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HOW LARGE IS THE GAP BETWEEN PRESENT AND EFFICIENT TRANSPORT PRICES IN EUROPE?[ϒ]

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Abstract

In this paper we analyse the gap between present transport prices and efficient transport prices. Efficient transport prices are those prices that maximise economic welfare, including external costs (congestion, air pollution, accidents). The methodology is applied to six urban and interregional case studies using one common optimal pricing model. The case studies cover passenger as well as freight transport and cover all modes. We find that prices need to be raised most for peak urban passenger car transport and to a lesser extent for interregional road transport. Optimal pricing results for public transport are more mixed. We show that current external costs on congested roads are a bad guide for optimal taxes and tolls: the optimal toll that takes into account the reaction of demand is often less than one third of the present marginal external cost.

Keywords

Transport pricing, external costs, social costs, congestion pricing

JEL Classification

H21, H23, R41, R48

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1. Introduction

The present policy mix in European transport markets contains measures ranging from traffic safety and environmental performance regulation of vehicles to public transport subsidies, excises on fuel and taxes on the ownership and use of vehicles. The Green Paper of the European Commission on Fair and Efficient Pricing (CEC,1995) concludes that this mix of instruments yields unsatisfactory results, including excessive congestion, an excessive accident rate and excessive pollution. The Green Paper pleads for a more fundamental role of pricing policies to control the negative side effects of transport activities.

In this paper we analyse the gap between present transport prices and efficient transport prices with the help of six case studies. First, we discuss to which extent current prices deviate from the corresponding marginal social costs. This requires the computation of resource costs, external costs and current taxes on all transport markets. Next we compute what is the most appropriate correction of transport taxes.

The case studies focus on the pricing of urban and interregional transport. Long range international transport flows have not been studied, e.g., airline and shipping problems are not treated. All other modes have been considered. Case study results are presented for four urban areas (Amsterdam, Brussels, Dublin, London) and for interregional transport in two countries (Belgium and Ireland). For each of these cases we construct a reference equilibrium with unchanged policies for 2005. By adding to this reference equilibrium information on the different types of external costs, the resource costs and the tax levels, we are able to measure the gap between expected prices and efficient prices. Next, we compute the optimal prices. This computation assumes that perfect pricing instruments are available, allowing to discriminate taxes between peak and off-peak time, between types of cars etc. Implementation costs are not taken into account. This scenario should therefore be considered as a benchmark, giving information on appropriate directions and magnitudes of price changes.

The same modelling tool has been used for all the case studies. The TRENEN models represent the transport market of a given zone by modelling the demand and supply of all modes of transport with their interactions. The major limits of the TRENEN models are their degree of aggregation and their static character. TRENEN represents transport demand behaviour for a given region by representative consumers or firms. The transport network properties of a region are aggregated into one speed-flow relationship per mode. The model is static: it represents the transport markets in a given period, considering the road and rail network as fixed and assuming that the car, truck, bus and rail carriage stocks are automatically adjusted. More precisely we assume for public transport that occupancy rates are fixed and that the number of carriages and buses is automatically adjusted. We also assume that the mileage per car and truck is fixed and that the car and truck ownership adjusts in function of the desired number of vehicle-kilometres (vkm). The model therefore is well suited to discuss optimal short-run pricing of infrastructure but not to study optimal investment decisions in infrastructure. The case studies all focus on the year 2005.

Using the same model structure for each of the case study areas has several advantages. First, not only does this approach yield results that can be easily compared, it also allows us to trade off the effects of pricing reform in urban and interregional transport markets. A second advantage is economic consistency: all modes of transport are treated simultaneously and the same principles are applied to each of them. A simultaneous treatment of all modes is necessary as there may exist strong substitution possibilities.

This paper extends the literature on computing efficient transport prices in a multi-modal framework pioneered by Glaister and Lewis (1978) and Small (1983). De Borger et al. (1996) used a simpler model having only two modes, without an explicit welfare criterion. De Borger et al. (1997) used a simplified TRENEN model that was only applied to Belgium. The second version of the TRENEN model used for this paper incorporates new features, such as the inclusion of parking costs and of economies of density in public transport. Also, the model is applied more widely. The structure of the model and all case studies reported in this paper are analysed more extensively in De Borger and Proost (2001).

The structure of this paper is as follows. Section 2 briefly presents the modelling principles. The next section describes some characteristics of the various case study areas. Section 4 is devoted to an analysis of the reference equilibrium: to which extent do current pricing policies imply prices that deviate from social marginal costs? Section 5 studies the optimal pricing scenario. Implementation issues are discussed in Section 6. Finally, section 7 presents conclusions.

2. Model description

2.1. Methodology

The TRENEN models are of a strategic nature. The idea is to analyse desirable directions of pricing reform for a given region or urban area, taking into account different constraints on policy instruments. These strategic models have a different purpose than the traditional network models and are not suited to assess transport infrastructure investments.

The use of distinct model versions for urban and interregional transport is necessary because of the specificity of the problems: both the relevant transport modes and the relative importance of various externalities differ substantially.

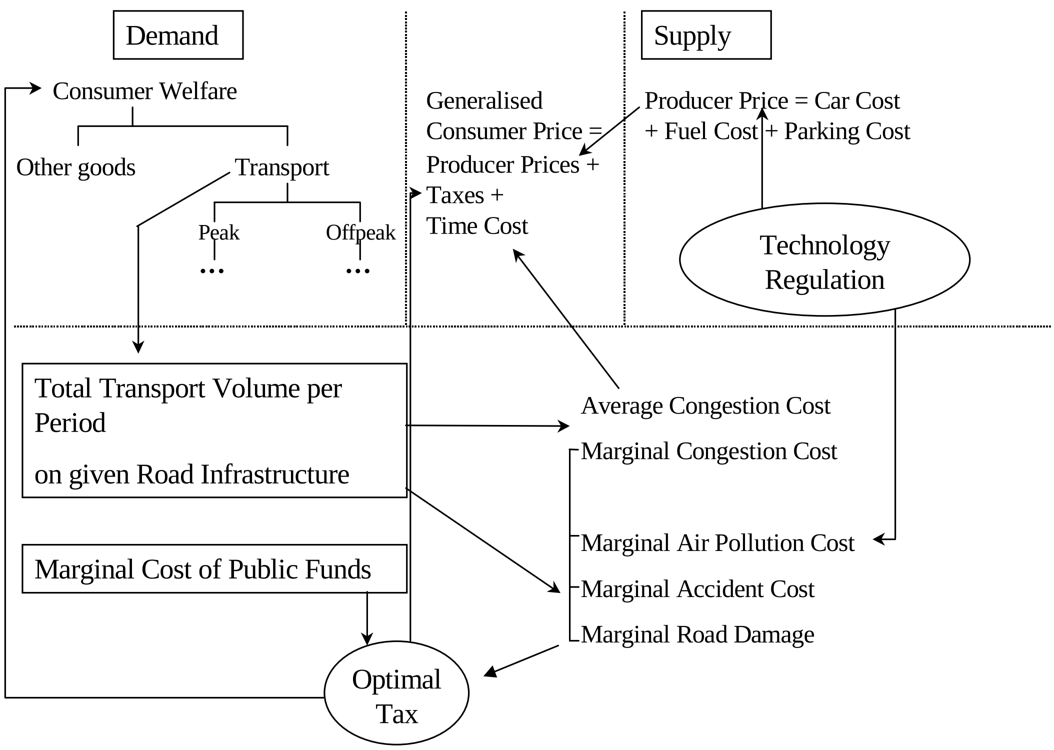
The basic structure of the urban and interregional models is illustrated in Figure 1.[1] This diagram contains three components: a demand module, a supply module and an equilibrium price module. Both demand and supply are highly disaggregated, so the figure is only a simplified representation.

The *demand side* of the model represents the choices of the users of passenger and freight transport. Demand for passenger transport in both the urban and interregional model is generated by assuming that a representative individual optimally allocates her income

[1] For a complete mathematical description of the urban model and the interregional model see Proost and Van Dender (2001a, 2001b) and De Borger (2001).

between passenger transport and other goods. Many passenger transport services are available: the individual can choose between motorised and non-motorised transport, between time periods of travel (peak versus off-peak), and she has the option to use her car or one of the available public transport modes (metro, tram or bus for urban transport, bus and rail for interregional traffic). If the car mode is chosen, different types and sizes of vehicles are available. Moreover, the individual has the explicit options of solo driving or car pooling. The modal choice is adapted to the available infrastructure in each city or region. The demand for freight transport in the interregional model is derived as the demand for one of the inputs in the production process of an aggregate domestic firm (inland transport and import and export transport) and an aggregated international firm (to represent transit through the region). The domestic firm chooses between three modes (road, rail, inland waterways) and two time periods. The international firm is included for two reasons: transit may have more options for rerouting, and the transport costs of transit firms are not passed on to domestic consumers.

