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The impact of fuel taxes on public transport — an empirical assessment for Germany

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Abstract

An increase in fuel taxes is often connected with the hypothesis of a triple dividend: Apart from the modal-shift-effect, which relieves the environment as well as the infrastructure, and the fiscal effect, which should increase the public revenue, the movement of passengers to public transport systems should decrease its deficit. However, this calculation fails because higher fuel prices increase peak-hour transit use but not leisure or off-peak transit. But the typical attribute of peak traffic is above-average marginal costs and below average revenues. Therefore, higher fuel taxes will increase public transport's deficit rather than decrease it. The fiscal lucrativeness of higher fuel taxes will be significantly lower than is often expected. © 2001 Elsevier Science Ltd. All rights reserved.

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1. Introduction

The reduction of environmental problems is one of the urgent goals of transport policy. Increasing land use, noise emission, local pollution (e.g. CO, SO_2 and NO_x) and the global increase in CO_2 levels are considered to be particularly problematic. Motorists are viewed as the major culprits with special emphasis on the fact that most of the resultant costs have to be borne by society.

Public debate on ways and means of internalizing these so-called 'external' costs centers on fuel price increases (e.g. by means of petroleum, energy or CO_2-taxes), a solution which would appear to have the appeal of killing several birds with one stone and offering a triple dividend:

1. Higher fuel taxes should lead to a modal shift from private car traffic to public transport. This will reduce traffic congestion and improve the environment.
2. Further, fuel tax increases are the focus of politicians and the public since they should, as a first step to an ecological tax reform, finance the decrease of indirect labor costs. Thus, the central fiscal function of fuel taxes is obvious.
3. Finally, the fuel taxes will increase transit ridership and increase transit revenues. This will decrease the deficit of public transport (e.g. Weizsäcker et al., 1997, p. 289).

However, on closer inspection it is obvious that there is a conflict of goals. Since price increases generally induce a decrease in consumption, the achievement of objectives depends on the relationship between the price increase and the decrease in quantity consumed. If the demand is inelastic the fiscal effect will be dominant while the regulative effect will be very small. If, on the other hand, a high price elastic demand is connected with a high regulative effect, the tax revenues could even decline on balance. Numerous studies aimed at quantifying the price elasticities of fuel consumption have already been compiled and the interrelationships involved are described extensively in published work (e.g. Goodwin, 1992; Oum et al., 1992). As the impact of increases in fuel taxes on public transport is less well known both in academic circles and to the public at large, this paper concerns itself primarily with this issue.

A positive net effect for public transport companies cannot be assumed a priori. It is true that the tax-induced modal shift leads to higher revenues, but these additional revenues come with higher costs, the amount of which depends on the scope, time of performance and nature of the services in demand. While the marginal costs of off-peak transit are probably near zero, the costs of peak-traffic are extraordinarily high. This is due to the legal obligation of public transport companies to design their system capacity to meet demand during peak periods. Transit agencies' fleet size is exclusively determined by rush hour demand, most of

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that remains unused during normal and off-peak times. If, in addition, below average marginal revenues owing to reduced fares (e.g. job tickets, student tickets) were taken into account, a specific modal shift of working people, students and pupils to public transport for everyday commuting could lead to a negative net effect. A further increase in production costs, a decrease in revenues per passenger kilometer, and the necessity of additional public financial support cannot be ruled out.

The overall fiscal effect is determined by the price elasticities. Very low elasticities for commuter traffic (to/from work and school) will lead to very low regulative effects, i.e. almost no modal shift, and therefore to high tax-induced additional revenues. In this case the additional costs of public transport are relatively low. On the other hand high price elasticity will cause a substantial shift: The additional tax revenues tend to zero and the financial needs of public transport could lead to a negative overall effect. Therefore, the overall fiscal effect is mainly determined by:

- the absolute amount of the fuel price increase;
- the price and cross-price elasticities of different travel purposes;
- marginal revenues of public transport for each trip purpose;
- marginal costs of public transport for each trip purpose.

This study is based on an econometric model for public transport in Germany which explains and quantifies the complex relation between prices, passenger transport, modal split, production costs and deficit (Storchmann, 1999). After a short description of the model and its key concept (Section 2) and an evaluation of the impact of a fuel tax increase on modal split and tax revenues (Section 3), a detailed view of the impacts of a tax increase on transit ridership, costs, and revenues of public transport is given (Section 4). A brief description of the cost structure is followed by an explanation and quantification of the most important implications of fuel price increases. The paper ends with a summary of the results.

