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COST-BENEFIT-ANALYSES FOR GOODS TRANSPORT ON ROADS

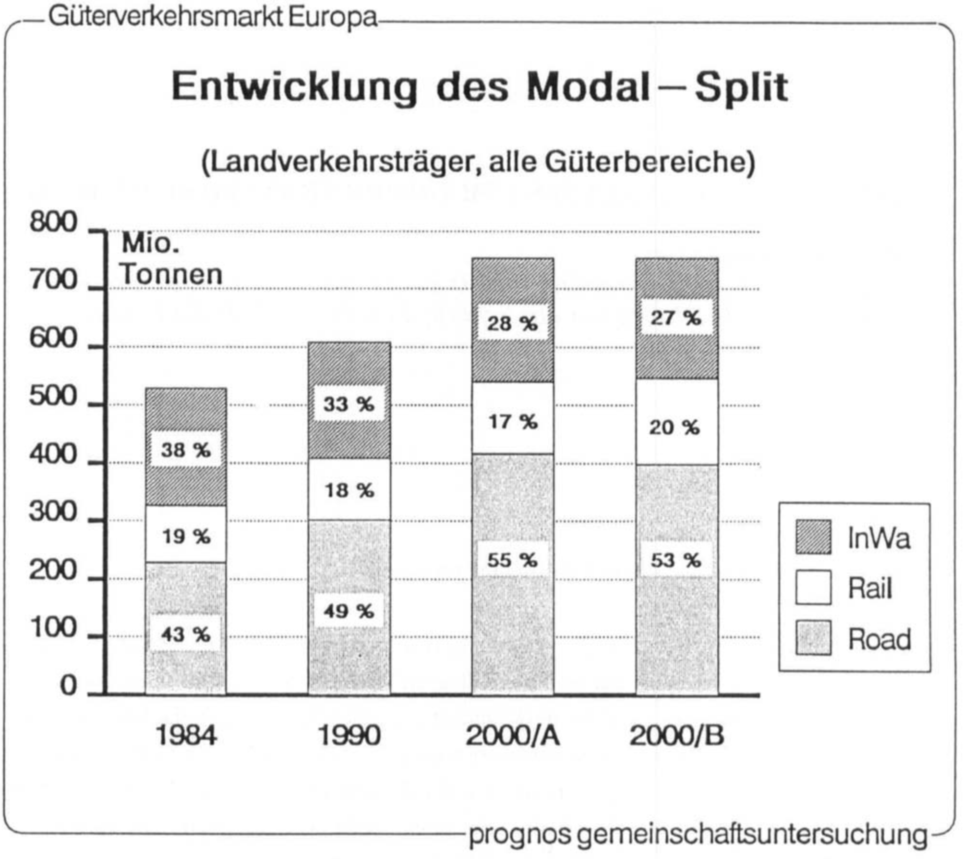
Werner Rothengatter
Institut für Wirtschaftspolitik und Wirschaftsforschung der Universität Karlsruhe (TH), Kollegium am Schloß, Bau IV, D 7500 Karlsruhe, Germany

Development of goods transport on roads

Goods transport in Europe is growing fastly at a speed which has not been anticipated by the forecasts. In particular the border crossing traffic shows a most dynamic motion due to the European integration and the development towards a free common market without any trade barriers. Apparantly the prospects of Cecchini's report to the European Commission (Cecchini, 1988) are going to become self-fulfilling prophecies in the sense that the economic agents believe that they come true and behave such that they confirm the speculative expectations in a self-enforcing bootstrap circle.

Under the present regime of transportation policy the growth of the economy is closely linked to the growth of goods transport. The growth rate of goods transport is greater than the growth rate of the weight of the GNP but smaller than its value. A trend projection shows that the border crossing goods transport in West Europe will grow by more than 50 % in the time from 1988 to 2010.

An analysis of the trend development of the modal split yields the clear result that the modal shares of inland waterways and rail will drop while the share of road transport will rise dramatically (see Figure 1).



2000/A: trend forecast
2000/B. public assistance for the railways

Figure 1: Development of modal shares in European border crossing goods transport
Source: Prognos, 1988

This seems to be surprising if one considers that the economic integration of Europe leads to increasing transport distances which could improve the market potential for railways. A closer look to the spatial pattern of economic activities and of the profile of the logistic requirements of the shippers however provides the insight that most of the expected changes of the European transport market favor the transport on roads.