Figure 1 **Structure of the TRENEN models**



The above procedure allows us to represent the demand for each transport service in a given geographical zone (urban area or region) as a function of (1) the generalised price (the sum of money price and time cost) of the available transport alternatives, and (2) other factors (like income and taste variables).

The *supply side* of the model is a reduced form representation of the activities and choices made by the producers of cars, trucks, buses, fuel, car maintenance, etc. Every trip by car is produced by combining several inputs (car, fuel, parking etc.), all of which are sold at marginal cost. As we assume constant returns to scale, this is compatible with perfect competition on these markets. The policy maker can restrict the available type of vehicles through environmental regulations. So the supply side is represented by marginal resource costs per type of vehicle, where the environmental characteristics of the vehicles are regulated.

For public transport we assume that the total cost function is linear and that the fixed cost component represents all costs that are not variable with the number of buses or passengers. The average variable cost per passenger is constant and is determined by the occupancy rate. The variable resource cost is different for the peak and the off-peak, because of differing occupancy rates and because the carriage (or bus) capacity cost is included in the peak period. This is in line with the peak load pricing principle, as peak demand determines the total number of busses or train carriages needed. So the supply of a public transport mode is represented by one constant marginal cost per passenger-kilometre (pkm) for the peak and by one constant marginal cost per pkm for the off-peak. The Mohring effect in urban public transport is added via increased frequencies that reduce the expected waiting times.[2]

In the *equilibrium price* module, generalised prices are computed for the different types of transport services. The generalised price will be the sum of three elements.

- The producer price for different types of vehicle-kilometre, as determined by the supply module. Since mileage per car is constant, the producer price will contain resource costs of car ownership (production and maintenance costs), of fuel and of parking. Given the fixed occupancy rates for public transport, the producer price per passenger-kilometre will consist of a production cost of carriages and variable maintenance, personnel and fuel costs.
- A transportation time cost, which is a function of the total volume of traffic in equilibrium. This transportation time contains the average congestion cost and, in the case of public transport, the value of walking and waiting times.
- A tax (or subsidy) that has two policy functions: to raise tax revenue or subsidise certain modes of transportation and to correct for external costs like air pollution, marginal congestion costs, noise accidents and road damage. This tax will be differentiated according to the different types of transport goods.

The optimal magnitude of the taxes will be determined by the cost of public funds[3], by the level of the marginal external costs and by the demand elasticities for the different transport

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[2] Mohring (1972) shows that there are economies of scale in the production of transit services. When the density of demand increases, one can reduce the waiting and walking time by increasing the frequency over time and space of services, for a given cost of provision per passenger-kilometre. The alternative is to keep the frequency constant, increase the sizes of the buses and reduce the cost per passenger-kilometre. In the urban model version, the occupancy factor is fixed in the peak and in the off-peak period, but the frequency of metro and bus services (which determines the waiting time) is a function of the level of public transport demand. Sensitivity studies on the way the Mohring effect is modelled in TRENEN can be found in Van Dender and Proost (2001).

[3] The cost of public funds is a simplified way to take account of the effects of tax changes and changes in public revenues on the rest of the economy. When extra tax revenue is collected in the transport sector and used to decrease labour taxes, this can decrease the distortions caused by labour taxes and can thus generate an extra efficiency gain. In this case the cost (or better “value in alternative

goods. A marginal cost of public funds larger than one means that, even in the absence of external costs, the optimal tax should be larger than the marginal resource cost for those goods with inelastic demands, because this is a more efficient way to raise taxes than in the rest of the economy (Ramsey pricing). When internalisation of external costs and tax revenue raising have to be combined on several interrelated transport markets, a numerical model is needed to compute optimal taxes.

Besides taxes, the policy maker can also impose certain regulations under the form of ad hoc constraints on the supply part of the model: maximum emission limits per car, banning certain types of fuels, etc.

In the urban model we distinguish four types of representative consumers: those who pay for parking or not, and those who commute (from out of town to the CBD) and those who do not. Those who do not pay for parking face a lower average cost per vehicle-kilometre. Commuters and inhabitants all travel on the same abstract urban link, so that out of town travel is not explicitly modelled. Distinguishing commuters and inhabitants is however interesting to test imperfect pricing instruments as there are cordon tolls (only for commuters) and parking charges (commuters make longer trips so that parking charges affect their cost per car-kilometre relatively less.

The model is *calibrated* for a given reference equilibrium. The observed reference equilibrium corresponds to a computed equilibrium on all markets, for the observed or forecasted money prices and quantities for all modes. Information on the ease of substitution between transport and other goods as well as between the different means of transport is supplied exogenously.[4] Other important inputs are the structure of resource costs for private and public transport, the external costs and the congestion function. The congestion function summarises the available network information on the relation between volume of road transport and average speed. The model is static: it represents the equilibrium for a given year and assumes that the stock of all means of transport (private and public) is perfectly adapted to the demand for transport. The road infrastructure and public transport infrastructure (e.g. the rail network) are kept fixed.

Several equilibria are possible on the transport market. We assume that the policy maker ranks them with the help of a *welfare function* which makes a weighted sum of consumer surpluses, producer surpluses, tax revenues and external costs. The external costs include noise, air pollution and safety. The marginal external congestion costs are endogenously valued in the model because they are included in the generalised costs.

Although the overall structure of the urban and interregional models is quite similar, there are some noticeable differences. For example, the urban model includes parking costs, a Mohring effect for public transport[5] and a positive marginal cost of public funds (of 1.066) while none

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uses") of public funds is higher than one. Other uses of tax revenue are possible and this implies lower values for values for public funds. We refer to Proost and Van Dender (2001a, 2001b) for more details.

4 Nested CES utility and production functions have been used to represent the passenger and freight transport behaviour.

5 Mohring (1972) showed that there are economies of scale in the production of transit services. When the density of demand increases, one can, at a given cost of provision per passenger-kilometre, reduce the waiting and walking time by increasing the frequency over time and space of services. The

of these are included in the interregional version. The latter, on the other hand, contains freight transport (including transit freight) and feeds back the cost of higher freight transport into consumption prices. Obviously both models are compromises and none of the two models can include all features simultaneously.

2.2. Model Use

The models can be used in two ways. First, they can be used to compute the welfare effects of a given policy proposal. This enables the comparison of different policy packages in terms of the resulting welfare effects (as well as traffic volumes, pollution, etc.). Second, the model allows the design of optimal policy packages. In this approach the welfare function is optimised by selecting the optimal transport and environmental policy variables. This optimisation can be performed under different sets of restrictions on the policy instruments. In this paper we only present the 'full optimum' scenario where there are no restrictions on the policy instruments. When there are restrictions on the instruments, one obtains second best results that trade off in a complex way the deviations from full marginal cost pricing in the different transport markets. A typical example is the optimality of pricing below marginal social costs for public transportation in the peak when prices for car traffic cannot be differentiated between the peak and the off-peak period. This is an indirect way of relieving congestion in the peak period.

3. Description of the study areas

Table 1 summarises the characteristics of the four urban areas and the two regions studied in this paper. It is clear that in all cities and regions peak period congestion is a severe problem. In London, off-peak congestion is high as well. The cities and areas studied differ substantially in size and traffic flows and composition. Coverage of Northern and Southern Europe would probably show even larger differences.

alternative is to keep the frequency constant, increase the sizes of the buses and reduce the cost per passenger-kilometre. In the urban model version, the occupancy factor is fixed in the peak and in the off-peak period but the frequency of metro and bus services and the walking time is a function of the level of public transport demand.

Table 1 Characteristics of the areas studied (expected for 2005)

Location		Amsterdam	Brussels	Dublin	London	Belgium	Ireland
I. Population (Mio potential transport users)		0.492 (not potential but actual users)	1.585	1.26	7.499	9.988	3.654
II. Passenger transport							
Mio pkm/mode/year							
	Private	1287	1151	3854	18981	69386	21607
	Public	412	443	1138	6302	10381	2072
III. Freight transport in Country							
III.a Total tonne-km/year						34078	6066
III.b Tonne-km/mode/year							
Road (Mio tkm/year)						22471	5459
Railways (Mio tkm/year)						6676	607
Waterways (Mio tkm/year)						4931	
IV. Number PCU per hour							
Peak (Mio PCU/hour)	Highway	-	-	-	-	5.739	3.342
	Other	-	-	-	-	10.335	-
	Urban	1.260	0.643	2.602	6.32	-	-
Off-peak (Mio PCU/hour)	Highway	-	-	-	-	1.967	1.615
	Other	-	-	-	-	3.312	-
	Urban	0.235	0.148	1.077	2.88	-	-
V. Perceived severity of problem		Peak congestion; strict parking policy in place	Peak con-gestion	Peak con-gestion	Peak and off-peak con-gestion	Peak con - gestion	Peak con-gestion

4. Reference Equilibrium

4.1. Structure of Generalised Prices and Costs

The starting point for the model is the construction of a reference case for each city and region. A crucial element in constructing reference equilibria is the determination of prices and marginal social costs for all relevant transport services. First, prices in the reference case are to be interpreted as generalised prices that include the value of travel time experienced by the user. For example, for car traffic the generalised price per kilometre is calculated as the sum of the corresponding resource cost (for fuel, maintenance, etc.), the time cost of the traveller (the monetary evaluation of the time spent in traffic) and any taxes that are being paid, expressed on a per kilometre basis. For public transport the generalised price consists of the money price plus the value of travel time; if public transport is subsidised beyond the fixed part of the costs, the money price will be below the corresponding marginal resource cost. It is clear that because of differences in congestion the generalised price per kilometre may be quite different for the peak and off-peak periods.