2. Framework and model

2.1. Concept

The subsidy required for public transport services (D) is the difference between revenues (R) and costs (C):

$$D = R - C \tag{1}$$

A distinction in variable and fixed revenues and costs, respectively, leads to Eq. (2):

$$D = (R_v - C_v)\cdot \mathrm{PKM} + R_f - C_f \tag{2}$$

where R_v and C_v stand for revenues and costs per pkm of public transport. R_f are non-transport revenues derived, for instance, from rental of advertising space and C_f are non-operating costs which are independent from passenger ridership arising in the middle-run, e.g. from office buildings or track networks. If total costs exceed total revenues D will turn negative, i.e. to a deficit. Given the assumption of a Leontief production function, where the marginal effect is not calculated as that of one incremental passenger but as the average cost per passenger of one incremental bus, the marginal deficit can also be expressed as the difference between marginal revenues and marginal costs:

$$D' = (R_v - C_v) = R' - C' \tag{3}$$

If an increase in fuel taxes leads to a modal shift from driving to transit, the induced additional deficit results from the product of marginal deficit ($R' - C'$) and the induced public passenger kilometers (ΔPKM) :

$$\Delta D = (R' - C')\cdot \Delta \mathrm{PKM} \tag{4}$$

The additional passenger kilometers depend on the current passenger kilometers of public transport, the cross-price elasticity (CPE), and the percentage fuel price increase ($\Delta P/P$)

$$\Delta \mathrm{PKM} = \mathrm{PKM}\cdot \mathrm{CPE}\cdot \left(\frac{\Delta P}{P}\right) \tag{5}$$

The induced additional deficit can also be written as

$$\Delta D = \sum_{i=1}^{n} (R_i' - C_i')\cdot \mathrm{PKM}_i\cdot \mathrm{CPE}_i\cdot \left(\frac{\Delta P}{P}\right) \tag{6}$$

where the summation index i indicates the difference of marginal revenues and costs, cross-price elasticities, and passenger kilometers relating to different trip purposes or times, respectively. It is apparent that trip purposes with high marginal deficits and strong cross-price elasticites could increase the additional deficit significantly. In contrast to that, cross-price elastic purposes with very low or even without marginal costs but high revenues could lead to a substantial decrease of the deficit. A brief description of an econometric model for German public transport is given below which will be used to quantify the overall effect of a fuel price increase on the transits deficit.

2.2. Database and structure of the model

The econometric model consists of 121 equations, of which 54 are behavioral equations and 67 are definitions. Its estimation period ranges from 1980 to 1995. In order to set out the conceptual rationale it seems to be useful to divide the model into the recursive blocks: 'modal split' and 'public transport costs'. The first block refers to the so-called KONTIV data published by the German 'ministry of transportation' in the yearly statistical handbook "Verkehr in Zahlen" (Bundesministerium für Verkehr, 2000). Within the modal split-block the travel purposes

- work;
- school (including university and vocational training);
- shopping;

- business;
- leisure;
- holiday;

were distinguished. First the number of trips for each of these purposes was estimated separately:

$$\text{trip}_i = f(\text{dem}, y, d91) \quad (7)$$

with trip_i, the number of total trips for purpose i; dem, the demographic variables (e.g. employees, students, households); y, the disposable income; and $d91$, the dummy variable $1991 = 1$.

The number of trips is mainly determined by demographic factors such as the number of employed persons, school children, students or households. Thus, within the model's estimation period the number of trips to school has been mainly determined by the age structure of the population, those to work have stood in close relationship to the employment pattern. A general rise of the number of trips is perceptible only for leisure and holiday trips since these purposes were also influenced by disposable incomes and transport prices. Finally, a dummy variable was defined to cover the structural upheaval in terms of demographic and economic factors caused by the German unification in 1991.

In contrast to the number of trips, the average distance traveled became significantly longer for all travel purposes. In particular, the increasing number of motorists on the roads and infrastructural development measures led to increasingly dispersed settlement structures with spatial function divisions. This is expressed by rapidly increasing commuter mobility, a spatial concentration of formation and shopping places as well as a spatial shift of leisure activities and vacation destinations. Thus the average trip distance has increased significantly for every travel purpose during the last decades. For instance, the distance for trips to work have grown from 7.3 km (1970) to 11.8 km (1990), those for trips to school have risen from 4.2 to 7.3 km. After a sharp decrease caused by the German unification in 1991, the distances reached the formerly high level again in 1995. The main factors of influence are the availability of fast transportation modes, i.e. the stock of cars, the price of their use, disposable income, the available infrastructure, e.g. the railroads or the road network, as well as the structural effect of the German unification. Therefore, the average distance traveled for each purpose can be set out as:

$$\text{dist}_i = f(\text{car}, p, y, \text{inf}, d91) \quad (8)$$

with dist_j, the average distance of trip for purpose j; car, the stock of passenger cars; p, the transportation prices; inf, the infrastructure; $d91$, the dummy variable $1991 = 1$.

The passenger kilometers for each purpose (pkm_i) are the result of the number of trips times their average distance,

$$\text{pkm}_i = \text{trip}_i \cdot \text{dist}_i \quad (9)$$

Since pkm_i comprises several modes it can also be written as

$$\text{pkm}_i = \sum_{j-1}^{n} \text{pkm}_{i,j} \quad (10)$$

where j denotes the different modes; car, public transport, railway, air, bicycle and pedestrian travel. For each of these modes a behavioral equations was estimated. To get a consistent calculation the mode with the highest share is determined as remainder, which usually concerns car traffic:

$$\text{pkm}_{i,j-n} = \text{pkm}_i - \sum_{j-1}^{n-1} \text{pkm}_{i,j} \quad (11)$$