The development of land use still continues to disperse the economic activities over space rather than bundling them along corridors, which would bring advantages to rail transport. The logistic requirements of the shippers lead to smaller transport units and growing importance of qualitative services such as just in time, flexibility, accessibility or packet supply of complementary products. The European railway companies have not succeeded in adjusting their operations to the market demand. Besides the slow speed of technological change for improving their services there are still the persisting problems of technical and organisational coordination between the companies. Such the result of a Prognos-study (Prognos, 1989; see Figure 1) is, that also the "high level" services of the railways such as container and piggy-back transports only can extend their market share considerably if the goverments give sufficient political support.

A most important argument for the road transport to be the winner in the European transport market race is the expected outcome of the liberalisation of this market. Removing the market barriers of national regulations and introducing free choice of location of the transport industry as well as cabotage will lead to a drastic reduction of transport tariffs. Firms are free to choose the location associated with the lowest cost of taxation and regulatory control and to operate in every market they want if the plans of the European Commission will be implemented. But the plans for harmonizing the economic side conditions like taxation, subsidization, social requirements and regulatory control will most probably fail to be introduced on a sufficiently high level, because of the constellation of interests and the voting mechanism in the EC (decisions enforcing liberalisation can be taken with the majority of EC-countries, decisions on harmonisation require the agreement of all EC-countries).

As a result of this political mechanism the road transport is favored despite its environmental problems. It should be remembered that market liberalisation is the crucial issue documented in the Treaty of Rome (1956) while social and environmental needs are not documented and thus treated as arguments of minor importance. The European Law

Court has underlined this interpretation in summer 1990 by the interim injunction as to the W. German road user charges for heavy truck loads. The W. German government had to draw back the law for implementing these user charges, which would have left the tax burdens for the W. German truckers almost unchanged while they would have forced foreign truckers to contribute to the infrastructure costs according to the territoriality principle. As a consequence the tax burdens of W. German truckers have been cut by half. They save about 1.1 Bill. DM per year now which implies an additional comparative advantage in the road/rail competition.

In a forecast for the W. German Ministry of Transport the effects of liberalisation on the market shares have been quantified for a situation without opening the borders to the East. It turns out that the expected loss of transport volume for the Deutsche Bundesbahn will be about 6 % under the regime of EC-liberalisation (Figure 2).

After opening the borders to the East and starting a process for integrating the GDR into the market system of the FRG many experts first believed that this would provide an chance for the railways to extend their market. The reason for this expectation was that the market share of the Deutsche Reichsbahn on the goods transport market in the GDR was about 75 % compared with 35 % of the Deutsche Bundesbahn (long distance transport volume 1985 related to the FRG). A detailled analysis however proved that the long term market potential of the railways in the GDR is not much different from that in the FRG. Consequently the future market share of the railways in both German states will drop to about 30 % (Table 1). Behind this figure stands the assumption that the technological and organisational adjustment of the railway companies according to the market requirements will be successful.