Second, the marginal social cost associated with a particular transport service consists of the marginal resource cost, the time cost experienced by the traveller, and the marginal external cost. The latter includes the marginal external cost of congestion, pollution, noise, accident risks and road damage. Note that the gap between generalised price and marginal social cost for each mode and transport service gives an indication of the most important inefficiency of current transport pricing policies.

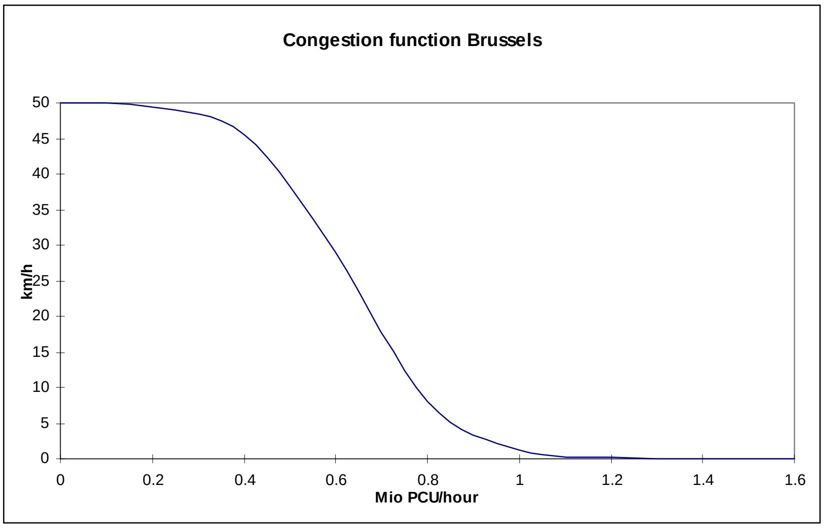
The resource costs of transport are those associated with the (internal) production of transport; it is a private cost to the provider or user. It depends on three main elements: the capital costs of the infrastructure and the vehicles, the choice of fuel and the speed of traffic (which depends on traffic flow). This latter factor is particularly relevant in determining time costs and fuel usage. The resource costs are derived from a detailed analysis of the capital and depreciation costs and the direct operating costs of each mode, varying according to size of vehicle and fuel type. Road infrastructure is taken as fixed, but the stock of cars, buses, trucks and rail carriages is assumed to be fully adjustable to changes in demand. Similarly, rail and waterway infrastructure are assumed to be fixed, but the number of rail carriages and inland navigation ships can be completely adapted to demand. The marginal capacity costs of rail carriages and buses are allocated to the peak period, consistent with the peak-load pricing principle which states that in the case of fully flexible capacity, the peak load price should equal the marginal operating costs and the marginal capacity cost.

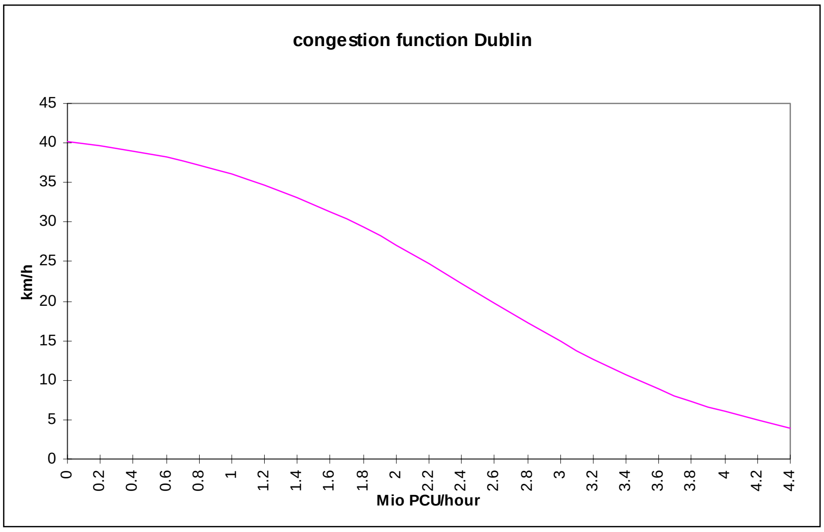
One element which requires some discussion is that of parking costs since this is an important element in the different policy scenarios for the urban areas considered. Typically, large groups of the population do not have to pay the full resource costs of parking. We assume that a parking spot is only needed for urban trips at the final destination. In the reference cases, it is assumed that only 30% of cars actually pay the resource cost of parking, the remainder park for free (except for Amsterdam where the assumption is that 70% are payers). The way parking is introduced in the TRENEN model is discussed in great detail in Calthrop et al. (2000).

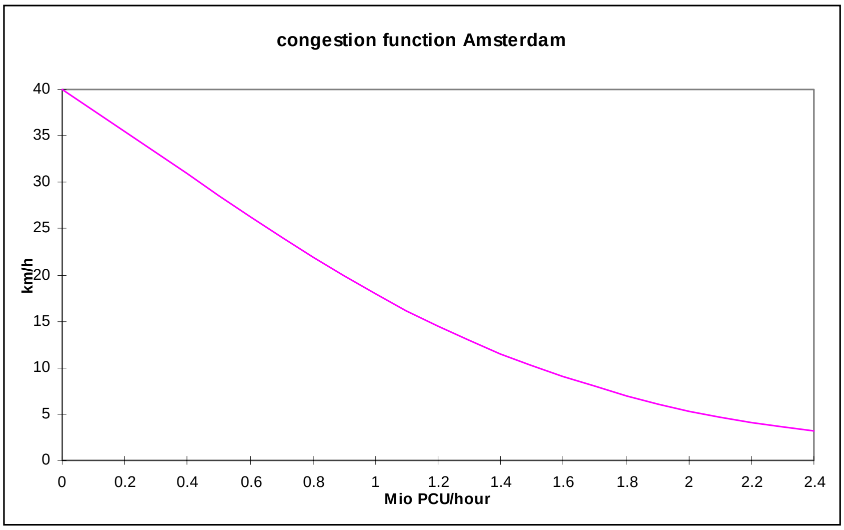
As previously indicated, the generalised price is obtained by adding to the resource costs (obviously excluding parking resource costs for non-paying car travellers) the current level of taxes payable in the form of vehicle and fuel taxes, and an estimate of the time costs experienced by travellers. The latter is based on appropriate values of time and estimates of the speed-flow relationship for each mode and time period. The marginal social cost includes the private resource cost of the mode (and the resource cost of parking where relevant) and the time cost as above, to which the marginal external cost of the mode is added. The marginal external cost depends on congestion, as given by the speed-flow relationship, and on the various external costs. Of these, the key element is the congestion cost which is driven by the relevant speed-flow relationship, as estimated for each case study on the basis of 'fitting' a congestion function to observed data and results of detailed network models. The functional form of the speed flow relationship is identical for all case studies and is based on O'Mahony et al. (1997).

To get a feeling for the congestion functions used, they are graphically reproduced in Figure 2 for the urban cases and in Figure 3 for the interurban cases (congestion functions are presented for both highways and other main roads in the case of Belgium). Both the position and the shape of the congestion functions highly depend on the characteristics of the road network. The current congestion levels (and associated speeds) as well as the corresponding marginal external congestion costs additionally depend on local or regional traffic flows.