Depending upon the respective trip purpose the distribution of travel modes is based more or less on number of trips, average distance, income or prices variations. While all modes can gain from a rising number of trips, the influence of the trip distances is, however, quite different. While in particular cars and railways gain from dispersed settlement structures, rising travel distances for non-motorized traffic become increasingly an obstacle due to lower speed. The influence of transportation prices on mode choice varies to a greater or lesser degree with the individual modes. While non-motorized types of traffic react rather price-inelastically, an intensive price competition prevails among the other means of transport, depending upon trip purpose. Not only the price of a particular mode of transport itself ($p_{i,j}$), but also that of the competing modes ($p_{i,k}$) are relevant, so that in addition to specific price elasticities cross-price elasticities are also crucial factors. These ratios are model-endogenously determined for all traffic purposes and modes. Additionally, the respective capacities (cap) are important variables, since they indicate the possibility of use, the attractiveness or convenience of a mode.

$$\text{pkm}_{ij} = f(\text{trip}_i, \text{dist}_i, p_{ij}, y, \text{cap}_j, \text{cap}_k) \quad (12)$$

The purpose-specific passenger kilometers of public transport determined in this way are received as crucial inputs into the cost block. The following cost factors for transit systems are modeled separately (see Fig. 1):

- vehicles and depreciation;
- rents for buses;
- wages and salaries;
- old-age pensions;
- traction energy;
- material;
- others.

The capital costs in the segment vehicles and depreciation refers mainly to the peak traffic generated from commuter passenger miles for work and school. These peak passengers determine the required capacity, i.e. the size of the vehicle fleet and the number of personnel. The central definition equation calculates the number of required vehicles for a given amount of peak traffic, the average capacity of each

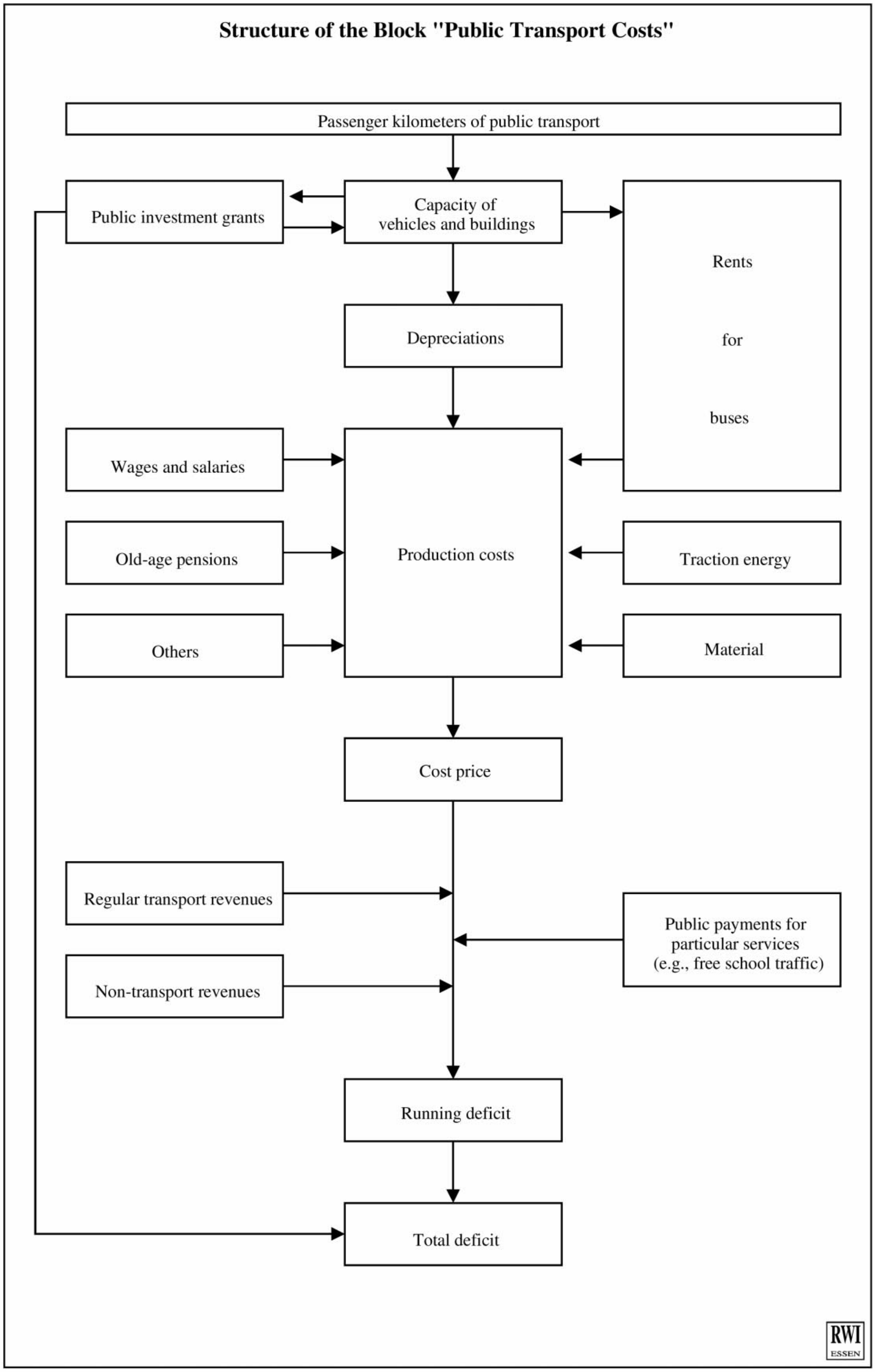

Fig. 1. Structure of the block "public transport costs".