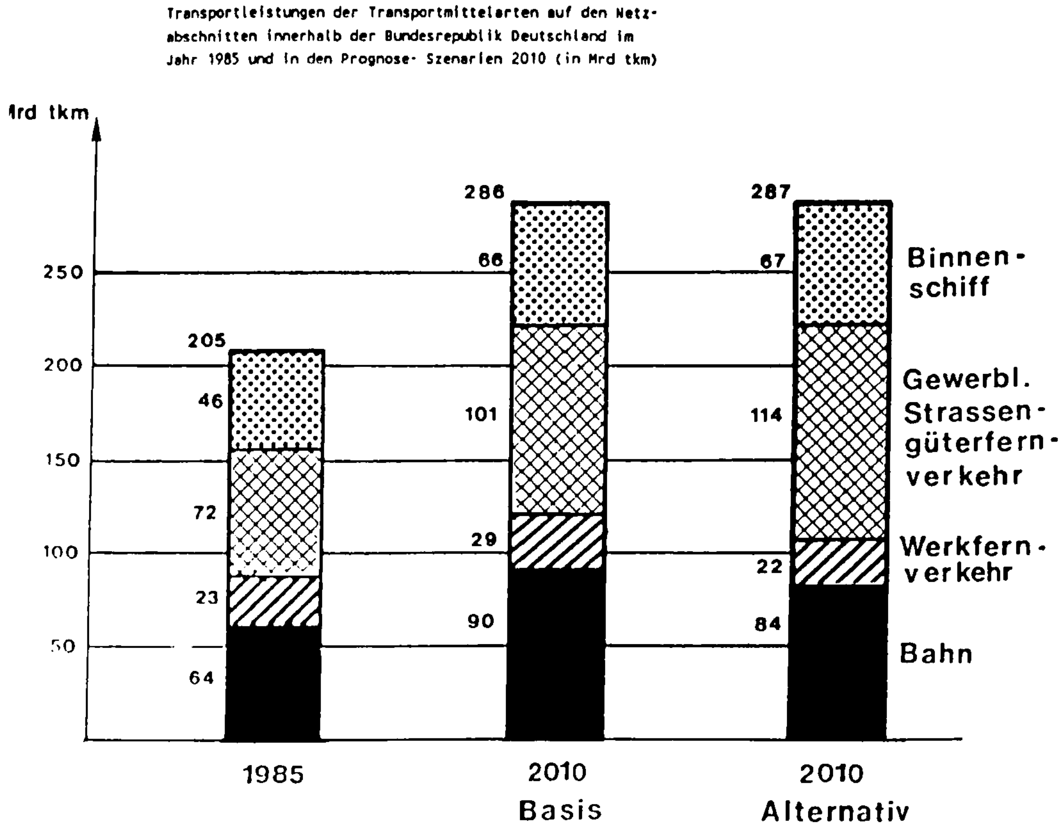


Figure 2: Development of the transport market in the FRG with/without EC-liberalisation
Source: Prognos/BVU, 1989

Transportrelationship	1985 (BVWP)	2010 (BVWP)	2010 (Szenario DDR)
Domestic Transport FRG			
- FRG without Berlin (West)	45	37	36
- FRG - Berlin (West)	18	14	12
Orig./Dest. Transport FRG			
- Western Europe	16	17	17
- GDR	64	66	28
- other RGW-countries	61	69	41
Transit FRG			
- West - West	20	28	29
- Western Europe - GDR	50	50	19
- Western Europe- other RGW countries	34	50	44
Total transport volume FRG	35	30	29
Domestic Transport GDR	-	-	29
Additional Orig./Dest. Transport			
- GDR - Western Europe	-	-	33
- GRD - other RGW-countries	-	-	22
Total Additional Transport Volume GDR	-	-	27
Total Transport Volume FRG - GDR	-	-	29

Table 1: Modal share of the railways in West and East Germany, Scenario for 2010
Source: Kessel and Rothengatter, 1990

Transportrelationship	1985 (BVWP)	2010 (BVWP)	2010 (Szenario DDR)
Domestic Transport FRG			
- FRG without Berlin (West)	224	295	320
- FRG - Berlin (West)	10	13	6
Orig./Dest. Transport FRG			
- Western Europe	121	186	201
- GDR	1	1	119
- other RGW-countries	4	6	58
Transit FRG			
- West - West	12	17	16
- Western Europe - GDR	1	1	16
- Western Europe- other RGW countries	2	3	13
Total transport volume FRG	375	521	749
Domestic Transport GDR	-	-	62
Additional Orig./Dest. Transport			
- GDR - Western Europe	-	-	9
- GRD - other RGW-countries	-	-	29
Total Additional Transport Volume GDR	-	-	100
Total Transport Volume FRG - GDR	-	-	849

Table 2: Transport volume of road transport in East and West Germany (Mill. t/year)
Source: Kessel and Rothengatter, 1990

Goods transport on roads and pollution

For the FRG forecasts of emittent pollutions of road goods transport have been (prepared by the Umweltbundesamt (1990) and a research group (DIW, ILS, ISL, IFEU, TÜV-Rheinland) on behalf of the Enquête Commission "Protection of the Atmosphere" of the W. German parliament. The most important figures are exhibited in Table 3.

Referring to the study for the Enquête Commission only we can draw the following conclusions from Table 3:

(1) The ton kilometers traveled for the goods transport on roads are expected to grow by 42 % from 1987 to 2010. The effects of opening the borders and integration of the GDR are not considered in this figure. If we add these by a rough estimate we result in an increase of about 60 %.

(2) The exhaust emission of carbon dioxide grows by 29 %. This is remarkable insofar as the government of the FRG has decided to reduce the CO_2-emissions by 25 % until the year 2005. Obviously the trend development of road transport is counterproductive with respect to this objective.

(3) The exhaust emissions of nitrogen oxide fall slowly by 4 % This again is counterproductive to the political goal to reduce the NO_x emissions by 30 % until the year 1998 (convention of Sofia). The goods transport on roads is expected to become the dominant pollutant of NO_x in the FRG.