Figure 2 **Speed-flow relationships for a car in the urban model**







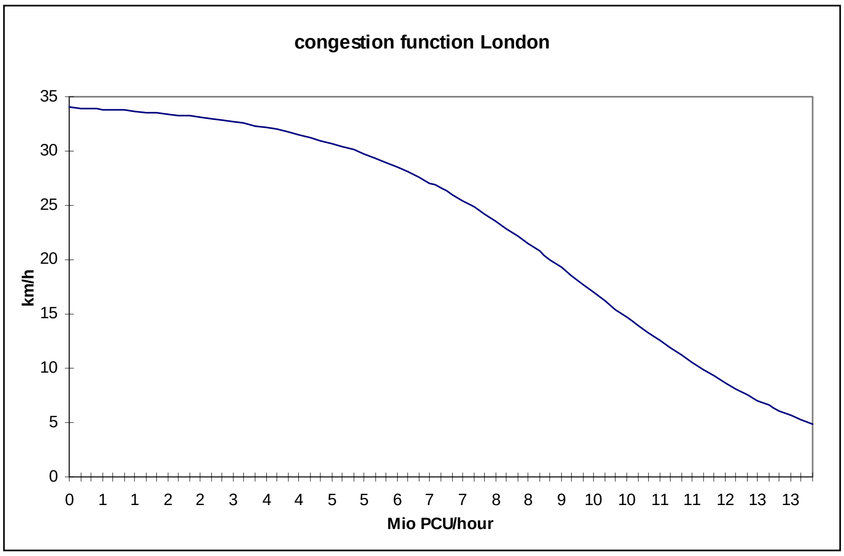
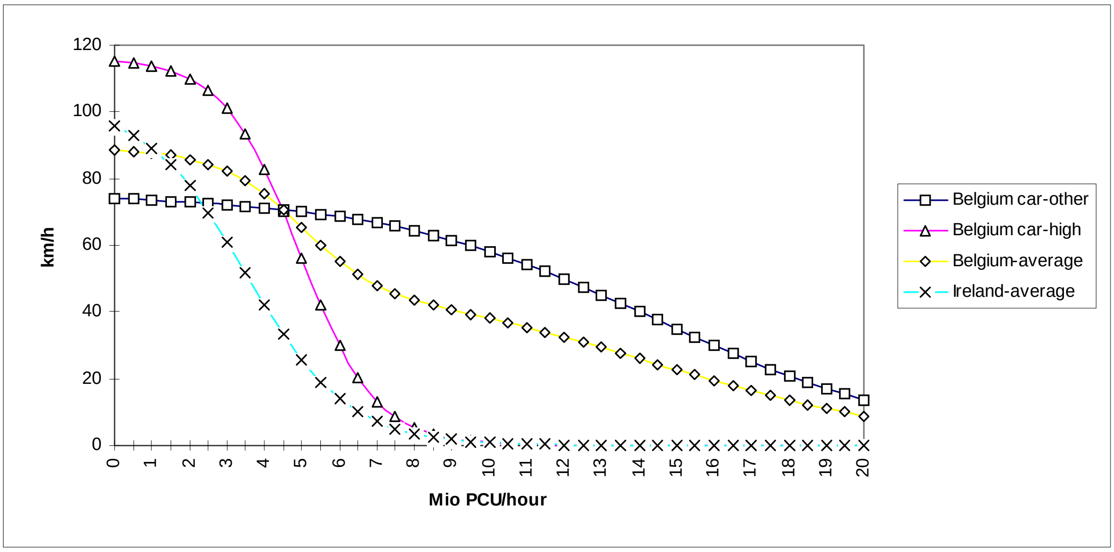


Figure 3 **Speed-flow relationships for a car in the interregional model**



To give an example of the comparison of generalised prices and marginal social costs in the reference situation, consider the example for London in Figure 4. The figure gives the different components of the calculated reference prices and marginal social costs for four types of transport service: a small petrol single occupancy car in peak and off-peak, assuming that the driver benefits from free parking and also the use of a bus in the peak period and in the off-peak period.

Each pair of columns in Figure 4 represents generalised price and marginal social costs per passenger-kilometre for one of the four cases. With respect to the car mode the figure shows that peak prices and marginal social costs are substantially higher than the corresponding figures for the off-peak period. Moreover, marginal social costs in both periods are approximately twice the level of generalised prices. A large part of this is due to the high levels of parking resource costs which are not paid for in the case where free parking is available, the remainder can be explained by external (congestion) cost differences. Note that if parking were to be paid for at resource cost, this element would also appear in the price paid and the shortfall of price from cost would be correspondingly less. It is also clear that, at least for the London case, marginal external cost exceeds the tax paid (expressed on a per passenger-kilometre basis) in the peak period, but that the opposite holds in the off-peak. Again, congestion is mainly responsible for this finding.

For bus transport, the prices are marginally higher than the marginal social cost. Taxes substantially exceed marginal external costs. Bus prices per pkm are similar to those for car, but marginal social costs are smaller, especially in the peak.

Figure 4 **Reference prices and costs for London**

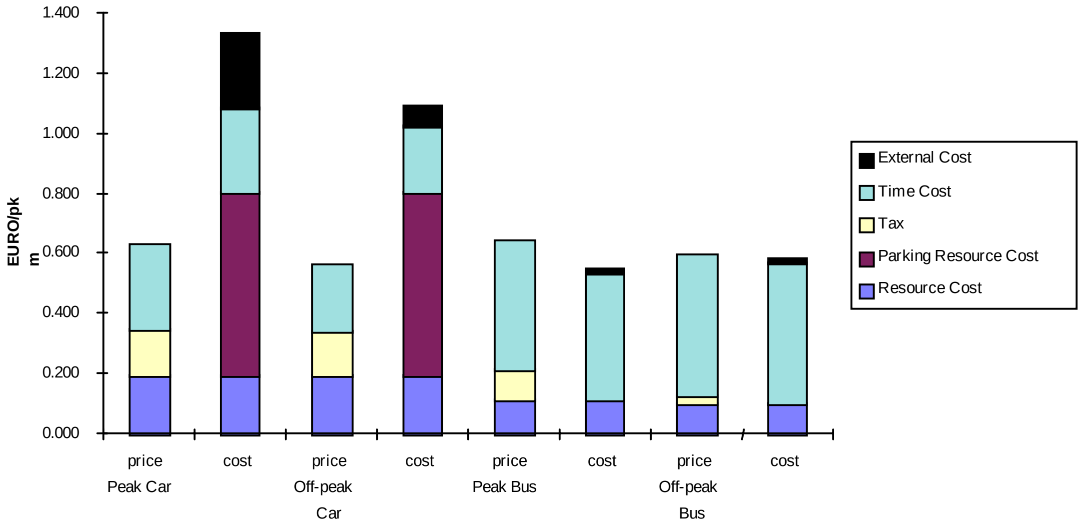


Figure 4 shows clearly that the external congestion cost dominates in the peak period. Other important external costs are accidents and air pollution. The methodology for the estimation of the marginal external costs is described in Mayeres and Van Dender (2001), the accident externalities computation draws on empirical work by Dickerson et al. (2000). The external air pollution costs are based on emissions of new cars and uses results of the Extern-E study of the European Communities (Bickel et al., 1997).

4.2. Comparison of the Reference Equilibrium between Case Studies

The same procedure was followed in each of the study areas to estimate generalised prices and marginal social costs.

Some interesting results for the reference equilibria in the different cities and regions are given in Figures 5 to 11. Information is provided for each of the same four transport services discussed in connection with the London example underlying Figure 4. In each of these figures one finds for each case study, two rectangular blocks. The left hand side diagram shows the composition of the private cost per passenger-kilometre, the right hand side column shows the different components of the social marginal cost. The figures demonstrate some substantial differences both in the estimated level of marginal social costs between cases, and in the disparity between generalised prices and social costs.

Consider estimated peak car costs in Figure 5. The figure shows that marginal social costs in Amsterdam and Brussels are almost twice those in London or Dublin, mainly due to congestion cost differences. Brussels and Amsterdam seem to operate at a much stronger sloped point on the speed flow diagram than Dublin and London. Estimates of generalised prices are reasonably close together, although their composition is quite different. For example, tax levels are much higher in London and time costs are much higher in Amsterdam. In the two regions considered (Belgium and Ireland), peak car prices and marginal social costs are much lower than in the urban cases analysed. This is mainly due to higher average speeds in the interurban environment. The generalised price is slightly higher in Ireland than in Belgium, but the opposite holds for the marginal social cost, mainly due to external cost differences.

Turning to off-peak car costs and prices (see Figure 6) we observe a more consistent pattern across the different cities with the exception of substantially higher costs in London, due to the much higher resource costs of parking. Off-peak prices are also higher in London due to higher congestion levels (time costs) and higher tax levels. For most case studies the marginal external cost estimates do not differ so much in the off-peak, where congestion is less of a problem. For the interregional cases, off-peak marginal social costs as well as prices remain lower than in the urban situations. External costs are much lower than in the peak, and they are higher in Ireland than in Belgium. This is due to higher road maintenance costs as well as higher air pollution emissions. Note also that taxes in both countries slightly exceed the corresponding marginal external cost, at least for the off-peak period.