Table 1
Test statistics of selected variables ex-post-simulation 1985–1995 (own calculations. MAPE, mean absolute percentage error; MEAN, mean error; MAE, mean absolute error; RMSE, root mean square error)

Variable	Description	MAPE	MEAN	MAE	RMSE
PKPTWOR	Pkm public transport for trip purpose work, bill	0.67	0.025	0.134	0.164
PKPTSCH	Pkm public transp. for trip purpose school, bill	0.86	0.011	0.135	0.160
VEHPT	Number of public transport vehicles	0.45	31.179	172.951	211.641
EPPT	Employed people of public transport	1.34	75.640	1418.454	1700.381
DEFRUN	running deficit, mill DM	2.70	−1.163	132.606	155.394
DEFINV	Investment deficit, mill DM	2.41	14.877	58.173	77.071
DEFTOT	Total deficit public transport, mill DM	2.16	13.714	164.159	204.538
TAXREV	Fuel tax revenues (only pass. cars), mill DM	1.16	96.892	313.707	387.065

vehicle, the average speed of the vehicles, the average peak load factor, and a reserve capacity of 15%:[1]

$$VEH_{PT} = \frac{PKM_{PTPEAK}}{SEATVEH \cdot LOADFAC \cdot AVGSPEED} \cdot 1.15 \quad (13)$$

with VEH_{PT} being the required number of vehicles; PKM_{PTPEAK} the peak traffic pkm; SEATVEH, seats per vehicle; LOADFAC, average peak seat load factor during peak periods; AVGSPEED, average speed during peak periods.

The required capacity can be accommodated with both owned and rented buses. However, the maximum outsourcing ratio is limited by collective bargaining agreements to approximately 30% and is already exhausted to a large extent. Capacity increases will require mainly public transport systems' capital investments, which are supported with public funds. Stock, new registrations and the retirement of buses, trams and underground trains are modeled separately by a vintage approach. This is imperative since induced cost effects do not directly affect the capital stock but do affect the required new registrations. While the depreciations are affected by the age structure of the existing vehicle pool and the new registrations, the personnel costs are closely related to the size of the vehicle pool. The deficit is defined as the result of all costs plus public investment grants and deducting all revenues resulting from passenger fares. Table 1 shows some test statistics of a simultaneous ex-post solution from 1985 to 1995.

The item public transport covers all urban public transport by bus, tram and underground. According to the statistical definition suburban commuter railway traffic is not considered *public transport* but *railway transport*. All results are based on an ex-post-simulation that might be termed a 'what-would-have-been-if-scenario'.

[1] A reserve capacity is required because of unexpected demand peaks or repair of vehicles. The ratio varies widely among the authorities. Whereas the German average rate is about 15% the number of reserve vehicles in the US seems to be significantly higher. For instance they are18% in New York, 25% in Chicago, 28% in Atlanta and even 124% in Houston (Federal Transit Administration, 1998).

3. Elasticities and modal split

3.1. Price elasticities

The travel purpose-related price elasticities of each mode of transport were calculated endogenously within the model. Since they are of central importance to subsequent steps in this investigation, a description of these ratios is given first.

In general elasticities denote the relationship between the percentage change in price and the percentage change in quantity, i.e. the influence of price with respect to the passenger miles demanded. Elasticity ratios by mode as well as by travel purpose are calculated according to the disaggregation of the model. Table 2 shows the main results of a simulation of the model. However, the following points should be taken into account:

- The values shown are substantially lower than long-term fuel price elasticities. Since only the modal split and not the structural change within the capital assets is taken into account, the elasticities shown here are best compared with short-term fuel price elasticities, although the estimation period covers an entire decade (Goodwin, 1992).

Table 2
Fuel price elasticities of automobile and public transport by various trip purposes ex-post-simulation; 1995 (own calculations)

Mode	Trip purpose	Elasticity
Automobile	Work	−0.092
	School	−0.136
	Business	−0.009
	Shopping	−0.020
	Leisure	−0.120
	Holiday	−0.240
	Overall	**−0.102**
Public transport	Work	0.202
	School	0.121
	Business	0.047
	Shopping	0.031
	Leisure	0.045
	Holiday	0.016
	Overall	**0.070**

Table 3
Impacts of an increase in fuel tax on the modal split 1995; in billion pkm (own calculations)

		Reference solution[a]	Simulation[b]	Deviation[c] absolute	Deviation[c] in %
Automobile	Work	150.9	148.8	−2.1	−1.4
	School	16.1	15.8	−0.3	−1.7
	Business	125.9	125.8	−0.2	−0.1
	Shopping	81.8	81.6	−0.2	−0.3
	Leisure	324.0	318.4	−5.6	−1.7
	Holiday	51.4	49.5	−1.9	−3.6
	Overall	**750.8**	**740.5**	**−10.2**	**−1.4**
Public transport	Work	20.4	21.1	0.8	3.8
	School	18.6	18.9	0.3	1.5
	Business	3.2	3.2	0.0	0.5
	Shopping	13.9	14.0	0.1	0.5
	Leisure	25.8	25.8	0.0	0.0
	Holiday	4.6	4.6	0.0	0.0
	Overall	**86.6**	**87.6**	**1.0**	**1.2**

[a] Simultaneous ex-post solution.
[b] Fuel tax increase of 25%.
[c] Deviation from reference solution.