(4) Despite the expected technical progress the percentual change of reduction of pollutant emissions is relatively small compared with the railway system which may realize further considerable reductions of specific emissions although it operates already on a low level of emissions.

	Goods Transport					
	Rail		Inland Waterways		Road	
	1987	2005	1987	2005	1987	2005
ton kilometers	58	69	50	60	145	206
primary energy	39	43	29	33	419	533
total emissions (kt/a)						
carbon dioxide	2,364	2,081	2,071	2,372	30,052	38,900
methan	4	3	3	3	43	53
TVOC	5	4	7	8	163	139
nitrogen oxide	13	5	25	28	516	495
carbon oxide	3	1.1	8	10	350	231
specific emissions (g/tkilometer)						
carbon dioxide	41.00	30.00	42.00	40.00	207.00	189.00
methan	0.06	0.04	0.06	0.05	0.30	0.30
TVOC	0.08	0.06	0.10	0.13	1.10	0.70
nitrogen oxide	0.20	0.07	0.50	0.50	3.60	2.40
carbon monoxide	0.05	0.02	0.17	0.17	2.40	1.10
primary energy	677.00	623.00	584.00	550.00	2,889.00	2,587.00

Table 3: Development of ton miles and air pollution of goods transport in the FRG (Trend-Scenario)
Source: DIW, ILS, ISL, IFEU, TÜV-Rheinland, 1990

Following these results there isn't any doubt about the road goods transport being a main emittent of air pollution. Furthermore it is also clear that the goods transport on roads is responsible for a good part of noise emissions. Although the share of trucks is low their contribution to noise emissions and the following detrimental impacts on people's health is high.

From these figures one can easily follow that policy strategies toward an improvement of environmental quality has to include the trucking industry, although the number of trucks less than 4.5 % of the total number of vehicles in W. Germany.

Possibilities for evaluating the environmental impacts of goods transport on roads

In environmental policy often the "polluter pay principle" is postulated. This principle simply says that a polluter should pay for the damage he has caused. Translated into economic terms this means that the external economics should be internalized by charging the polluter the difference between marginal social and marginal private costs of his activities ("Pigonus principle"). Although this principle is straightforward and clear it is neither theoretically true for the general case nor practically implementable. Coase (1952) has shown that Pigonus principle holds only for particular properties of the technology of the polluter and the preference mappings of the people concerned. In other cases it may be welfare optimal to avoid the damage and invest in another technology.

From the practical side of view the polluter pays principle cannot be applied in the transport sector, because it is impossible to find out how much trucker has contributed to an environmental damage. The environmental media not only carry the emitted pollutants over long distances but also provide the means for their storage and accumulation as well as for their conversion either by natural processes or by synergetic effects of different pollutants. A direct functional relationship between emission and damage is the exception rather than the rule.

Much more typical are the features characterising the action of the pollutants:

- The location, time and intensity of the pollutant emission do not match those of the environmental impact.
- The marginal contributions of certain emission sources to local damages owe not identifiable.

A combination of emission sources which contribute differently to total emission according to their group, is matched by a combination of recipients that are affected differently by immissions according to their group. In this kind of common pollutants and joint impacts the polluter pays principle must fail despite its convincing appeal on the grounds of equity and fairness.

As environmental quality is a heterogenous rather than a homogenous good it cannot be treated by one economic concept of measurement and evaluation. There are at least three approaches to be applied which reflect resources, utility and social risks.

a) Resource approach

The resource approach establishs a functional relationship between emissions, immissions and damages. In the case of traffic noise the reduced rents for houses, appartments or hotels indicate the damage of the landlords and can be used as a benchmark for evaluation.

There are also some examples for evaluating the costs of exhaust emissions by their detrimental effects on health, measured by the production losses and costs of medical care caused by infections diseases of respiratory organs (Marburger, 1987). As in general the links between emissions and immissions and the list of potential damages of the future are incomplete this approach can only provide an estimate for the lowest bound of the value of damages.

b) Utility approach

Whereas the resource approach tries to evaluate substantially the loss on the basis of a generally accepted indicator (modified national product), the utility approach is founded on the individual value estimates of those concerned. The theory is based on the hypothesis of individual behaviour used in general equilibrium theory.

