These scale effects also play an important role in warehousing.

Examples of tighter scheduling are the just-in-time principle in manufacturing and quick-response principles in the retail sector. The application of these principles presupposes the existence of a well developed and reliable infrastructure. These principles induce a decrease in the stocks and an increase in freight traffic, although, as noted by McKinnon (1996) due to various consolidation and collection schemes, this increase is smaller than often thought.

The general conclusion is that improvement of transport infrastructure does not only lead to larger trade flows as indicated earlier, but also to a more transport intensive way of organization of production and distribution having distinct effects on the spatial distribution of production and distribution activities.

2.2.4 Productivity

Transport infrastructure can be considered as a stock of a certain type of capital available to a region or a country. A general formulation of a production function for sector i in region r, with various types of infrastructure is:

$$Q_{ir} = f_{ir}(L_{ir}, K_{ir};\ IA_r, \ldots, IN_r) \tag{1}$$

where Q_{ir} is value added in sector i, region r, L_{ir} employment in sector i, region r, K_{ir} private capital in sector i, region r, IA_r, ..., IN_r infrastructure of various types in region r.

This function indicates that production takes place by means of combining labour, private capital and infrastructure. The relationships between these inputs may have a substitutive or complementary character. For example, with better roads a transport firm needs fewer trucks and fewer drivers to reach the same level of production (substitution). On the other hand, with broader canals a transport firm may use larger ships (complementarity) so that the number of workers can be reduced (substitution).

It is not so easy to take into account the *network* properties of transport infrastructure in the production function approach. One thing one can do is to distinguish various types of transport infrastructure according to their spatial range: intraregional, interregional and possibly international. A related problem with infrastructure is that its impact may transcend the boundaries of regions. A certain region may benefit from a university or airport, even though these facilities are not located in the region itself. This problem of spatial spill-overs may be solved by using the concept of *accessibility* of certain types of infrastructure in the production function (see, e.g., Johansson 1992). An alternative approach to study the role of infrastructure in production processes is to use cost functions (Elhance and Lakshmanan 1988, Seitz 1993). The productivity impacts in empirical studies may vary strongly among economic sectors (Fukuchi 1978; Blum 1982) and between various transport modes (Blum 1982; Andersson et al. 1989).

Production functions have been applied at various spatial levels: national, regional, metropolitan. Their orientation can thus be characterized as macro to meso. Production functions give an aggregate view of the contribution of infrastructure to productivity. Note that this approach does not cover all welfare aspects of infrastructure supply: the impact on the consumers is not taken into account. Due to the aggregate nature of the production functions it can hardly be used to give an ex-ante prediction of specific projects. Only when the network properties of infrastructure are adequately represented in the production function, this approach may become useful for this purpose. A strong point of the production function approach is that it represents the sum of direct and indirect productivity effects, though in an implicit way.

Note that in this production function an increase in the infrastructure stock leads to a shift in productivity: it does not lead to a permanently higher growth rate. Such a permanent increase in the growth rate might be present, however when transport infrastructure investments lead to a higher level of knowledge production – for instance, through improvement of existing technologies, or development of new technologies during the project – which would affect the growth level according to endogenous growth theory.

2.2.5 Housing and labour market

It is conventional wisdom that improvement of infrastructure leads to better functioning of labour markets. More workers can be recruited within reasonable commuting distances leading to a reduction of unemployment and vacancies due to spatial frictions and a better match between the demand and supply side of the labour market. In the long run the effects are more diffuse, however. Urban economic theory predicts that a decrease in transport costs will lead to a shift in settlement patters towards a more diffuse pattern of land use (Fujita 1989). This will lead to an increase of commuting distances. This means that next to a reduction of spatial frictions indeed implying an improvement of productivity of firms due to improved spatial organization and distribution mechanisms mentioned above, there is also a welfare effect on households because they can now live in a more spacious dwelling and in a nicer environment. There is ample evidence that commuting distances in many countries have increased considerably as a response to the improvement of transport infrastructure. These longer distances are not so much the consequence of new recruitments at a longer distance, but much more of voluntary moves of households who relocate to another dwelling (see, for example, Rouwendal and Rietveld 1994). It is probable therefore that the welfare improving effects for households are larger than the productivity improving effects for firms.

2.2.6 Monopolistic (monopsonistic) prices

A final point of interest is that improved infrastructure leads to an increase in the number of suppliers (or demanders) in the market. This has a favourable effect on consumer welfare because it reduces the probability of collusive behaviour between suppliers. Large improvements may take place in the more extreme case that areas are dependent on only one trader, as may be the case in isolated regions in developing countries (Johnson 1970).

2.3 Distributive and generative effects

An important feature of transport infrastructure is that improvement of infrastructure will generally lead to both ‘distributive’ and ‘generative’ effects. Distributive effects occur when positive impacts of infrastructure improvements are compensated for by negative impacts elsewhere in the economy (both in a sectoral and in a spatial sense). Generative effects, on the other hand, refer to the net (welfare) improvement that accrues to the total spatial system affected by the investment. This distinction is important, in particular because the generative effect of an investment may be overestimated when the study area is too narrowly defined.