- Price elasticities are variable. On one hand they depend on other variables, e.g. the disposable income.[2] On the other hand they are determined by the magnitude of the price variation. Accordingly, several simulations lead to the assumption that elasticities decrease with rising changes in prices, i.e. there is a decreasing marginal price elasticity. Therefore, the data shown is based on moderate price variations which were already observed within the estimation period.

For automobile travel a 10% increase in gasoline and diesel prices impacts leisure and holiday travel the most. Elasticities of −0.120 and −0.240 are relatively high compared with those for other purposes. Only the demand for school trips seems to be relatively high elastic with a value of −0.136. This seems to be a significant indication that car travelers perceive automobile use to be essential for work and business trips, while it is not that essential in the leisure segment. These findings are expected based on the results of previous investigations (e.g. Drollas, 1984; Oum et al., 1992; Espey, 1996).

In contrast, the demand for public transport is far less sensitive to fuel prices; the overall cross-price elasticity amounts to 0.07. This low level was also confirmed by many preceding empirical studies (e.g. Rus, 1990; Oum et al., 1992). However, it is surprising that these values are not a reflection of car travel elasticities. High price elasticities of leisure travel by car are not accompanied by comparable high cross-price elasticities of public transport demand. People who use their cars for leisure purposes virtually never switch to public transport: there is almost no substitution between the two modes.

The opposite applies to commuting regarding work and school trips: since these transportation needs are unavoidable, a small percentage decrease in car use leads to a relatively high increase in use of public transport. This is of course also due to the different magnitudes of the modes: A decrease of 1% of car use for commuting induces a rise of 4.2% in use of public transport. Summing up, it may be said that price increases affecting car use cause mainly modal shifts in the traffic segment relating to commuting by working people and students. In comparison, if increasing gasoline prices reduce the use of cars for leisure purposes, these trips are avoided rather than shifted to public transport.

3.2. Impact on modal split and tax revenues

In order to illustrate the impact of this policy strategy the following scenario assumes an increase in fuel taxes of 25%. Referring to the 1995 values this leads to increases for unleaded gasoline from 1.50 to 1.73 DM/l and for diesel from 1.13 to 1.27 DM/l. The assumption is made that public transport is unaffected by the fuel tax and the passenger fare remains constant. Further, the tax is assumed to have an 'ecological tax design', i.e. the additional income is determined to finance exclusively non-transport purposes.

Because of the relatively high elasticities for holiday, leisure and school travel, the relative and absolute highest decreases in car passenger miles are to be found with these trip purposes (Table 3). Public transport cannot take advantage of this phenomenon except in the case of commuting by working people and students. Overall, the passenger kilometers accounted for by car travel will decrease by 10.2 billion while public transport will gain only 1.0 billion pkm. Hence, increases in fuel prices induce a substantial

[2] It is obvious that car ownership and use tend to become a kind of base consumption with increasing disposable incomes. Hence the price elasticities of car use will decrease (Hsing, 1990; Oum et al., 1992).

Table 4
Tax revenues for different price elasticities. Reference solution and deviations for 1995 (own calculations)

Fuel price elasticities	Consumption, bill (l)	Fuel tax revenues, bill (DM)	Deviation to reference solution, bill (DM)
Reference solution	48.5	45.2	0.0
$\eta = -0.1$	47.5	53.0	7.8
$\eta = -0.5$	44.9	50.1	4.9
$\eta = -0.8$	42.7	47.7	2.5
$\eta = -1.0$	41.2	46.1	0.9

shift only at peak times. Leisure travel, which typically occurs at off-peak times, will be avoided rather than shifted.

Since the short-term fuel price elasticities are comparatively low, the fuel consumption of cars will diminish only by 1 down to 47.5 billion l (see Table 4). Thus, in the short term a rise in fuel tax revenues of 7.8 billion DM from 45.2 to 53.0 billion DM can be anticipated. The quality of this source of revenue, however, has to be qualified if long-term fuel price elasticities were referred to. While short-term effects could merely lead to variations in car use (i.e. vehicle–km), in the long run there also will be adjustments to capital assets, i.e. size, efficiency and structure of the car stock.[3] Hence, long-term elasticities are in principle higher than short-term elasticities. Empirical investigations established values between −0.2 and −0.9 (e.g. Sterner et al., 1992; Oum et al., 1992; Drollas, 1984; Gallini, 1983; Wheaton, 1982). It is evident that revenue from gasoline taxes will decrease with increasing elasticity values. In Table 4 some results based on the assumption of exogenous long-term price elasticities within the model are shown. While a short-term adjustment ($\eta = -0.1$) leads to an additional tax yield of 7.8 billion DM, an elasticity of $\eta = -0.8$ leads only to 2.5 billion DM and $\eta = -1.0$ even to 0.9 billion DM.[4]

4. Public transport: services and costs

4.1. Service profile

The demand for public transport is characterized by a marked daily cycle. Fig. 2 shows the weekday public transport traffic in the main urban regions in Germany, including the Berlin, Munich, Rhine-Ruhr, Rhine-Sieg and Stuttgart public transport networks, which account for almost two-thirds of the entire volume of public transport in Germany. Early morning, noon and late afternoon commuter traffic result in peaks which are far in excess of the off-peak demand. The morning peak is significantly higher than the others, accounting for almost 15% of the total daily load on public transport between the hours of 7 and 8 AM, owing to people setting out for work and school at the same time and in roughly equal numbers.