Figure 5 Peak car reference prices and costs

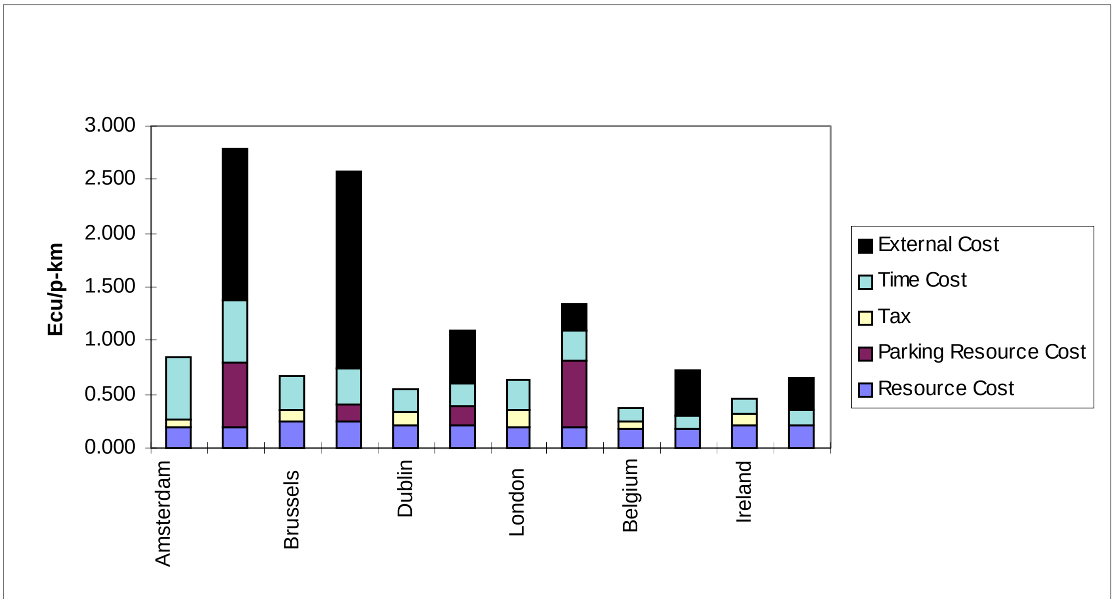
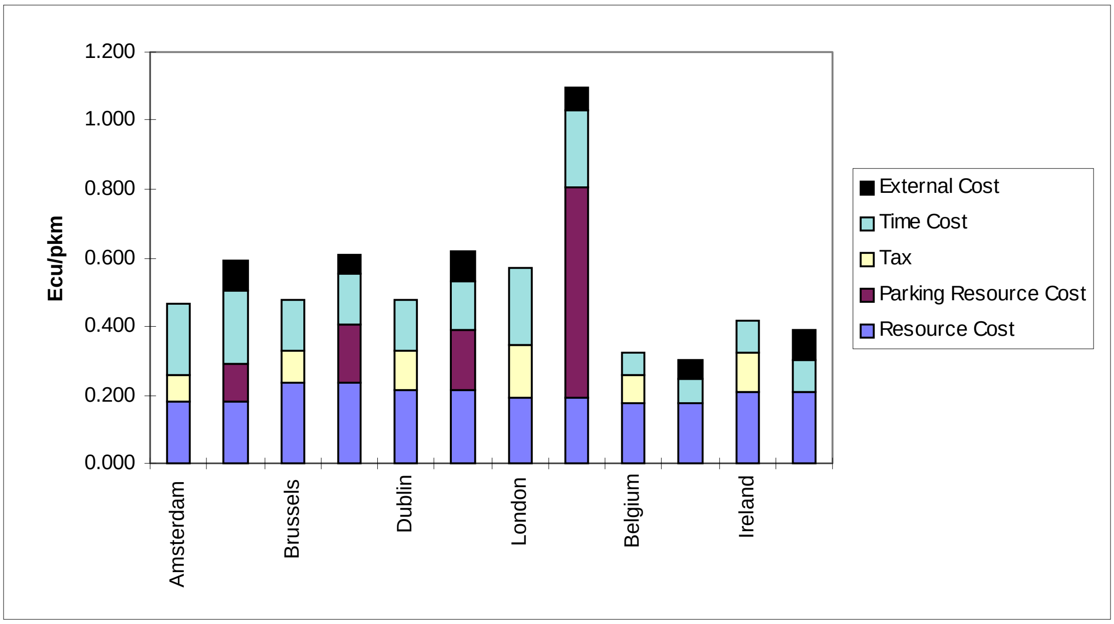


Figure 6 Off-peak car reference prices and costs



Bus costs and prices in the reference case are affected principally by the extent to which bus services are subsidised. The cost of public transport was assumed to consist of a fixed component (independent of the number of passengers) and a variable component. The marginal social cost of public transport only captures the variable cost component. Per vehicle-kilometre, the marginal social cost is greater in the peak than in the off-peak period because it includes the capital costs of vehicles and carriages. However, occupancy rates are higher in peak periods, so that the per passenger-kilometre cost can be lower in the peak. We interpret subsidies consistently as a situation where variable costs are not covered by revenues.

With these ideas in mind, consider Figures 7 and 8. Note that subsidies[6] are identified in both Amsterdam and Dublin in the peak period, whereas both in Amsterdam and especially in Brussels off-peak public transport is subsidised. These negative taxes are set against the resource costs in each case. Generally there is a closer fit between generalised prices and marginal social cost for bus transport than for car traffic in both the peak and off-peak periods in all of the urban areas. In London, where support to public transport is much lower, prices tend to exceed social marginal costs. In the other cities, prices are generally smaller than social costs, although for Dublin (in the peak) and Brussels (in the off-peak) this is only due to the level of subsidy. Per passenger-kilometre, external costs are generally much less significant for buses than for cars. Finally, in the two regions considered, subsidies are identified in the peak period; in the off-peak, Irish bus use is subsidised but in Belgium bus users pay slightly more than the resource cost, resulting in small taxes. A similar analysis can be made for other public transport modes (underground, rail, tram).

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6 By subsidies we mean prices below marginal resource costs. We assume that the fixed costs of public transport are covered from public revenues.

Figure 7 **Peak bus reference prices and costs**

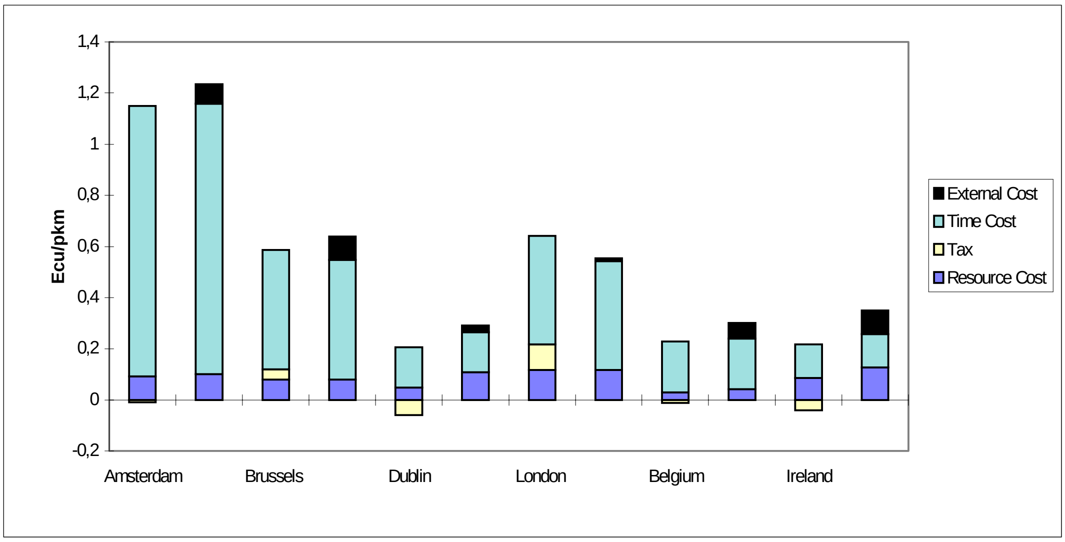
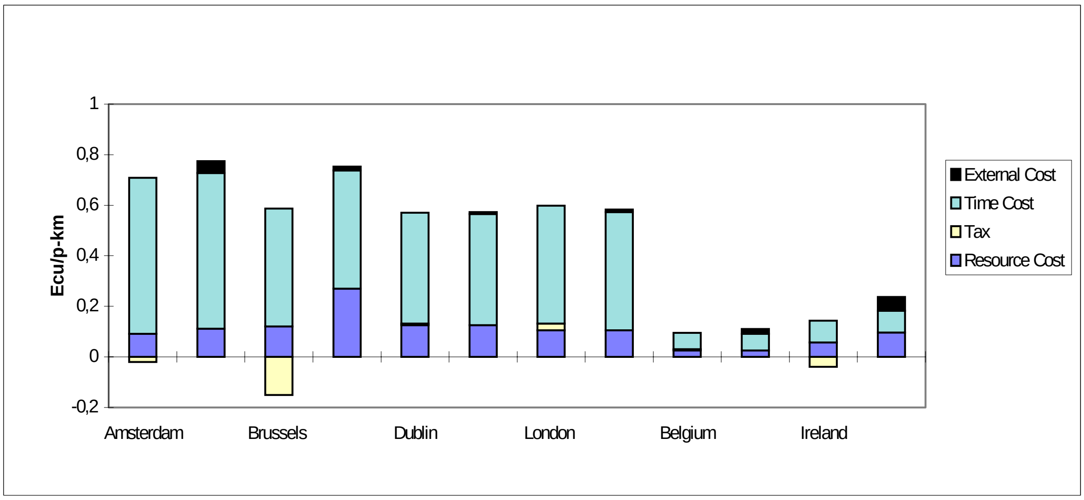


Figure 8 **Off-peak bus reference prices and costs**



Finally, consider Figures 9, 10 and 11 in which information related to interregional freight transport is presented for Belgium and Ireland. Road transport is characterised by fairly similar generalised prices and marginal social costs in the two countries. Prices are way below marginal social costs. For rail freight transport, resource costs and subsidies in Ireland are much larger than in Belgium. However, generalised prices in the two countries are similar. External costs by rail are quite small.