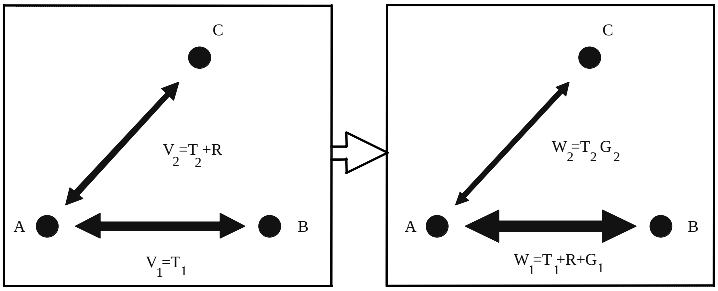


Fig. 2. Network effects of an improvement in link 1 (between A and B)

An important reason for this feature of infrastructure is its network character. Improvements (and construction) of links will usually not only affect that link itself, but will also affect other links in the network, and therewith welfare in the nodes not directly served by the improved link. Figure 2 (based on an example in Button 1993) shows this for a very simple network with one origin (A) and two possible destinations (B and C). For the determination of the benefits of an improvement in link 1 between A and B, it is necessary to distinguish three groups of users: those who do not change their behaviour (groups T_i; i denotes route); those who will switch from choosing destination C before the improvement, to B afterwards, due to its increased accessibility (group R); and newly generated traffic (groups G_i). These groups together determine the change in total traffic for both routes ($W_i - V_i$). Especially when the network was originally congested, none of the groups will generally be of zero size.

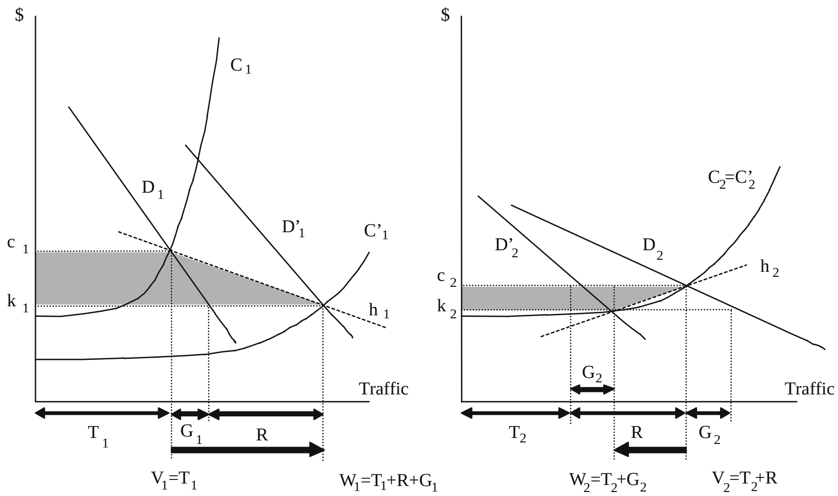


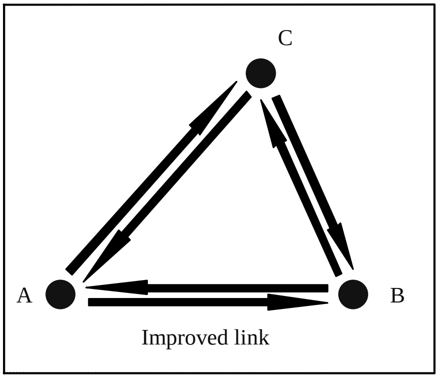
Fig. 3. Impacts and total benefits on a two-link network owing to an improvement on one of its links

Figure 3 shows the economic equilibrating principles underlying the changes in traffic volumes (from V_i to W_i). D_i denotes the demand curve for link i, C_i the cost curve (which are rising due to congestion effects), and primes denote the situation after the improvement. The cost curve C_1 shifts down owing to the improvement; D_1 shifts outwards and D_2 inwards due to route switching of group R, equilibrium user costs are reduced from c_i to k_i on both routes, and usage increases on link 1 and decreases on link 2. Assuming linear demand relations, and a linear cross-demand relation, the total benefits of the improvement are given by the so-called 'rule of half', stating that the benefits of an improvement in a network is equal to the sum (over all links) of the average usage (before and after the improvement) times the decrease in equilibrium cost on that link (see also Button 1993):

$$\sum_{i}^{I} \frac{1}{2} \cdot [V_i + W_i] \cdot [c_i - k_i] \qquad (2)$$

(this expression carries over to larger networks of I links). In Fig. 3, these benefits are indicated as the shaded areas.

After 'closing' the above network by adding link BC, we find the network given in Fig. 4, which can be used to explore the network implications of infrastructure improvements somewhat further. Consider a model of interregional trade where the share of imports into region j from a certain region i depends negatively on transport costs between i and j relative to an indicator of aggregate transport costs from all regions to region j. Then, in this spatial configuration an improvement on link A-B can be shown to have an unambiguously negative effect on the trade share of region C (Amano and Fujita 1970). For the regions A and B, the effect on trade shares is not clear, as this depends on the extent to which the loss on the home market can be compensated for by an increased



		Destination		
		A	B	C
Origin	A	-	+	0
	B	+	-	0
	C	-	-	0

Fig. 4. Response of trade shares to transport cost reductions in a three-region network owing to an improvement on link A-B

penetration on the other region's market (Rietveld and Nijkamp 1993). Note that this model is concerned with trade *shares* only; when total production changes, and especially economies (or dis-economies) of scale occur, the picture becomes more complicated.

