

The Impact on Transport and Economy of a Levy on Mobility

Consequences of spending the revenues of the levy

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Abstract. The paper examines how and to which extent a levy on mobility influences freight and passenger transport as well as the economy. The interaction between transport and the economy, and the way of spending the revenues of the levy are taken into account. On the basis of the research results, preferences are formulated for different ways of spending.

Keywords: revenue recycling, spending options, MOBILEC model, scenario analysis, preferences

1 Introduction

In Europe, a levy on mobility is generally realized in the form of an excise on fuel. Recently however, a congestion charge is applied in Central London and lorries are charged for the use of German motorways. The German example of charging freight transport by means of a levy per kilometre driven offers the possibility of differentiation to distance and time in order to reduce congestion and environmental damage. Contrary to an excise, a levy per kilometre makes it no longer attractive for people living in border regions to refuel in neighbouring countries where no levy or a lower levy exists.

It is observed that a transport model can be used to estimate the impact on transport of a levy on mobility. The result of such an estimation is a reduction of transport. However, this estimation neglects the effects of spending the revenues of the levy on mobility, when the economy in the model is exogenously determined. The revenues can be used to finance an increase of government spending and tax reductions. In that way transport can decrease by a levy on mobility on the one hand and it can increase by the economic effect of a rise of government spending and tax reductions on the other hand.

If the transport model assumes an exogenous economy, we cannot use it for estimating the impact on transport of a levy on mobility including the spending of the revenues of the levy. Moreover we want to estimate its impact on the economy. Therefore, we use the dynamic and interregional model MOBILEC (MOBILity/Economy), which specifies the relationships between the economy, mobility, transport infrastructure and other regional features. It contains freight and passenger transport by mode, using the same infrastructure to a considerable extent. Substitution between transport modes is possible. The main characteristic of the model is the interaction between the economy and transport: the economy influences transport and transport influences the economy.

Some alternatives of spending the revenues of a levy on mobility are put into the model. We consider the following spending options:

- increase of government spending: increase of government consumption, improvement of infrastructure and decrease of the employers' contribution to social security in the gross wage rate;
 - tax reductions: decrease of direct taxes and indirect taxes, including a fixed road tax.
- These ways of spending are specified in the paper in more detail.

A general analysis of these spending options shows their influence on the economic growth, but its distinguishing power between the options is limited. Therefore, we make an empirical study in the form of a *scenario analysis* for Belgium. This methodology is also applicable to other countries. The aim is to show the effects of the spending options on the regional product and employment of Belgium on the basis of region specific calculations. In addition, the effects on transport of goods and passengers by mode are presented. On the basis of the empirical results, preferences are formulated for different ways of spending the revenues of a levy on mobility.

2 Revenue recycling

A levy on mobility and the spending of the revenues of this levy can be denoted with the term *revenue recycling*. This notion has been introduced into the domain of environmental economics within the framework of the question how the revenues of an environmental taxation can be used in other parts of the economy, for example a reduction of labour taxation. In this connection, the concept of *double dividend* is commonly applied. An optimal environmental tax corrects the external effects (first dividend), after which the revenues can be used to correct distorting taxes (second dividend). The result would be an increase in welfare (in terms of welfare theory).

Is the concept of double dividend correct? To answer this question, a general-equilibrium model is used. A difference is made between a weak and a strong double dividend (Metcalf & Babiker, 2003):

- A weak double dividend occurs when the welfare gain achieved by using the environmental tax proceeds to lower a distorting tax is greater than the gain achieved by distributing them in a lump sum fashion.
- A strong dividend is the case where implementing the environmental tax and using proceeds to reduce distorting taxes improves welfare without consideration of the environmental benefits arising from the tax.

The strong version is much more controversial than the weak one. The results in terms of welfare strongly depend on the assumptions of the analysis.

An extensive literature review is given in Goulder (1995), De Borger & Proost (1997) and Bovenberg (1999). Applications in transport economics can be found in Parry & Bento (2001) and Mayeres & Proost (2002). These studies mostly contain a static general-equilibrium model on microeconomic foundations, where optimal levies are calculated. Our paper gives a dynamic, interregional macroeconomic analysis of the impact of a given levy on mobility. It calculates the effects on the regional/national product, employment and transport of goods and passengers by mode in the course of time.

Analogous to the double dividend, we can distinguish two effects:

- (1) effects without considering spending the revenues of the levy;

(2) effects of spending the revenues of the levy.

Finally, we are interested in the overall effects on freight and passengers transport as well as on the economy. As we will demonstrate, the overall effects depend on the spending options. These options concern not only tax reductions but also an increase of government spending.

3 The MOBILEC model

MOBILEC (MOBILity/EConomy) is a dynamic, interregional model that describes the interaction between transport and economy in connection with infrastructure and other regional features. It belongs to the category of *land-use transportation interaction models* (see for instance Wilson, 1998 and Van der Hoorn & Van der Vlugt, 1998), but it does not have the restriction that the economy on a higher spatial scale is exogenous. It can be also characterized as a neoclassical growth model, but one that is adapted in such a way that it can simulate unemployment.

The model has region specific productions functions. However, their specification is different from *production function models* (see for instance Aschauer, 1989; Munnell, 1992; Gramlich, 1994; Gillen & Waters II, 1996; Gomez-Ibanex & Madrick, 1996; Rietveld & Bruinsma, 1998; Banister & Berechman, 2000). The production functions of MOBILEC do not contain the total infrastructure as a production factor, but the extent to which the infrastructure is utilized by transport for the production. The variable describing the transport infrastructure utilized is function of the mobility for productive ends, expressed in terms of the number of passengers and the number of tons of goods that have been moved through this infrastructure.