Analogous to the demand side there is also a daily cycle on the supply side. However, since the load factors differ widely between peak and off-peak periods, the imbalance is not that marked with regard to the number of vehicles used. Hence the load factor, measured in passenger kilometers per available seat kilometer, in peak load times is significantly higher than the daily average. In spite of this tendency towards adjustment, the vehicle service follows the same pattern. Many empirical investigations have confirmed that about 50% of public transport's deficit is caused by peak load requirements, i.e. vehicles as well as wage costs (Travers Morgan and Partners, 1976; Bauer 1983; Jansson 1984).

Hence it is obvious that the simple formula 'more passengers — more revenue — less deficit' has only a restricted validity. The question of marginal costs and revenues is more important. While a peak load passenger causes above average marginal costs and leads in general to below average marginal revenues, the opposite applies to off-peak passengers. This is due to an inverse fare structure of public transport which is justified by second-best arguments (Glaister, 1974): The uncovered marginal costs (i.e. the external effects) of private car use arising from factors such as traffic congestion and environmental damage, are somewhat higher than those of public transport. Thus lower second-best prices are supposed to cause a modal shift from car use to public transport. The fare reduction should be inversely proportional to the difference in marginal external costs between car traffic and public transport. According to this pricing rule only off-peak passengers could make a contribution towards reducing the deficit. By contrast, work and school commuter traffic, which occurs mainly during peak times, will induce an increase in the deficit of public transport.[5]

[3] A theoretical model to explain the long-run effects within the vehicle stock is provided by the household production theory which interprets fuel consumption as a derived demand (Becker 1965; Lancaster 1966).

[4] The additional tax yield of a price elasticity of −1 occurs because an increase in fuel taxes by 25% leads to a price increase of only 15% for gasoline and 13% for diesel.

[5] The overall cost of public transport in Germany in 1995 amounted to 22.6 billion DM (US$11.9 billion), of which approx. 44% was accounted for by labor costs, 30% by capital assets (vehicle, equipment, buildings) and about 26% by services. With fare revenue standing at 10.7 billion DM (US$5.6 billion) the deficit came to about 12 billion DM (US$6.3 billion).

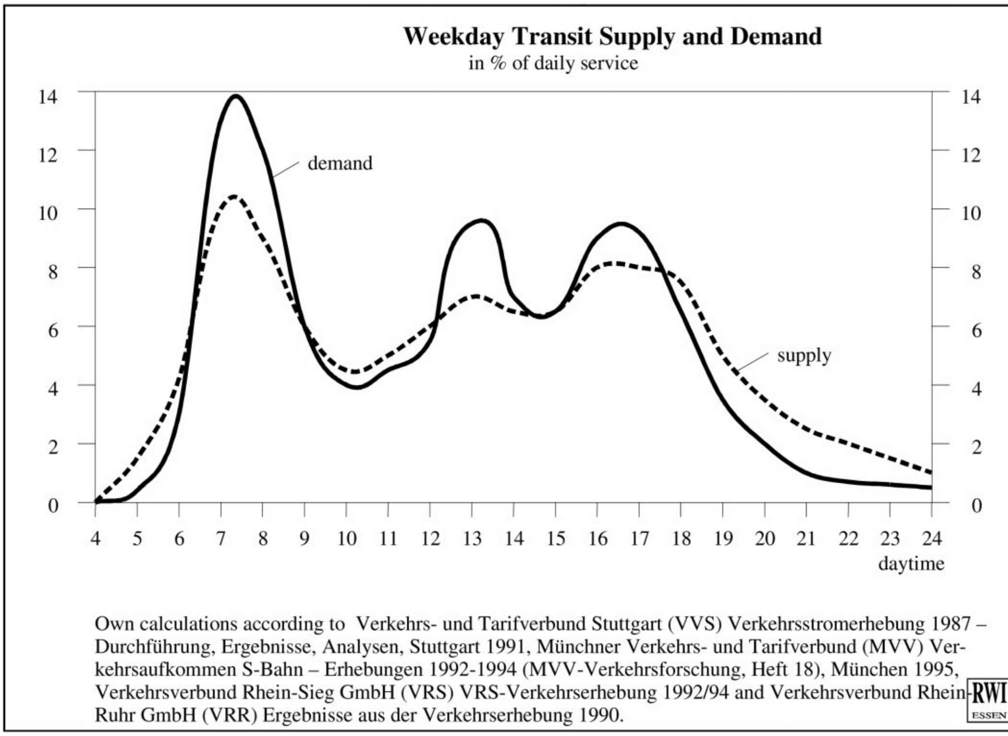

Fig. 2. Weekday transit supply and demand in % of daily service.