Individuals`notions of utility are presumed to be expressed in their demand behaviour, so that this behaviour also provides the basis for measuring changes of utility. As demand functions normally contain the price as an independent variable, utility quanta defined in money units are obtained.

The decisive element is that individuals respond to changes in their economic situation by a willingness to pay or to sell. This form of evaluation is also "direct", i.e. closely related to economic gains and losses. But contrary to the resource approach the evaluation base is "subjective", i. e. based on individual preferences.

In the environmental field the adaption of the utility approach is promissing if there is a high private awareness of the problem. This applies both to local environmental impacts (by smog or water contamination) and to environmental damage with a high publicity status such as the devastation of forests. The issue here is who should pay for what, i.e. the property rights in the environment have to be assigned to one party - the polluters or the polluted.

If the property rights of the environment are held by the polluter, the polluted party is under an obligation to offer the former payment to refrain from disturbing the environment. In these circumstances the willingness to pay approach has to be applied. If on the other hand the property rights are held by the polluted party, then it is the originator of the pollution who must purchase readiness to accept disturbance of the environment, and in this case the willingness to sell approach applies.

The results of these two principles may diverge widely from each other, especially when the information about effects of the pollution is incomplete. The amount of money which must be paid to an individual to obtain his agreement to a deterioration of the environment may then be much greater than the maximum sum he would be prepared to pay to avert an equal deterioration of his environmental conditions.

c) The risk approach

The relationship between transport activities and environmental impacts is stochastic in character as every trip is not linked to a certainty of loss but "merely" increases the risk that a loss may occur. Another approach to the related additional costs is to screen risk categories and possibilities of risk management at the individual and collective levels.

The risk approach is primarily concerned with the future. The resulting action does not rest on a retrospective view of past losses but addresses future losses. This approach assigns specific probabilities to future losses and manages such losses with a strategy mix which comprises of diversification, insurance and prevention.

Diversification

The diversification strategy is of specially close concern to the theory of business finance as investors are inclined to opt not for a stock paper carrying the maximum expected field but for a portfolio embracing a range of risk categories so that their risks are spread.

Society may adopt a similar strategy for transport by not exclusively backing one type of vehicle such as the car now and in the foreseeable future, but instead catering for the parallel development of alternative, e. g. public transport modes in order to reduce environmental risks and provide other options in the event of acute threats to the environment.

This is exemplified

1) by the smog alarms prohibiting the use of private cars and diverting traffic to public transport and
2) by the demand for the increased rail transport of hazardous goods following a number of spectacular accidents with tanker vehicles in W. Germany.

The reason why many countries provide ample and high standard loss-making transport facilities may well be in part an attempt to spread risks in this way, so that the losses of short-haul public passenger services may be seen as the price of risk prevention (they are indeed often referred to as "survival precautions").

Insurance

Insurance contracts could be suitable means of placing future risks into economic categories. For analytical purposes it is for the expedient to disregard the existence of insurance companies and to look at insurance contracts as a mutual obligation.

As soon as the risks borne by individuals are correlated, they can no longer be allocated with actuarial fairness on the principle of the probabilities of loss. The issue then becomes one of social risks (cf. Hirshleifer and Riley, 1979), which is analogous to the external economies in a world of uncertainty.

Since environmental risks bear a heavy social imprint, the willingness of the private sector to insure these risks is therefore too weak to provide full cover from the premium payments. In these circumstances the state may react by imposing mandatory insurance, and we do indeed find such examples in the case of compulsory third-party insurance e.g.,for road accidents. It is conceivable in principle to extend the insurance premiums to the uncovered social costs of environmental damages.

Prevention

The utility of the individual is normally regarded as dependent on his consumption or, in the case of an indirect utility function, as income-dependent. It is, however, quite possible that utility also depends in the nature of objects which cannot simply be described by reference to income equivalents. This would, for instance, be true of an irreplaceable heirloom, the individual`s own life or that of his friends or relatives (Hirshleifer and Riley, 1979, p. 1387).

The question whether or not the individual wishes to be insured against such risks depends on the extend to which income and the heirloom variable are substitutes, i. e. are mutually exchangeable in terms of utility compensation. With heirlooms such as old paintings it is impossible to make a general prediction. Some will regard their loss as being capable of compensation, others will not.

In the case of human health or life however, it is natural to regard these "human capital goods" to be complementary to material consumption goods.

In a case like this it is reasonable to transfer income from the "state with loss" to the "state without loss", i.e. to practise a kind of reverse insurance by doing everything to prevent the occurance of the loss. As preferences are distorted (merit quality) and social risks occur, it is up to the state to make the optimum provision for loss.