It may be clear from these examples that, even in very simple networks, improvements in infrastructure will generally have an impact not only on the links and in the nodes or regions directly involved, but will often have effects also on other links in the network and on other regions and nodes. The distinction between 'distributive' and 'generative' effects is therefore indeed important. Moreover, these interdependencies imply that the impacts of certain infrastructure improvements not only vary over space and sectors within the area directly concerned, but may often carry over to (much) larger areas. Generally, areas directly involved will benefit (although this certainly need not hold for all interest groups within these areas; compare Fig. 1), whereas the indirect effects for other areas may well be negative (compare Fig. 4). This implies that infrastructure investments can be seen as a strategic game, where improvements in one area may induce the need for other areas to follow.

A central government, deciding on its infrastructure policies, faces the dilemma that accessibility is both an absolute and a relative concept. Therefore, favouring certain regions may have perverse impacts on other regions (relatively and absolutely speaking). Although the distribution of the total benefits of a rationally selected infrastructure investment will of course not be a zero-sum game, trade-offs between economic efficiency and (spatial and sectoral) equity in infrastructure policies are often unavoidable.

Finally, it should be mentioned that the cost-benefit type of analysis considered above is often performed under the assumption of first-best conditions applying throughout the economic system. As soon as this is not the case, such analyses may become a lot more complicated. In particular because unpriced external costs often exist in transport (see also Sect. 3.3), this problem should be taken serious in cost-benefit analyses in transport. For reasons of space, we will not discuss this issue here; important contributions on this topic can be found for instance in Wheaton (1978), Wilson (1983) and d'Ouville and McDonald (1990).

2.4 External benefits to transport?

From the above list of (spatial) effects it is clear that changes in transport may bring about a large number of changes in the economy, many of them having welfare improving effects. An important question is to what extent these are taken into account in an appropriate way in standard cost benefit analysis. Are they fully reflected by the consumer surpluses as shown in Figs. 1 and 3? This question has been addressed among others by Willeke (1992) who claims that there are substantial benefits owing to infrastructure (road) improvement, and Rothengatter (1994) who claims that such benefits if they exist at all would be small. The political importance of this debate lies in the fact that road transport is paying substantial Pigouvian taxes in many countries to correct for its external costs (see Sect. 3). Therefore, if there would exist external benefits to (road) transport this would imply that there is a case for subsidies to infrastructure use, or at least a reduction in the tax levels.

Indeed it is true that transport infrastructure provision has effects that are much wider than only take place in the transport sector itself. Without infrastructure our economies would collapse. This, however, is not the issue at stake here. Two important aspects should be considered.

First, we should not focus on the *average* contribution of transport to our welfare, but on the *marginal*. When discussing a subsidy for infrastructure use because of positive externalities, the relevant question is not how large the welfare gain is when we compare an economy without and with (road) transport; instead, the relevant question is what is the marginal change in social welfare given a marginal change in the number of kilometres driven (compare the difference between the average and marginal utility of drinking water: the first is close to infinite because life is almost impossible without it, the last is close to zero because nobody cares about another glass of water).

Second, it should be checked whether in the procedure of estimating benefits of infrastructure improvements via consumer surpluses as shown above there is a neglect of certain benefits which take place outside the transport sector. For most of the examples given above it is clear that there is no need to worry. For example, in the trade case dealt with in Sect. 2.1 we find that the total benefits due to a reorientation of production and consumption are fully reflected by the area under the demand curve for transport.

External benefits would imply that the total benefits of the use of infrastructure are larger than the willingness to pay of the immediate user. Thus there must be another party who gains without there being a payment by this beneficiary to the actor using the transport infrastructure. A closer look reveals that in the relevant cases discussed in Sect. 2.1 such a payment always takes place, and hence there are no externalities involved.

However, some additional cases can be listed where positive marginal externalities might be present. We will discuss them in some detail below.

Plane (or car-) spotters. These consumers indeed get a welfare increase from observing planes or cars without a financial transfer. The economic importance of this phenomenon is limited and often negligible.

Trips with a social purpose. Many trips give positive utility to those who get a visit. The visitor pays the costs of the visit, and the person visited does not compensate him for it. As indicated by Verhoef (1996) these trips are characterized by reciprocity (the compensation of the visit is a counter visit), or by altruism (the visitor includes the utility of the person visited into his utility). In the first case there is no external element involved, in the second there may be an external benefit, e.g, when the person visited feels that his utility does not receive sufficient weight in the visitor’s utility. In principle, the person visited could reveal his willingness to pay to the visitor by offering a compensation (for example in the form of a good meal), so why would the government subsidize the visitor’s transport costs? Thus, this does not provide a convincing case of a positive externality. Note further that some people may dislike visits of certain persons so that one would arrive at a negative externality. It is clear that this example is in general too weak and unimportant to serve as a case for a subsidy to social visits in (road) transport, let alone to (road) transport trips at large.