This analysis of the reference case shows clearly the potential for better adjustment of prices to marginal social costs.

Figure 9 **Peak truck reference prices and costs**

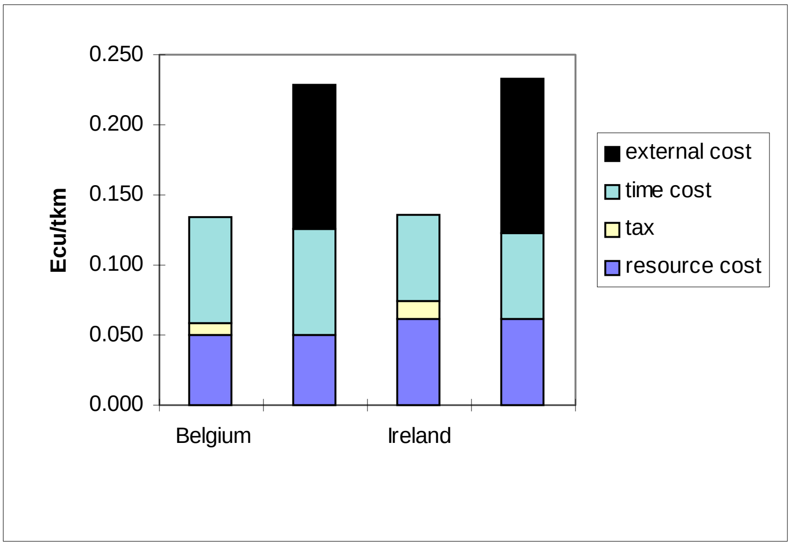


Figure 10 **Off-peak truck reference prices and costs**

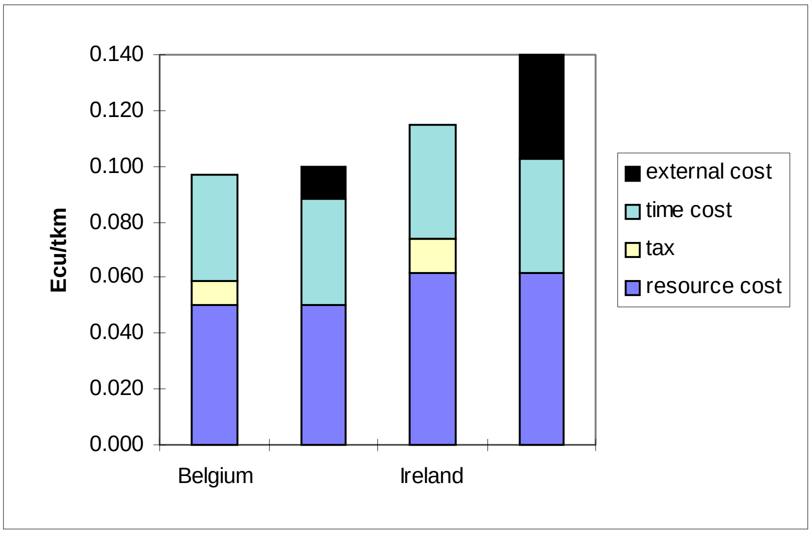
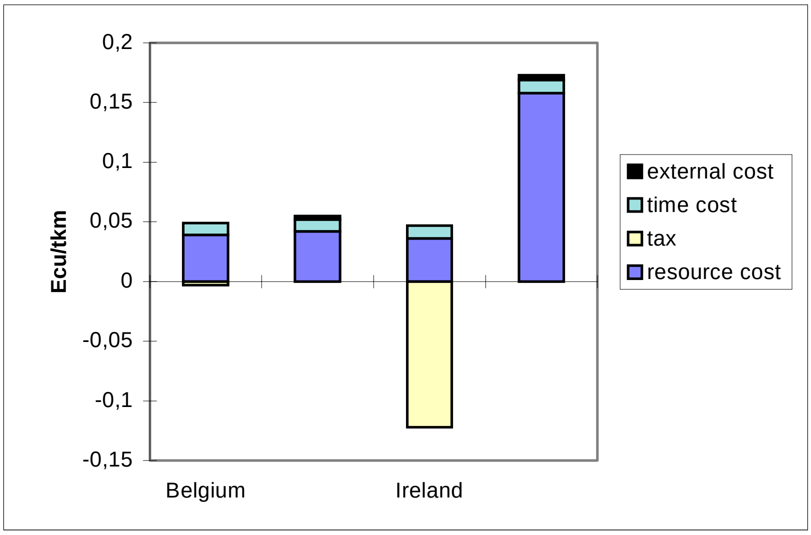


Figure 11 **Rail reference prices and costs**



5. The full optimum scenario

The full optimum scenario for the various cities and regions was calculated by maximising economic welfare under the assumption that perfect pricing instruments are available. This implies, amongst others, the existence of a pricing technology that allows price differentiation between peak and off-peak road traffic, according to the differences in external costs generated. Moreover, in the urban model it implies the possibility to discriminate between inhabitants and commuters, and to operate a system of charges so as to make drivers pay the resource cost of parking. In the interregional model it implies the possibility to differentiate between domestic and transit traffic, and to differentiate between the use of highways and other main roads. Finally, in both models it implies the possibility of introducing improved vehicle emission technologies. Although refined discriminatory charges may prove very costly to implement, the full optimum yields an interesting estimate of the maximum gross benefit from improved pricing in the transport sector.

In the remainder of this section we present some summary results. We discuss the optimal prices in the different cities and regions, we look at the correspondingly optimal traffic volumes, we describe the main welfare effects relative to the reference equilibrium, and we briefly discuss the impact on travel speeds. We limit the presentation and discussion of results to a few relevant submarkets.

5.1. Passenger transport

We first focus on passenger transport prices in the different cities. In Table 3 we present three pieces of information for a few submarkets (for example, a small gasoline car used in the peak period, off-peak bus transport, etc.) in all cities: the percentage increase in the full optimum price relative to the reference situation, the optimal tax (EURO/pkm), and the marginal external cost (EURO/km) at the optimum. To calculate percentage price increases we took into account the fact that only a fraction of car users pay the resource cost of parking in the reference case. In other words, the reference prices used to determine the percentage changes were a weighted average of prices for those that paid for parking and those that did not.

Several implications of the results are worth noting. One finding is that optimal pricing requires very large percentage increases in the price of car use in the peak period in all cities studied. Figures vary from 73% (London) to over 280% (Amsterdam) for inhabitants and from 74% (Dublin) to 282% (Amsterdam) for commuters. The large price increases come from two sources: high congestion in the peak implies high marginal externality taxes, and all car users pay the resource cost of parking in the full optimum. Another important finding is that the optimal price adjustment is much lower than the marginal external cost measured in the reference equilibrium. For Brussels, the marginal external cost in the reference equilibrium is over 1.5 Euro/vkm for a small gasoline car. The optimum tax is only 0.6 Euro/vkm. This is due to the external congestion costs that depend directly on the volume of traffic. The efficient volume of traffic is much lower than in the reference and this implies a much lower congestion tax. Also note that, in all cities, peak car users optimally pay somewhat more than the corresponding marginal external cost. This can be explained by the non-zero shadow cost of public funds used in urban models, which means that 1 EURO of government tax revenue is valued at 1.066 EURO of consumer benefits. The consequence is that deviations between taxes and marginal external costs tend to be higher for non-elastic goods. Accounting for parking costs also introduces a remarkable difference between inhabitants and commuters. Inhabitants face at the optimum a higher tax per kilometre than commuters. Since commuters can spread out the parking fees over a larger average distance travelled, the impact of parking fees on the tax per kilometre is much smaller than for inhabitants.