Table 5
Impacts of an increase in fuel taxes on passenger kilometers, capacities, and investments 1995 (own calculations)

		Reference simulation	Simulation	Deviation	
				Absolute	in %
Passenger km	Passenger cars, billion	750.776	740.538	−10.238	−1.4
	Public transport, billion	86.565	87.573	1.008	1.2
	Daily morning peak, million	29.122	29.855	0.733	2.5
System capacity	Vehicles, 1000	51.754	53.058	1.304	2.5
	Staff, 1000	123.134	127.029	3.895	3.2
Investments	Vehicles, billion DM	2.334	2.442	0.109	4.7
	Buildings/equipment, billion DM	2.802	2.832	0.030	1.1

4.2. Impact on public transport

Given the above-mentioned behavior pattern, according to which car use for leisure purposes is generally inhibited by rising running costs with no significant shift to use of public transport as a substitute whereas the less price-elastic work and school commuter traffic switches to public transport, increasing tax on fuel will cause the morning peak load to soar. There will be a 1.2% rise in total public transport passenger kilometers, but — assuming that it is virtually impossible to defer work and school trips — the morning peak will rise by twice this amount (Table 5). Clearly, any attempt to cope with this must involve adjustment of capacity and capital expenditure. On the ‘ceteris paribus’ condition that factors such as average speed, vehicle size and reserve capacity (see Eq. (13)) remain the same, the available pool of vehicles will have to be increased by 1300 and staffing levels by 3900 to a total of 120,000.

Capital expenditure on structures and equipment (excluding vehicles) consists mainly of fixed costs and significant increases are not to be expected. In contrast to this, investment in vehicles will increase by 100 million DM or 4.7% (Table 6).

The proposed increases in tax on fuel are likely to raise public transport cost by a total of about 446 million DM, mainly as a result of higher labor costs: expenditure for wages and salaries will increase by 326 million DM. Depreciation will increase by 3.7% as a result of expansion of capacity, but the absolute figure of 41 million DM seems to be rather marginal. This on one hand is caused by the fact that depreciations are spread over a certain period and therefore need a certain lead time to exceed a particular order of magnitude.

Table 6
Impacts of an increase in fuel taxes on costs and deficit of public transport 1995; in billion DM (own calculations)

		Reference solution	Simulation	Deviation	
				Absolute	in %
Cost	Depreciation	1.091	1.133	0.041	3.7
	Wages/salaries	10.245	10.571	0.326	3.2
	Rents for buses	1.803	1.814	0.011	0.6
	Material	2.376	2.416	0.040	1.7
	Traction energy	0.933	0.960	0.027	2.9
	Total	**16.448**	**16.894**	**0.446**	**2.7**
Deficit	Investment	3.969	4.053	0.084	2.1
	Running	8.192	8.492	0.301	3.7
	Total	**12.161**	**12.545**	**0.385**	**3.2**

On the other hand, the term depreciation only covers investments funded by the public transport companies themselves. As the greater part of public transport investments are subsidized with public money, only a fraction can be depreciated. The subsidy is revealed as an 'investment deficit' which will rise by 84 million DM.

Assuming that fares remain constant, the running deficit of public transport will increase by 300 million DM. Together with the investment subsidies increases in fuel taxes will induce an additional total deficit of about 385 million DM.[6]

Returning to Eq. (6) and making a rough calculation, this result is little surprising since all figures needed to insert into the equation are now available: With the affected peak travel purposes work and school trips accounting for a total of 39 billion pkm, their average cross-price elasticity is about 0.16; the fuel price increase amounts to 15%. Furthermore, several estimations undertaken for the German government (e.g. Planco Consulting, 1991; Wibera, 1996) indicate that (private) marginal peak costs are somewhat below 0.60 DM/pkm while peak revenues were slightly above 0.20 DM/pkm in 1995 (Statistisches Bundesamt, 2000). This difference of about 0.40 DM/pkm inserted into Eq. (6) leads to an additional deficit in the mentioned range.

Moreover, when long-term elasticities of, for instance, −0.8 are assumed (see Table 4), the additional revenue from a tax increase of 25%, i.e. 2.5 billion DM, should be set in relation to rising financial requirements for municipal public transport of almost 400 million DM. These 400 million DM are merely sufficient to cover the direct impact of induced peak load traffic. The often claimed improvement of the attractiveness and efficiency of public transport would require additional finance. Similar increases in costs must also be assumed for suburban railway commuter traffic, which makes the fiscal sense of raising fuel taxes even more questionable.

However, this induced deficit will not burden the budgets of the federal and state governments which will collect the additional revenue. On the contrary, it will be funded by the local governments who generally use profits from the public energy utilities to cross-subsidize the municipal transport services. However, this financial scope will be reduced sharply as energy markets are opened up to competition. Hence, the additional burden will be paid by the municipal budget. Accordingly, besides increasing the public transport deficit, raised fuel taxes will also have an adverse effect on the distribution of income between local authorities and federal and state government. This aspect should not be overlooked, especially when revenue from fuel taxes is appropriated for purposes other than transport.