Emergency services (police, ambulance, fire-brigade). These services may save lives and properties; they are mentioned by Rothengatter (1994) as one of the few possible exceptions to the rule that positive externalities do not exist in the use of transport infrastructure. Without a proper transport system these services cannot function. Does this imply that these services deserve a subsidy? Note that demand for these service trips is (almost) price inelastic: the willingness to pay for it is very high, so that for the relevant price ranges of transport costs the demand can be considered as fixed. In most institutional settings the services are offered by the public sector and the consumer does not pay. Expenses are usually covered by taxes. The risk that the fire-brigade will not show up because its budget does not allow it to pay for the use of the road is negligible. We conclude that the willingness to pay for these emergency services is high; this will be reflected by a relatively large contribution to consumer surplus implying a strong case for the construction of the infrastructure. However, there is no externality involved so that this is not a solid case for a subsidy on infrastructure use. A paradoxical result of making road use cheaper would be that it may increase congestion implying a deterioration of the quality of emergency services.

National security. Transport infrastructure may fulfil an important strategic role for the national defense sector. This holds for roads as well as airports, ports, and railways; the latter especially in the past. Considerations of national security may and do certainly play a role in discussions concerning, for instance, privitization of national transport infrastructures, but for the same reasons as given above in the context of emergency services, the benefits of increased national security due to better infrastructure[1] do not imply that ‘normal’ use of this infrastructure should be subsidized at the margin.

Image effects related to infrastructure. For example, port A becomes a more attractive transfer seaport when it has a railway connection to the hinterland; even when the railway will not be used (because existing water and road connections with the hinterland are appropriate and cheaper), it improves the status of A so that its market share as a transfer port increases. If the status of hinterland connections really matters in the decision of container lines to include port A into their operations, an investment into a railway line may indeed be profitable. From a welfare economic point of view it is most probably not a good investment, because it is difficult to see how it will yield additional consumer surplus. Since the status effect is assumed to be independent of the volume of traffic on the line, there is no reason to subsidize the use of the line. There are external elements here but they do not relate to the use of the infrastructure, and therefore there is no need to bother about subsidizing its use. This is an extreme example of a status effect. A more realistic example would be that the railway line will be heavily underutilized but again there is no reason in that case to subsidize its use, even if the regional or national authorities decide to subsidize the investment for spatial competitive reasons. Note that, if regional or national governments engage in this type of competition based on image effects, the result may well be that in the end everybody is worse off due to excessive investments in socially unwarranted infrastructure.

We conclude that no clear and significant case of a positive externality of infrastructure usage has been identified. Important sources of confusion seem to be (1) that transport has many (positive) effects outside the transport sector itself; however, as shown above these effects are properly represented in the consumer surplus of the transport demand curve, and (2) the benefits of infrastructure supply as outlined in Sect. 2.2 are often mistaken to be the same as ‘external benefits of transport’. Note, in particular, that the total net social benefits of a certain infrastructure investment are maximized when its usage is optimized through a proper internalization of the external costs resulting from its usage. There is no need to worry that there would be an underinvestment or underutilization of transport infrastructure accordingly. There is no solid basis for a subsidy to infrastructure use.

It appears that the major issue should not be whether cost-benefit analysis overlooks certain (external) benefits of infrastructure. The real problem is that cost-benefit analysis should be based on properly estimated demand functions. The demand functions should reflect the various indirect effects mentioned in Sect. 2.2. Priority is needed for research to improve integrated ex-ante impact studies of transport infrastructure. This does not imply that cost benefit analysis itself is without problems, but the problems seem to be located at other places:

[1] For the sake of the argument, being in search of possible external benefits, we assume here that a better infrastructure does increase national security on the whole. It is of course often the case that, once a country is occupied, the enemy benefits from the infrastructure.

the way negative externalities are valued, and the possibility to take into account (spatial) equity problems (see Sect. 2.3)

2.5 Infrastructure and employment

The main focal points of this article concern the costs and benefits of transport infrastructure use. Cost-benefit analysis provides a useful framework to analyze these effects in a policy oriented context concerning investment decisions and pricing. However, cost benefit analysis also often meets criticism. Some of these are indeed not easy to overcome (lack of knowledge how to value external effects, how to deal with equity issues). Another criticism of cost-benefit analysis is that it is too soft in the sense that its outcomes depend strongly on welfare effects such as time gains of persons travelling; instead one would like to concentrate on the effects of infrastructure on the business sector. The basis of this criticism seems to be that only effects that can be measured via the GDP are important. In our opinion this is a risky view, that does not sufficiently recognize the importance of infrastructure for the consumer.

Another issue concerns the employment effects of infrastructure investments. It is striking that especially local and regional governments base their argumentation in favour of employment effects. Obviously it is easier to communicate to the general public that a project will generate 500 jobs than that its internal rate of return is 9%. A question is to what extent projects may be expected to lead to identical rankings when cost benefit analysis is used, compared with employment based rankings. The answer is that there is little reason to expect that the two criteria run parallel. The first reason is that the employment approach ignores the positive effects on consumers, which often play a dominant role at the benefit side. The second reason is that productivity gains as can be studied by means of the production function approach (Sect. 2.2) may have a negative effect on employment. The background is that substitution effects would lead to a decrease in demand for employment. One cannot be sure a priori whether such a substitution effect will be compensated by a positive output effect. This depends on the extent to which the productivity increase leads to a decrease in prices of the various goods produced and on their price elasticities.