If it can be assumed that the cost of prevention are lower than the damages caused by pollution then there is an economic obligation to adopt the prevention approach. In this case a technology is available which is socially more cost-effective than the technology presently used. Therefore a future transition to new technology which is associated with lower environmental disamenities is an economic imperative.

.The magnitude of prevention costs depends on:

- the level of prevention defined by specified limit values, and
- the preventive technology used.

The setting of rules for limit value measurements is crucial to the formulation of possible preventive technologies. For instance, it is important for noise emission limits to define the point at which these are to be measured e.g., the boundary of the land plot or an inside wall of the house or the flat of the affected individual.

4 Basic cost figures for road pricing and cost-benefit analyses

4.1 Cost-benefit analysis of the "BVWP"

In the FRG there are two standard procedures for performing cost-benefit analyses in the transport sector: the guidelines for economic appraisal of road investments and the evaluation scheme of the Ministry of Transport for transport investments which concern the responsibility of the Federal Government. The basic features of both appraisal schemes are identical, in particular both approaches apply strict monetary evaluation techniques. In the following we will stress on the second approach which is known as the "BVWP" (Bundes-Verkehrs-Wege-Planung) evaluation technique.

The BVWP-evaluation introduces seven different sources of benefits:

- reduced operation costs
- reduced travel or operation time
- reduced accidents
- reduced level of air pollution
- reduced regional dispension of economic development
- unimproved potential for international trade.

The benefits stemming from a reduced noise level are evaluated by means of an abatement approach if a targeted level of 45 dB(A) for the night is exceeded and if the difference of the noise levels between the "with" and the "without" cases exceeded 2 dB(A). It is assumed that the desired reduction of the noise level is attained by sound proof windows which are installed in the affected buildings.

Impacts of air pollution are considered if the concentration of the "main indicator component" carbon monoxide exceeds the respective target value of 5 mg/m^3 at the facade of the affected building. The other components of traffic emissions are adjusted to the main component any means of toxicological weighting factors. The economic evaluation is performed by measuring the emission reduction necessary to match the immission target level and calculating the associated operation cost swings for the "with" compared to the "without" case.

While the monetary analysis is carried out in a standardized way for all projects an additional ecological risk analysis is added in particular cases. This applies if there is suspected a major influence on the ecological system and if the length of the projected link exceeds 15 km. In the ecological risk analysis investments are investigated with respect to changes of

- soil quality
- fresh water quality
- biotopes
- recreation potential.

The ecological risk analysis is performed using multiple criteria analysis. The results are summarized by an impact matrix without any further aggregation to construct a comprehensive risk index. There is also no formal procedure given for aggregating the results of CBA and risk analysis. This means that the decision maker has to evaluate and aggregate the partial results by himself.

In the practical application for road projects of the Federal Transport Investment Plan the contribution of environmental improvements came out 16 % of the total benefits for two-lane streets and 4 % for four-lane streets. The reason is that most of the planned two-lane streets are bypasses of agglomerations which help to reduce congestion in these areas(Breuer, 1988).

20 out of 100 road investment projects which have been checked with respect to their ecological risks have been identified as high risk projects. These projects have been rescheduled for the next planning period, reduced in size (e.g. from 4 to 2 lanes) or given up at all. Out of 1000 minor projects 75 altogether have been given up because of potential ecological problems.

This list of performance of the environmental evaluation criteria applied is not very encouraging. Looking at the cost-benefit part the question arises why high environmental benefits can steen from road investments before the background of road transport being the dominant polluter of most components of exhaust emissions. The reason is that benefits are evaluated by means of partial rather than systems analysis. Therefore every transportation activity which is shifted from a bad road to a good one is associated with a positive utility. So if the new road attracts new traffic its cost-benefit index rises. A potential diversion of traffic from road to rail or to inland waterways is not evaluated.

4. 2 Recent recommendations for monetary evaluation of environmental impacts of road transport

In a recent study for the Deutsche Bundesbahn the Planco Consulting Company has summarized the approaches for evaluating the external diseconomics of transport in monetary terms. The outcome is that the transport sector in West Germany is responsible for external costs of 48 Bill. DM 1985. The road transport contributed 89 % to these costs while the rail caused 8 % and the inland waterways 0.2 %.