The prices of off-peak car use all increase as well, although typically by much less than in the peak (ranging from 37% in Brussels to 220% in Amsterdam). This is due to fully charging parking costs and external costs. Again, all off-peak taxes exceed marginal external costs, and the extra tax is relatively higher than in peak periods. Also note that diesel is generally taxed slightly higher than gasoline in order to reflect differences in external pollution costs. The recent Extern-E estimates have been used as a basis for the estimation of the air pollution costs. They show that external costs of diesel and gasoline vary strongly in function of population density, and that they are indeed higher for diesel.

Public transport prices rise in all cities and in both the peak and off-peak periods: existing subsidies are eliminated and replaced by taxes that reflect marginal external costs and a variety of own and cross-price elasticities. In Brussels and Dublin, off-peak public transport prices exceed those in the peak due to large differences in peak and off-peak occupancy rates.

Turning to the results in Table 4 for the interregional models applied to Belgium and Ireland, the following observations can be made. First, all prices equal marginal social costs, since a zero shadow cost of public funds was assumed in these analyses. Second, peak car prices rise by 38% to 45% for gasoline and by 79% and 57% for diesel; these differences are due to higher external costs and lower initial taxes on diesel. Off-peak car prices slightly decrease, by some 6% in Ireland and 10% in Belgium. The reason is that the existing tax system already implies taxes that exceed the marginal external cost at the optimum.

Bus prices rise in both the peak and off-peak periods. The larger increase in the peak can be explained by the higher external cost in this period and the lower initial tax in the existing tax system. Optimal bus taxes are much larger in Ireland than in Belgium, reflecting differences in external costs.

The drastic price increases of many transport services imply some obvious changes in transport volumes. The relevant changes are summarised in Table 5. Not surprisingly, all peak car traffic declines. The reduction is limited to some 9-12% in the interregional model, but ranges from 19% (Dublin) to 33% (London) in the urban areas considered. The response of off-peak car traffic volumes to optimal price changes is quite different in the urban and regional environments. A decline is observed in all cities (ranging from 8% in Brussels to 41% in London), whereas both in Belgium and Ireland interregional off-peak car volumes rise, by 7% and 6% respectively. The reason is that off-peak car use in the interregional environment becomes cheaper at the full optimal price levels.

Table 3 Prices (% change w.r.t. reference), taxes and costs (Euro/pkm) for the urban case studies in the full optimum scenario

	URBAN MODEL *											
	Amsterdam			Brussels			Dublin			London		
	Money Price	Tax	MEC	Money Price	Tax	MEC	Money Price	Tax	MEC	Money Price	Tax	MEC
Peak car petrol												
Inhabitants	147%	0.91	0.80	155%	0.60	0.46	116%	0.45	0.24	152%	0.54	0.11
Commuters	233%	0.84	0.80	138%	0.56	0.46	91%	0.39	0.24	128%	0.44	0.11
Off-peak car petrol												
Inhabitants	179%	0.13	0.08	61%	0.20	0.05	67%	0.25	0.076	135%	0.44	0.06
Peak car diesel												
Inhabitants	146%	0.93	0.82	134%	0.61	0.49	143%	0.47	0.27	176%	0.55	0.13
Peak bus												
Inhabitants	63%	0.05	0.05	38%	0.08	0.02	424%	0.15	0.012	23%	0.15	0.00
Off-peak bus												
Inhabitants	-1%	-0.02	0.05	210%	0.10	0.01	124%	0.17	0.00	71%	0.12	0.00

*Improved emission technologies

Public transport volumes in the peak period increase everywhere, with the exception of Ireland. The reason for the latter finding is the strong public transport price increase because of high initial Irish subsidy levels. In the off-peak period no consistent picture emerges due to differences in optimal price adjustments: Amsterdam and London experience a strong increase in public transport use, Belgium (including Brussels) and Ireland face a reduction of some 20%.

Optimal pricing induces reductions in total transport volumes of some 7% to 14% in the urban areas considered, and much smaller effects (2-3%) in regional transport. The largest impact is to be expected in Dublin and London.

Table 4 Prices (% change wrt reference), taxes and costs (Euro/pkm) for the interregional case studies in the full optimum scenario

	Belgium			Ireland		
	Money Price	Tax	MEC	Money Price	Tax	MEC
Peak car small petrol						
Inhabitants	45%	0.195	0.195	38%	0.234	0.233
Off-peak car small petrol						
Inhabitants	-10%	0.056	0.056	-6%	0.097	0.096
Peak car small diesel						
Inhabitants	79%	0.202	0.202	57%	0.240	0.239
Peak bus						
Inhabitants	127%	0.027	0.028	143%	0.082	0.082
Off-peak bus						
Inhabitants	47%	0.018	0.020	110%	0.056	0.056

Table 5 Total volume and composition of traffic (% change wrt reference)

	*URBAN MODEL**				*INTERREGIONAL MODEL**	
	Amsterdam	Brussels	Dublin	London	Belgium	Ireland
Peak private	-28%	-22%	-19%	-33%	-12%	-9%
Peak public	34%	28%	-30%	32%	11%	-33%
Off-peak private	-19%	-8%	-14%	-41%	7%	6%
Off-peak public	53%	-22%	0%	84%	-20%	-19%
Total volume	**-6.66%**	**-8.25%**	**-14.32%**	**-13.73%**	**-2.86%**	**-2.35%**

*Improved emission technologies

Finally, consider the implications of optimal pricing for the speed of passenger transport flows. These are summarised in Table 6. All average speeds in the peak period substantially increase, reflecting congestion reductions. In the off-peak the impact is small.

Table 6 Speeds (% change wrt reference)

	*URBAN MODEL**				*INTERREGIONAL MODEL**	
	Amsterdam	Brussels	Dublin	London	Belgium	Ireland
Peak private	50%	70%	32%	13%	5% (86%)	12%
Peak public	50%	70%	32%	14%	86%	12%
Off-peak private	3%	0%	3%	2%	0% (-1%)	-1%
Off-peak public	3%	0%	3%	2%	0%	-1%

* improved vehicle emission technologies

5.2. Freight transport

Freight transport is explicitly included in the interregional models only. Therefore, results are limited to the Belgian and Irish interregional case studies. Results are in Table 7.

At the full optimum, road transport is substantially more expensive as compared to the reference situation. In the peak period the price per ton-kilometre increases by 63% (Belgium) and 100% (Ireland) respectively. Off-peak road freight transport prices rise as well, by 7% to 36%. Prices of rail freight services at the optimum reflect marginal social costs, which implies price increases of 15% and 353% for Belgium and Ireland, respectively. The figure for Ireland is to be interpreted in view of extremely high subsidies in the reference case. No notable price change is in effect for inland waterways, which are only relevant in Belgium.

The implications for freight traffic volumes are summarised in table 8. As far as Belgium is concerned, domestic freight traffic flows by road decline by 5% in the peak, and by some 3% overall. Rail loses traffic as well, some 12%. The main beneficiary of optimal prices is waterway transport: flows increase by 3%. The picture for transit freight is slightly different: road traffic gains, rail loses substantially (26%), waterways gain (some 9%). Total freight flows decline by 3.73% as a consequence of optimal pricing policies.

The enormous rail price increases in Ireland yield a different picture. Total road traffic volume actually increases as a consequence of the relative price reduction in comparison with rail services. Rail loses substantially. Overall there is a marked reduction in freight flows by some 7.5%.

Table 7 Prices (% change w.r.t. reference), taxes and costs (EURO per tonnekm)

	Belgium			Ireland		
	Money Price	Tax	Marginal exter. cost	Money Price	Tax	Marginal exter. cost
FREIGHT (domestic)						
Peak road	63%	0.046	0.046	100%	0.085	0.085
Off-peak road	7%	0.013	0.013	36%	0.039	0.038
Railways	15%	0.003	0.003	353%	0.004	0.004
Waterways	0%	0.004	0.004	-	-	-

Table 8 Volumes of freight traffic (% change wrt reference)

	Belgium	Ireland
Domestic freight		
Road	-3%	1.50%
Railways	-12%	-87.85%
Waterways	3%	-
Transit freight		
Road	4%	-
Railways	-26%	-
Waterways	9%	-
Total volume	-3.73%	-7.44%

5.3. Welfare gains

A summary of the welfare implications of optimal pricing policies is given in table 9. Welfare gains are presented as a percentage of total income.[7] They are gross gains, since specific implementation costs of new pricing systems are not taken into account. First note that households are better off in all cities and regions considered. The reduction in congestion and pollution combined with the reimbursement of tax payments outweighs the utility loss due to the price increases of transport services. The largest percentage gains are observed in Brussels and Amsterdam, the welfare gains in Ireland are proportionally smaller. Second, optimal pricing induces large tax revenue increases. For passenger transport, increases are much more limited in interregional transport than in the urban areas considered: they range from 25% in Belgium to over 170% in Amsterdam and Brussels.