The concern about employment can be understood from the situation of chronic unemployment experienced by many economies during the past 25 years. Indeed, in this case the use of the current wage does not reflect the opportunity costs of labour. Many more workers would be prepared to work for the current wage. Therefore a lower shadow price for labour should be employed. This holds true for both the temporary employment generated during the project and the permanent employment effect (if there is any) after the project. Our conclusion is that in situations of chronic unemployment cost-benefit analysis should be based on a shadow price of labour which is lower than the market price. If this is not taken care of, it underestimates the net benefits of infrastructure supply. However, in situations of more balanced labour markets there is less reason to focus on employment. From a welfare economic viewpoint, employment is not a goal per se and it makes no sense to increase employment without taking into account its welfare implications in terms of leisure and consumption opportunities. In economies plagued by overheated labour markets one would even like to see infrastructure projects of a labour saving nature.

We conclude that in situations of chronic unemployment, the use of the wages observed on the market leads to an underestimate of the net benefits of projects. This provides an argument to pay special attention to them in impact studies. Since also equity aspects and (intangible) environmental effects have to be dealt with, we arrive at the conclusion that multicriteria analysis as a tool for a systematic analysis of conflicting criteria is a welcome complement to the standard cost-benefit approaches (see Van Pelt 1994).

Summing up, the benefits of infrastructure supply and investment (that is, offering an increase in supply) consist of the (discounted) stream of the net benefits of transport. These, in turn, are often hard to measure, as transport often is a derived demand. Accessibility as such yields no benefits; only when it is used, through spatial interaction, are the benefits to be reaped.[2] For the net benefits gains in freight transport, this means that one would have to predict the dynamic behaviour of a spatial economic system, often much larger than the area in which the investment takes place due to network effects, to assess the benefits of infrastructure improvements. Moreover, a complicating factor is that the incidence of benefits will usually strongly vary over space and over interest groups, and that some groups may actually be made worse off due to infrastructure improvements. Whereas the benefits for freight transport can be monetized by predicting the impact on regional economic growth, the benefits for passenger transport are often even more difficult to assess. Once the improvement is in existence, however, the rule of half may give an *ex post* impression of the net benefits enjoyed. Finally, there is no *a priori* reason to believe that market forces would not be able to realize the benefits of infrastructure improvements. In other words, the benefits of transport are market internal, and there is no need for Pigouvian subsidization of transport. Nevertheless, but not in contradiction with the foregoing remark, these benefits often manifest themselves on other markets than the transport market itself, through, for instance, increased efficiency in production. The benefits of infrastructure provision, on the other hand, often have a public character, which justifies public intervention in the provision of transport infrastructure.

3 Costs in transport systems

Also on the cost side, and actually even more clearly than on the demand side, a distinction can be made between costs of infrastructure supply and costs of its

[2] Hence, pure ‘existence values’, which in environmental economics are often distinguished from the more traditional ‘use values’, seem to have no specific relevance for transport infrastructures, and we would not advice transport policy makers to base investment decisions on such considerations.

usage. Although we will pay more attention to the latter in what follows, we also wish to highlight a few issues surrounding the former in the next sub-section.

3.1 Costs of infrastructure supply

The costs of infrastructure supply are usually subdivided into costs made during the construction, and costs which are subsequently incurred over the lifetime of the project (for instance, maintenance costs). For road infrastructure, the latter are usually in the order of 1-2% (per year) of the former. Along with the public good argument and the above discussed (spatial) equity considerations in addition to issues of economic efficiency, this lumpiness of costs of infrastructure supply, as well as the uncertainty of future returns (should there be pricing on it), are often seen as important additional reasons for public provision.

An important question concerning the costs of infrastructure supply is by whom these costs should be borne. Traditionally, it is ‘the tax payer’ (sometimes partly the payer of vehicle ownership taxes) who will pay for the publicly provided infrastructure. In such cases, there is no direct link, or sometimes even no link at all, between those who pay for the infrastructure and those who use it. On the basis of principles of fairness, it could be asked whether the link between using the infrastructure and paying for its costs should not be as close as possible. This principle is used, for instance, in Scandinavian toll-rings, where the main purpose of the tolls is often to raise revenues for financing the local road infrastructure. The question then becomes whether the purpose of pricing on infrastructure should be cost recovery or regulation of externalities. One of the most famous results in transport economics, found by Mohring and Harwitz (1962), however, is that under certain assumptions – in particular constant returns to scale in user cost and capacity construction – it can be shown that the revenues of optimal congestion pricing are just sufficient to cover the cost of optimal capacity supply. This means that these two possible goals of pricing need not be as conflicting as one might think at first sight.

Despite its appeal, it is clear that the above principle will in practice be difficult to apply, in particular because of the already mentioned lumpiness of transport infrastructure investments. Hirschmann (1958) already pointed out that one will often see relatively long periods of excess demand or supply. Moreover, the question towards scale effects in user costs and capacity construction also has not been settled yet (see Small 1992a).

3.2 Internal costs of infrastructure usage

For a discussion of the costs of infrastructure usage, we confine ourselves to the case of road transport; firstly for reasons of space, secondly because it is the most important mode of inland transport, and thirdly because it is probably also the most intriguing one.