Even if these modalities of financing and distribution might be a particular trait of transit in Germany, however, it is apparent that the results are of a general nature. Thereby, the amount of the additional deficit is of course a question of the respective cross-price elasticities as well as the difference between marginal revenues and costs. For instance, it is true that calculations for Belgium indicate that the difference between marginal peak revenues and costs is rather half the German amount (De Borger et al., 1996). On the other hand the cross-price elasticity of peak transit seems to be much higher. Hence, a value of 0.7 indicates a rather higher impact than a lower one.

5. Conclusion

With regard to the supposed triple dividend obtained by increased fuel taxes, this investigation employing an econometric model leads to the following results:

1. The comparatively low price elasticity relating to car use — about −0.1 — will lead to a small reduction in kilometers traveled and therefore to a small reduction of pollution. Very small reactions are to be expected in work and business traffic. In contrast to this, there will

[6] It should be remarked that the more the external costs of car use are raised by increasing fuel prices, the less justification for 'second best' public transport prices there is. Peak prices could accordingly be raised and the deficit cut.

be a larger decrease in the kilometers driven by cars for leisure and holiday purposes.

2. This low elasticity will have a positive fiscal effect. In the short-term an increase in fuel taxes by 25% will lead to additional tax revenues of 7.8 billion DM ($3.9 billion) per year. Since the number and type of cars on the roads will slowly adjust to the new price conditions, the long-term effect will be somewhat less. Hence, a long-term elasticity of, for instance, −0,8 will lead to additional revenue of only 2.5 billion DM ($1.25 billion) per year.
3. Public transport ridership will gain from the price-induced modal shift only in the segments work and school, i.e. peak load traffic. Since this traffic is characterized by above-average marginal costs and below-average marginal revenues the additional peak load traffic will increase the deficit of public transport by 400 million DM ($200 million).

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References

Bauer, R., 1983. Die Kosten des Spitzenverkehrs und Vorschläge zu deren Abbau. Eine Untersuchung der VÖV-Landesgruppe Baden-Württemberg. Nahverkehr 1 (1), 28–32.

Becker, G.S., 1965. A theory of the allocation of time. Economic Journal 75 (299), 493–517.

De Borger, B., Mayeres, I., Proost, S., Wouters, S., 1996. Optimal pricing of urban passenger transport. A simulation exercise for Belgium. Journal of Transport Economics and Policy 30 (1), 31–54.

Bundesministerium für Verkehr, 2000. Bau- und Wohnungswesen (Ed.), Verkehr in Zahlen. Hamburg.

Drollas, L.P., 1984. The demand for gasoline: further evidence. Energy Economics 6 (1), 71–82.

Espey, M., 1996. Explaining the variation in elasticity estimates of gasoline demand in the United States: a meta-analysis. The Energy Journal 17 (3), 49–60.

Federal Transit Administration, 1998. National Transit Database, 1997. http://www.ntdprogram.com/NTD/ntdhome.nsf?OpenDatabase.

Glaister, S., 1974. Generalised consumer surplus and public transport pricing. Economic Journal 84 (336), 849–867.

Goodwin, P.B., 1992. A review of new demand elasticities with special reference to short and long-run effects of price changes. Journal of Transport Economics and Policy 26 (2), 155–169.

Hsing, Y., 1990. On the variable elasticity of the demand for gasoline. Energy Economics 12 (2), 132–136.

Jansson, J.O., 1984. Transport System Optimization and Pricing. Wiley, Chichester.

Lancaster, K.J., 1966. A new approach to consumer theory. Journal of Political Economy 74 (2), 132–157.

Oum, T.H., Waters II, W.-G., Young, J.-S., 1992. Concepts of price elasticities of transport demand and recent empirical estimates. Journal of Transport Economics and Policy 26 (2), 139–154.

Planco Consulting (Ed.), 1991. Externe Kosten des Verkehrs. Planco Cosulting, Essen.

Rus, G.de, 1990. Public transport demand elasticities in Spain. Journal of Transport Economics and Policy 24 (2), 189–201.

Statistisches Bundesamt, 2000. Straßenpersonenverkehr. (Fachserie 8: Verkehr, Reihe 3). Metzler-Poeschel, Stuttgart.

Storchmann, K.-H., 1999. Das Defizit im öffentlichen Personennahverkehr in Theorie und Empirie. Schriftenreihe des Rheinisch-Westfälischen Instituts für Wirtschaftsforschung, Neue Folge Heft 64, Duncker and Humblot, Berlin.

Travers Morgan and Partners, 1976. Costing of bus operations. An interim report of the Bradford Bus Study, London.

Weizsäcker, E.U., von, Lovins, A., Lovins, L.H., 1997. Factor four: doubling wealth — halving resource use; the new report to the Club of Rome. Earthscan, London.

Wibera Wirtschaftsberatung, A.G., 1996. Entwicklung der Kosten, Erträge, Betriebsergebnisse und Leistungen des ÖPNV im Jahre 1993 und Vergleich mit vorangegangenen Zeiträumen. FE-Nr. 70456/94. Wibera, Düsseldorf.