In all urban case studies improvements in technology are found to be welfare-improving. In the interregional environment this is the case for diesel cars, but not for petrol cars. For diesel cars used in interurban transport the reduction in pollution compensates for the increase in resource cost.

In all cities and regions, external congestion costs as well as other external costs decline. In interregional contexts, reductions in external costs other than congestion are much smaller.

[7] Note that these are percentages of total generalised income (money income plus total leisure time times value of time) and are therefore not negligible.

They amount to 3% and 5% in Ireland and Belgium respectively. This can be explained by the much smaller external air pollution and noise costs in interregional areas due to lower population densities. For this reason it seems no longer optimal to select improved car emission technologies for petrol cars in interregional areas.

Table 9 Welfare (% gain wrt the reference equilibrium), Total external costs and Tax revenues (% change wrt reference)

	URBAN MODEL;***				*INTERREGIONAL MODEL***	
	Amsterdam	Brussels	Dublin	London	Belgium	Ireland
Welfare gain	1.29%	1.22%	0.47%	1.04%	0.80%	0.29%
Tax revenue						
Passenger	171%	185%	123%	108%	25%	29%
Freight	-	-	-	-	233%	♣
Technologies						
Small gasoline	Improved	Improved	Improved	Improved	Standard	Standard
Big gasoline	Improved	Improved	Improved	Improved	Standard	Standard
Small diesel	Improved	Improved	Improved	Improved	Improved	Improved
Big diesel	Improved	Improved	Improved	Improved	Improved	Improved
External costs (other than congestion)	-14%	-13%	-16%	-35%	-5%	-3%

♣ % change not calculable because of negative value in the reference situation. Tax revenue increases from -0.027 (in the reference) to 0.696 (in the Full Optimum).

6. Implementation of new pricing policies

The case studies have shown that the pricing policies for transport are potentially welfare improving. The two major elements of the new policies are the overall higher price levels and their degree of differentiation over time and space. A general increase of the price levels of transport and appropriate differentiation brings them in line with the corresponding social costs. Of course, the translation of simulation results of highly simplified models to policymaking raises many issues. We discuss five of them: the reliability of the results, the costs of implementation, the use of tax revenues, the division of authority and the relation with environmental and safety policies.

6.1. Reliability of results

The main contribution of using highly simplified models is to advance a direction of reform that is logical and internally consistent. Of course, using simple models to simulate important changes comes at a cost and is always somewhat risky. Therefore, the results need confirmation in several ways. More sensitivity testing and use of the models on a larger part of the European Community is needed, as well as verifications on the basis of more detailed models and experiments. Network models can provide the necessary spatial disaggregation, while dynamic models are well suited to study in more detail the optimal transition to better pricing instruments.

6.2. Implementation costs of road pricing

In the simulation results, no account has been taken of the transaction costs of new pricing technologies such as road pricing. The implementation costs consist of the costs of extra equipment in the vehicles, sensor equipment along the roads and operating costs. The latter may include important enforcement and monitoring costs. We have not studied the practical implementation and it is therefore difficult to advance cost estimates for the different cities and countries. Previous studies have shown that the cost of the simpler pricing systems (e.g., one or two city cordons) cost about 30 to 50 EURO per car per year. This amounts to some 20 to 30% of the gross benefits of congestion pricing. Moreover, the cost of these systems decreases every year due to learning effects and technological evolution. A reliable and cheap road pricing technology with technical specifications that are harmonised all over Europe is a prerequisite for the pricing reforms studied in this paper.

6.3. Use of externality tax revenues

The pricing reforms studied can be an important source of net tax revenue. For public transport the case is different from country to country. In some cities and countries, the marginal resource costs of public transport are not covered by the fares and this subsidy is no longer justified for efficiency reasons when the other modes can be priced correctly. In other countries, an important extension of public transport is justified and this could, given the decreasing marginal social cost of public transport, require higher subsidies.

In the analysis it has been assumed that the net revenue from the transport sector is used in an efficient way in the rest of the economy. More specifically, the implicit assumption has been that these revenues are used to decrease other existing distortionary taxes (e.g., taxes on labour). When this efficient use of tax revenue is guaranteed, optimal taxes in the transport sector should in general be higher than the marginal social costs. Of course, if the increased tax revenue is used inefficiently by spending it on non-justified projects in the transport sector or in other sectors, the optimal level of taxes in the transport sector could very well be much smaller than those proposed here.

In the transport pricing debate, two ways of using the extra revenue often are advocated. The first is an investment in road infrastructure and in public transport. Investments in road infrastructure (beyond adaptation of the network to road pricing) are not necessarily justified by the mere fact that funds are available. Road pricing will decrease the use of existing roads to the most efficient level and can be seen as a short-term substitute for road extension projects. It is the new, lower level of road use that should be considered as the basis for investment appraisal. Investments in public transport infrastructure are probably needed in most cities and regions. There is, however, no relation between the net revenue from optimal pricing in the transport sector and the needs for subsidies to public transport. Every project has to be judged on its own merits given the transport demand levels that can be expected with new pricing. An important second type of claim on the increased tax revenues on the transport sector is based on an income distribution argument. An attempt can be made to compensate all victims and in particular low income groups. Although it is technically speaking impossible and inefficient to compensate all victims, all households will be compensated by a reduction of taxes and by improved transport quality (higher speeds in peak periods). The poor households may need a specific compensation because of equity concerns. The best way to do this is via specific income supplements rather than via reduced transport prices. As a consequence distributional arguments do not provide a compelling reason not to account for external costs in pricing structures.

6.4. Who decides best on new prices ?

The most important requirement of more efficient pricing systems is that they should be adapted to local transport conditions. This requires that the levels of taxes on road use should not be fully harmonised at a European level, but need to be varied, both between urban and interregional areas and between different cities. One implication of optimal pricing is that the role of fuel taxes and registration taxes decreases, because road pricing systems take over their revenue and regulating function. This requires that the authority on pricing decisions will have to move at least partly from the European level to the national and local levels. This raises two issues. First, what is the appropriate reallocation of transport tax revenues over levels of government? As there will be a shift of tax resources to the more local levels, this requires compensations for the other governmental levels if there is no parallel shift in public expenditure responsibilities. The second problem is related with the incentive of local governments to implement correct pricing levels. Local governments have superior information on local transport conditions but may abuse the new instrument to engage in tax practices where non-residents pay more than the marginal external costs. This can only partly be avoided by requiring non-discriminatory road pricing as the local governments may systematically charge more on routes or modes that are used more frequently by non-residents.

6.5. Safety and pollution policies

This study addresses several types of externalities simultaneously. The case studies have mainly been focused on the congestion externality. The major policy instrument studied has been the price of different transport modes at different times of the day. As the congestion problem is directly linked to the flow of transport this is the most successful instrument. Accident externalities and air pollution externalities have been reduced simultaneously but other complementary instruments should be used to reduce them. In the case studies, the imposed introduction of cleaner vehicles has been studied briefly. This needs to be complemented by instruments that address the present variance in car emissions as a function of make, age, fuel quality and maintenance. The same holds for the noise and road damage externalities. Furthermore, the accident externalities need to be addressed with specific instruments that pay attention to the driver’s behaviour (insurance and liability incentives) and to the potential of infrastructure and road safety policies.

7. Conclusions

In this paper a common modelling methodology has been used to estimate the gap between present and efficient prices for passenger and freight transport in six zones in Europe. Starting from observations on current prices and volumes, reference equilibria were constructed for the six cases. Combining current taxes with external costs estimates and unpaid resource costs produced estimates of the current inefficiencies in the pricing policies of transport in Europe. Peak private passenger and peak private freight transport were found to have marginal external costs which are considerably larger than the current tax levels and parking was found to be an important unpaid resource cost in urban areas. In the off-peak period, taxes on private transport are sometimes too high and sometimes too low. For public transport the picture is more complex with, depending on the case study, too low and too high subsidies on variable costs. Efficient prices need to be computed such that the price level corresponds to the marginal social cost at the efficient level of traffic. This means that optimal taxes are much lower than the marginal external costs measured in the reference equilibrium. Nevertheless, important increases in the money prices of peak private transport are required (between 35% and 233%) leading to decreases in volumes between 10 and 33%. This requires spatial and time differentiated road pricing. Also public transport prices will need to be revised in certain zones. A reduction of the important subsidies on the variable costs of off-peak public transport is one of the priorities.

Important welfare gains can be achieved when this type of reform is implemented. Of course, the results presented here are from a simple modelling exercise that needs to be confirmed by case studies in the rest of the EU, and by the use of more detailed models and experiments.

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