One of the most important distinctions one can make in the costs of road usage is between internal and external costs. The former are incurred by the individual road user herself, whereas the latter are those costs which are posed upon others, without a market taking care of the optimal allocation of these costs (see Verhoef 1994, for a formal definition and discussion of the external costs of road transport). This does not mean that all internal costs are actually priced: for instance, an important element in the private costs of road transport is given by time costs, which have a clear economic value, but no market price (note, however, that extra time losses posed upon other road users, in case of congestion, are indeed external).

Within the class of internal costs, a further distinction can be made between fixed costs, related to vehicle ownership, and variable costs, related to specific trips or to kilometres driven. In a standard neo-classical optimization framework, a road user would decide to purchase a car and carry the fixed costs over its lifetime (including fixed vehicle taxes, insurance taxes, and so forth) if the discounted stream of expected net benefits (net of variable costs) of individually optimal road usage – for each trip based on the marginal private benefits $\geq$ marginal private cost rule – exceeds the fixed costs of car ownership. In principle, from the viewpoint of economic efficiency, there is nothing wrong with this, and pleas for the variabilization of fixed costs, for instance through 'car sharing', make economic sense only if it is taken as a second-best alternative to optimal regulation of external costs of road transport.

Where efficiency in private optimization actually may fail is in the perception of variable cost. It is a well known result of transport studies that many persons are badly informed about the costs and benefits of transport alternatives (see Blaas et al. 1993). For example, car users are not aware of the full monetary costs of a trip. Apart from 'correctly' ignoring the fixed costs when deciding to make a certain trip, also wear and tear, and even fuel costs are sometimes overlooked; the only remaining cost component considered being the out of pocket costs for parking and presumably the time costs. It is not straightforward, within the standard economic framework, whether governments should actively intervene when people choose to 'mislead' themselves (there should be some benefits from doing so, otherwise people would not do so). It is likely, however, that a policy of education and information provision in such cases may enhance economic efficiency. Nevertheless, this problem would probably be considered as less serious if the induced extra vehicle-kilometres would not damage society through the external costs caused.

3.3 External costs of infrastructure usage: efficiency versus equity[3]

Road transport causes many types of external costs. Usually, at least the following main categories are distinguished: environmental pollution, road accidents, noise annoyance and congestion. These external costs of road transport can in fact be

[3] Sections 3.3 and 3.4 draw heavily on Lakshmanan et al. (1997).

subdivided into intra- and inter-sectoral externalities. The former are externalities that road users pose upon one-another (e.g., congestion, part of the costs of accidents). The latter are posed upon society at large (environmental externalities, noise annoyance, another part of the external accident costs). The relevance of these two types in a way depends on the viewpoint taken. From the viewpoint of economic efficiency, both are relevant for the regulation of road transport (both should be accounted for in optimal Pigouvian taxes based on marginal external cost pricing; see Fig. 5 below). From the viewpoint of equity, on the other hand, especially inter-sectoral externalities are important, as these make up the 'unpaid bill' that road usage poses upon society.

Depending on the viewpoint taken (equity versus efficiency), one may often arrive at different policy conclusions. For instance, consider the well-known Polluter Pays Principle. The question then is whether this principle means that the polluter should pay the total external cost, through average external cost pricing, or whether efficient tax rules based on marginal external costs should be used. The two pricing strategies will normally lead to different outcomes in terms of both allocative efficiency and equity, unless of course marginal external costs are constant and are therefore equal to average external costs.

Likewise, estimates of external costs of road transport[4] 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 goal, one can safely state that additional Pigouvian taxation of road transport is necessary (Maddison et al., 1996). However, representatives of for instance the road lobby tend to use equity-based arguments to point out that road users already pay a lot to society, and that additional economic regulation is 'unfair'. This brings us to the social feasibility of regulatory policies, which will be taken up in the next sub-section.

3.4 The social feasibility of regulating road transport externalities

Figure 5[5] demonstrates the over 75 years old Pigouvian principle that marginal external cost pricing will restore the efficient working of the market in case of market failures through external costs. The diagram considers road transport, and allows for the joint presence of intra-sectoral and inter-sectoral externalities. 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)[6], and the marginal private cost curve (MPC). With identical road users, MPC is equal to average

[4] Estimates of the external costs of transport show that these are high – for instance ranging from 0.6% to 5.1% of Dutch GDP in the low and high estimates of Bleijenberg et al. (1993), and up to 12% of US GDP (Madisson et al. 1996) and that, given the current policy practices, there seems to be room for considerable efficiency improvements by means of proper pricing of road transport (see also Button 1995, for a meta-analytical discussion of estimates of the social costs of transport).

[5] The discussion of Fig. 5 draws heavily on Verhoef et al. (1996b).

[6] Significant external benefits of road transport are not likely to exist; see Sect. 2. Hence, MPB and MSB are assumed to be identical in Fig. 5.

social cost (ASC), and it is positively sloped because of intra-sectoral externalities such as congestion. Taking account of these intra-sectoral externalities, MSC represents marginal social costs. Next when accounting also for the marginal inter-sectoral (e.g., environmental) external costs MEC, TMSC may give the 'total marginal social costs'. Optimal road usage is then at N^*, where net social benefits, given by the area between the curves MPB and TMSC, is maximized, and the shaded welfare loss is avoided.