The figures for the external costs of are given in Table 4:

Goods transport on	Air Poll.	Land, Water	Noise	Accidents	Separation effects	Total
Road	1.92	0.57	4.08	2.56	0.08	9.15
Rail	0.11	-	1.57	0.08	-	1.76
Inl. Waterways	0.10	-	-	0.01	-	0.11

Table 4: External Costs of Transport Modes in the FRG (Bill. DM)
Source: PLANCO, 1990

The estimation of air pollution was based on damage costs which didn't include the risks with respect to human health, fauna and flora. The impacts on land and fresh water quality were derived from abatement costs while disamenities of noise were evaluated on the base of avoidance costs. The costs of accidents have been calculated directly taking the production losses of idle human ressources and the separation effects have been quantified by the economic value of time needed for communication between separated areas.

This result doesn't contribute very much too for the environmental issue. Abstracting from the different theoretical bases of the cost categories (damage costs, abatement costs, avoidance costs) this approach suffers from the main weakness that it leaves the risks to human life and to that of animals and plants behind. Such the appraisal only concerns some disamenities and inconvenience but excludes the global risks to mankind such as the greenhouse effect. These results therefore only can be interpreted as lowest lower bounds for the detriments of the environment caused by the goods transportation on roads.

4.3. Road Pricing

a) Basic Ideas

Road pricing seems to be the most flexible and efficient way to internalize externalities. In the theoretical neoclassical model tolls can be imposed in such a way that the perceived marginal pricate costs equal the marginal social costs of road use. So the transport sector could be moved towards a socially optimal equilibrium position only by using the market forces. The only intervention needed would be to introduce the price adjustments.

The neoclassical model however doesn´t represent the world we live in. So marginal costing on the base of short term marginal costs which include the costs of congestion as a major element leads to wrong signals for private and public investment decision. Long term marginal costs include elements of the infrastructure costs and may turn out decreasing in the transport sector. In this case charging the marginal costs to the users provides not enough an income to cover the total costs of the infrastructure.

In this case Ramsey-pricing often is suggested to solve the financial together with the allocation problem. This implies a deviation of prices from the marginal costs according to the reciprocal value of the price elasticity of demand. But also this pricing principle can be shown to fail in a dynamic world when decision are made under uncertainty. Ramsey pricing encourages the high priced inelastic market segments to leave the club of users and try to stand alone.

In the dynamic context a road pricing scheme should

(1) yield enough income to cover the total costs,

(2) effect incentives to stay within the club of users,

(3) effect incentives to reduce the consumption of environmental ressources.

Such not only the size of charges is important but also their structure. For the road transport the fix part of the tariff has to be minimized whereas the variable part should be high to enforce the perception of the charge. Regarding the present system of taxation in many countries this implies to substitute the vehicle taxes by fuel taxes and tolls. The tolls should be linked to the mileage traveled without granting deductions for high usage.

b) Actual Figures for Cost Based User Charges

The group of the 12 railway companies of the EC has published the following figures for the external diseconomies of road and rail goods transport:

	DM/t km road	rail
Cost category		
air pollution (base:1982)	0.017	0.0009
noise (base:1984)	0.0013	0.0015
accidents (base:1983)	0.018	0.00004
sum	0.0363	0.0024

Table 5: External Cost Calculation of the Group of 12 EC-Railway Companies (1986)

Using the external cost calculation of Table 4 and the associated data for the ton mileage the results look different:

Average external cost per t km:

Goods transport on	Air Poll.	Land/ Water	Noise dents	Acci- tion	Separa-	Total
Road	0.0136	0.004	0.029	0.0177	0.0006	0.065
Rail	0.0018	-	0.026	0.0013	-	0.029

Table 6: External Cost Calculations of PLANCO (1990)

In both calculations the rail transport comes out favorable with respect to air pollution, land consumption and accidents. Surprising enough the difference between the average external costs of road and rail are equal (0.034 resp. 0.036DM/tkm).But there are however large differences in the evaluation of air pollution and noise. The noise impacts are even the dominating cost item of the Planco calculation. This result is due to the prevention approach which has been used for evaluating the noise impacts. Setting the limit value of noise sufficiently low one results in high cost figures for noise prevention.

Obviously the question arises whether the prevention approach associated with biting target values would also have increased the cost figures of air pollution. It seems to be unreasonable to weigh the local disamenities of traffic noise two times as high as the global risks of air pollution.

c) Price Elasticities

The estimation of price elasticities of demand is important for the evaluation of pricing policies. In a recent study for the Verkehrsforum Bahn Baum (1990) has estimated the elasticities of freight transport demand with respect to the relation between rail, road and inland waterway tariffs.

Some of the results are exhibited in Table 7.

Notation:

E : Elasticity

X : Transport volume on roads t/year

P_T: tariff of road transport DM/t

P_R: tariff of rail transport DM/t

P_W: tariff of inland waterway transport DM/t

Freight category	Time Series $E\left(X_R, \frac{P_T}{P_R}\right)$	$E\left(X_W, \frac{P_T}{P_W}\right)$	Questioning $E(X_R, P_T)$	$E(X_W, P_T)$
1 Agriculture Products	(1,72)	(1,98)	0,71	-
2 Foods Industry	1,52	1,62	1,62	-
3 Coal	0,61	(2,89)	0,31	0,16
4,5 Crude Oil Oil Products	1,14	0,75	0,67	0,13
6,7 Ores, Scrap Metal	(1,52)	4,88	-	-
8 Iron, Steel	(1,82)	2,96	1,17	0,26
9 Building Material	1,62	(1,38)	1,97	0,05
10 Chemical Products	2,01	(0,68)	0,46	0,14
11 Investment Products	(1,05)	-	0,85	0,05
12 Consumption Products	1,71	-	1,28	-

in brackets: reverse relationship (e.g.: 1: $E\left(X_T, \frac{P_R}{P_T}\right)$

Table 7: Elasticities of Freight Demand with Respect to Tariffs

Computing the elasticities on the base of the time series statistics of the Federal Agency of Long Distance Freight Transport which are listed in the first two volumns one gets the results:

* There are high elasticities of the rail transport volume with respect to the road/rail price relationship for

- agricultural products (1,72)
- chemical products (2,01)
- ores and scrap metals (1,52)
- consumption goods (1,71)
- building material (1,62)
- iron and steel (1,82)
- food (1,52).

* Relatively small are the elasticities with respect to

- crude oil and oilproducts (1,14)
- investment goods (1,05)
- coal (0,61).

Most of the price elasticities of inland waterway of inland waterway transport are rather high. Exemptions are crude oil (0,75) and chemical products (0,68). Investment and consumption products are shipped in minor quantities over the inland waterways and can be neclected.

A second estimation has been performed on the base of a questioning. This questioning has been motivated by the fact that the shipper's records to the Federal Agency are not very reliable because of the specific regulation of the goods transport market in W. Germany.

The results show high cross elasticities, in absolute terms, for road and rail transport for

- foods industry (1.62)
- iron and steel (1.17)
- building material (1.97)
- consumption goods (1.28),

while the branches

- agriculture (0.71)
- coal (0.31)
- oil products (0.67)
- chemical products (0.46)
- investment products (0.85).

are associated with low cross elasticities.

The outcomes for the cross elasticities between road and inland waterways are listed in columns 2 and 4.

There is an asymmetry of price reactions in sofar as the rail system cannot attract as much traffic by lowering the price as it looses if the road system lowers the price by the same percentage.

On the other hand the results don´t imply that increasing the price of road transport will effect an asymmetric rise of rail transport. As the quality of service plays an important role it is highly probable that a perceivable upwards shift of road transport prices will change the spatial pattern of shipments rather than shift the difference of road transport volume to other transport modes. This effect can hardly be quantified by statistical tools because it has not been observed in the passed years.

Therefore one can conclude: if the EC-liberalization policy is continued the railways will loose considerable transport volumes supposed that they leave prices unchanged. If they react with price decreases tremendous financial losses of the railway companies will incur. If the road transport is moderately priced for the environmental impacts the modal share of railways will grow slightly. If a high price is imposed for environmental impacts of road transport the shift to rail and ship is increased, but changing spatial trade patterns will decrease the shift from road to rail and ship.This means that the transport market doesn´t play a zero sum game.

5 Conclusion

Goods transport on roads is a major pollutant of exhaust emissions. Presently road transport is encouraged to grow by high growth rates because the price of environmental property rights is very low. If the price is adjusted for to induce an incentive compatible market mechanism there will not occur a compensating shift from road to rail and ship. Transport volumes and miles traveled will be affected. So adjusting the price of road transport for the environmental impact will result in a decrease of total transport activities. It is wrong to interprete this effect as a decrease of the welfare position because the environmental quality is an element of social welfare. But it might be necessary to reduce the growth of material consumption for to provide a better environment.

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