Implicit in the identification of N^* as 'optimal' is the use of the '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. This 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 among net-winners and net-losers.

This can be illustrated by considering two archetypical instruments for achieving N^* in Fig. 5: a prohibition on mobility between N^* and N^0, and the optimal effluent fee r^*. Let us assume for the moment that both policies succeed in achieving the Pareto optimum. Optimal regulatory taxation would then result in the same welfare level as physical regulation for both policies for three groups: the mobility foregone, the victims of the environmental externality, and of course also for society at large. However, because total tax revenues *abfe* necessarily exceed the reduction in congestion costs *abdc*, the remaining road users are worse off. These tax revenues of course accrue to the regulator, or more general, to the government.

Therefore, although both measures are equally efficient in terms of accomplishing N^* in this example, they are certainly not equivalent in terms of social feasibility (see Verhoef et al. 1996b). The road users generating optimal mobility enjoy a welfare gain with physical regulation because of reduced congestion, 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.

It is important to emphasize that for this conclusion, 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. In theory, it is of course 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. Moreover, it is evident that difficulties related to, for instance, preference revelation and heterogeneity of road users may of course prevent actual tax redistribution schemes, aiming to turn potential Pareto improvements into strict Pareto improvements, from being practically implementable.

Nevertheless, the allocation of tax revenues is often put forward as one of the main determinants for the social acceptability of pricing measures. Two main types of 'ear-marking' are tax recycling and investment. Recycling in practice can take place through the lowering of existing taxes within the road transport sector,

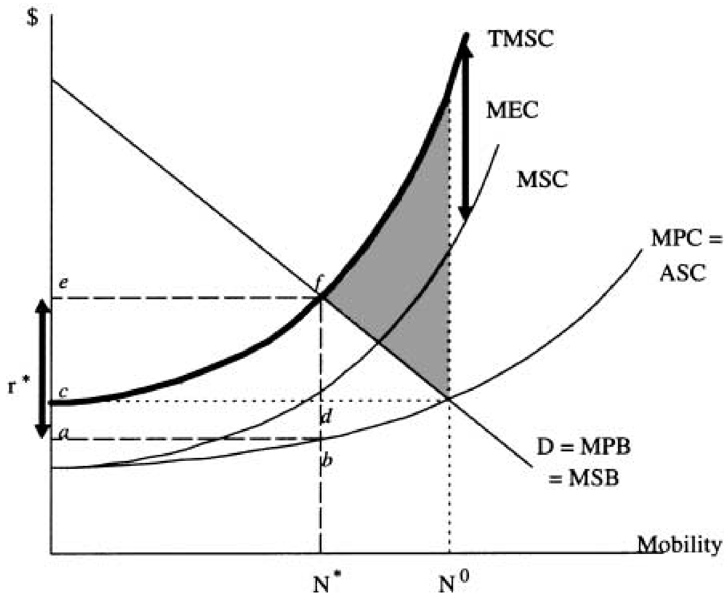


Fig. 5. Welfare implications of regulating road transport externalities

for instance fixed vehicle taxes or fuel taxes, or outside this sector, for instance the lowering of distortionary taxes on labour. In particular the former may help improving the social acceptability of pricing measures (Verhoef et al. 1997a, provide empirical evidence for this). Investments could for instance take place in terms of road capacity expansion (see also the Mohring and Harwitz (1962) rule mentioned in Sect. 3.1), or in terms of public transport. It could be argued that the latter, through improved public transport services, may reduce the regressive character of pricing and thus increase the social acceptability. Subsidies to public transport, although perhaps seemingly contradicting current privatization trends in many countries, may even be justifiable from an efficiency perspective in case of scale economies (we owe these observations to an anonymous referee). Clearly, also combinations of the above mentioned types of tax allocations can be envisaged. Also in the design of such packages, trade-offs between the allocative efficiency of the type of ear-marking and the extent to which public acceptance is enhanced generally will have to be made. A good example is the use of revenues for lowering taxes on labour. Although this may yield double-dividend type of efficiency gains, the eventual allocation may often be too far from the road users' direct personal interest to induce any significant improvement in the social acceptability of pricing.

Apart from differing in terms of social feasibility, different 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^0. In reality, with physical regulation, the regulator runs the risk of also affecting mobility with relatively high economic benefits. The reason is that it will be very hard in practice for a regulator to apply rationing in such a way that only drivers with a low willingness to pay are excluded from using the road. Regulation may then even be counter-productive (that is: efficiency-reducing). Such adverse effects may for instance occur with a physical measure such as the 'odd-even numberplates' regulation used in cities like Athens and Mexico City.

The 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 et al. 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 et al. 1995, and Verhoef et al. 1997a, provide surveys), although of course also the social acceptance of other instruments has been studied (Jones 1995). Central themes in the literature include the worry that the redistributional effects of road pricing may dominate the efficiency gains (Evans 1992), and the regressiveness of road pricing (Richardson 1974; Layard 1977; Arnott et al. 1994). Giuliano (1992), however, observes that such considerations may merely 'present an apparently legitimate basis for opposition that is actually motivated by other reasons' (p. 349), and Small (1983, 1992b) emphasizes that road pricing may actually be progressive given certain redistributions of revenues. The same argument of course holds for other types of Pigouvian regulation.

Finally, the limited social feasibility of regulatory taxes has induced some research into the possibility of designing socially more feasible economic instruments. Two of such instruments can be mentioned. The first of these is based on the notion of 'tradeable permits'. The idea is that a carrying capacity of the environment can be identified that corresponds to a maximum number of cars permitted on a certain network, or a maximum of vehicle kilometres allowed. Usage of a car would then only be permitted if the driver owns a permit allowing her to do so. By organizing then an auction which would lead to the sales of permits by all initial actors involved to all interested actors, an efficient and acceptable market solution may be found. The possibility of initially distributing the permits for free gives the regulator the opportunity to affect the distributional impacts of the policy in directions that are considered desirable. Secondly, it may have the psychological advantage of taking away some of the social resistance against economic instruments, based on the sentiment that tax instruments would primarily serve as a source of revenues for the government. With tradeable permits initially distributed for free, it is evident to the public at large that the government will not receive any such revenues. Although there have been some experiments (Singapore), a more thorough investigation of this opportunity would be needed. Verhoef et al. (1997b) provide a general discussion of the applicability of the concept of tradeable permits in the regulation of road transport externalities; Goddard (1997) investigates the possibility of tradeable permits as a more cost-effective alternative to a scheme in which car users are confronted with interdictions to use their cars at certain days (based on the ‘odd-even’ number plate method). Secondly, ‘feebates’ have been proposed as a socially more feasible alternative to regulatory taxes. The aim of such policies is to design a budget-neutral set of Pigouvian taxes for high externality generators, such as dirty cars, and subsidies for low externality generators in order to accomplish a favourable shift towards, for instance, cleaner technologies (see Button and Rothengatter 1997). This instrument shares the advantage of tradeable permits that scepticism of road users, about the government using them as a cash-cow, can be minimized.

4 Conclusion: the policy relevance of benefits and costs of transport

The foregoing sections discussed a number of issues surrounding the evaluation of the benefits and costs of transport. It was found that transport, for a number of reasons, cannot be treated as an ‘ordinary’ economic sector, and the implications of a number of peculiarities were addressed.

For the economic evaluation of the costs and benefits of transport, various viewpoints can be taken. One of these is the ‘traditional’ economic evaluation, solely according to the principle of allocative efficiency. The policy rules according to this viewpoint are as follows. On the benefit side, it can be observed that the benefits of transport infrastructure to a considerable extent exhibit non-rivalry in consumption, in particular at low levels of congestion, and non-excludability, particularly for road transport and given the cost of exclusion. Given this quasi-collective character of transport infrastructure, its provision should often indeed be the responsibility of local, regional, national or trans-national public bodies. The total benefits of infrastructure investments can be seen as the discounted stream of the net benefits of its usage, net of the costs of usage. Two important obstacles in the estimation of these benefits – apart from more common problems associated with dynamics and uncertainty – are caused by the network environment of infrastructure, and the derived character of the demand for transport. This implies that the distinction between generative and distributive effects becomes relevant; that the impacts of an investment – which can be positive and negative – are usually to be found in a much larger area than merely the link directly involved; and that one actually would have to have knowledge on the dynamic spatial behaviour of the economy involved to assess the benefits of such an investment. However, although the benefits of an investment of infrastructure are often to be reaped in other economic sectors, other than transport itself, these benefits do not constitue Pareto relevant externalities: there is no *a priori* reason to believe that market forces would not be able to realize the benefits of infrastructure improvements. On the cost side, in contrast, externalities actually do prevent the market from attaining allocative efficiency. Optimal Pigouvian taxes can be established, based on the marginal external costs at the individual level, implying that ‘intra-sectoral’ externalities, such as congestion, should indeed also be accounted for.

Notwithstanding the economic appeal of the criterion of allocative efficiency, considerations related to equity impacts and social feasibility are often at least as important in policy making. Also from this perspective, transport turns out to be a complicated sector. Considering the benefits of infrastructure investments, it can be observed that, in contrast to many other types of public investments, where often only 'winners' and 'non-affected' are involved, transport infrastructure improvements are likely to cause some groups to be better off, but also some to be worse off, where the incidence of gains and losses over different interest groups will generally vary over space. Accessibility is both an absolute and a relative concept. Therefore, spatial and sectoral equity considerations are therefore likely to be important determinants for the viability of infrastructure policies, and investments that may be warranted from an efficiency point of view may often be unacceptable to certain groups in society. For the regulation of road transport externalities, it turns out that the most efficient policies, based on the Pigouvian principle, are usually the least popular ones. Also here, regulators will often have to make trade-offs between the efficiency and social feasibility of regulation. Another source of tension between efficiency and equity considerations concerns the different policy conclusions that can be drawn depending on the viewpoint taken. Unfortunately, there often does not seem to be a clear correspondence between what is efficient, and what is socially equitable. The economic analyst will have to accept that, despite the stance taken in textbook economic policy evaluation, the former is only one of the relevant inputs in the process of policy making, and the social feasibility and equity implications may often dominate public decision making on transport policies. The provision of evaluation frameworks that are capable of consistently dealing with both of these sides to the benefits and costs of transport probably offers one of the greatest challenges in transport policy analysis.

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