Transport of goods and business traffic relates to *productive mobility* (expressed in the number of tons or passengers between two points in space). If the moving motive refers to shopping, attending of education courses, paying visits/staying, recreation/sport and driving/walking, it is a matter of *consumptive mobility* (expressed in the number of passengers between two points in space). Establishing the nature of commuter traffic is more complicated. Commuter traffic is linked to productive performance outside the home and therefore counts as productive mobility. On the other hand, it can be assumed to be the consequence of the consumer's wish to live in a more attractive environment than where one works, and from this angle it should be counted as consumptive mobility. This difficulty is solved by introducing separate mathematical equations for commuter traffic in the model.

The production function only contains productive mobility. In line with the production function, the direction of the causal connection goes from mobility to economy. In the case of consumptive mobility, the consumption function, which describes the relation between income and consumption, plays a part. In accordance with the consumption function, the causality goes from the economy to mobility.

Transport infrastructure is a limiting condition – to change by policy – for the total of productive and consumptive mobility and therefore for the economic development. Before the maximum mobility is reached, the limiting effect of infrastructure is revealed in the form of increased travel time and mobility price. The mobility price is defined as generalized transport costs per passenger or per ton (freight transport). It consists of two parts: *travel-distance costs* and *travel-time costs*; travel-time costs are the result of monetary evaluation of travel time (see for instance the Dutch Ministry of Transport, Public Works and Water Management, 1996). The smaller the difference between the actual mobility and the

maximum possible mobility (capacity of infrastructure), the lower is the velocity of transport and the greater the travel-time costs. The type of infrastructure imposes restrictions on the means of transport and its velocity. These restrictions, too, are expressed in the mobility price.

The model uses matrices of origin-destination where the quality of accessibility within and between regions is expressed in terms of travel distance, travel time, travel-distance costs and travel-time costs, on the basis of an infrastructure network. It generates the flows of transport within a region and between pairs of regions. It also takes into account that the infrastructure of a region is utilized by transit traffic between other regions.

Transport infrastructure is one of the factors that characterize regions. Other *regional features* in the model are technological development, the regional production structure, urbanisation (agglomeration economies and diseconomies), wage rates, the existence of recreation areas, the size of the population related to the area and the employment, investment premiums and geographic position. The influence of these factors on the economy and mobility is also considered. In this respect, the model corresponds to *location models* (see for instance Rietveld & Bruinsma, 1998), where investment and employment are explained by location factors or regional features. However, the difference is that MOBILEC also takes into account the impact of macro-economic variables on investment and employment.

The mathematical specification of the model, including the values of the coefficients, is described in Van de Vooren (2004). The model works as follows.

The regional income in period t determines regional (private) saving in period t , which – dependent on the balance of government spending in the region and taxes levied in the region, and on the balance of payments of the region – is used as (private) investment (see also section 4.1). The extent to which saving is used as investment in the own region or elsewhere, depends on the capital rate of return in relation to that in other regions. Regional (private) investment is just an extension of the (private) stock of capital goods; hence in the case of positive net investment, the region disposes of a larger *stock of capital goods* at the beginning of the next period $t+1$ than at the beginning of period t .

Neoclassical theory teaches that the marginal labour productivity determines the real wage rate. This relation is reversed in MOBILEC in order to simulate the possibility of unemployment. The real wage rate, agreed by employers and employees, is considered as an exogenous variable. It determines the *marginal labour productivity*. The real price of productive mobility determines the *marginal mobility productivity*.

The stock of capital goods, the marginal labour productivity and the marginal mobility productivity in period $t+1$ determine – given the production function – simultaneously the regional product, the employment and the productive mobility in period $t+1$. The state of technology, the regional structure of production and the degree of urbanisation in period $t+1$ are exogenous. The regional product accrues to the population in the form of regional income, which influences the consumptive mobility and the commuter traffic in period $t+1$. The consumptive mobility also depends on the price of consumptive mobility as well as the metropolitan character and the existence of recreation areas in the own region in relation to other regions. The commuter traffic also depends on the mobility price of commuter traffic as well as the per capita employment in the own region in relation to other regions.

From this point, the process starts again: the regional income determines regional saving in period $t+1$, which is used as investment in the own region or elsewhere, etc. The mobility prices rise as a result of an increasing utilization of the available infrastructure, which has a negative influence on the growth of the economy and mobility. Substitution between transport modes is possible in the model.

This system of equations produces, as most important output, time paths of the following variables:

- regional/national product, employment and investment by region;
- transport of goods by lorry, train and ship (productive mobility) within a region and between regions;
- transport of passengers by car, train and bus/tram/metro within a region and between regions, split up into business traffic (productive mobility), commuter traffic and other traffic (consumptive mobility).

The model can be used for forecasting these time paths and for calculating effects of transport policies (including a levy on mobility) and spatial planning.

A levy on mobility leads arithmetically to an increase of the mobility price. If the levy has the form of a fixed levy per kilometre, only the travel-distance costs increase. If the levy is differentiated to time, travel-time costs can also increase. In this paper, we assume a fixed levy per kilometre.

4 Spending the revenues of a levy on mobility

4.1 Extensions of the model

As we noted in section 3, regional (private) saving is used as (private) investment, dependent on the balance of government spending in the region and taxes levied in the region, and on the balance of payments of the region:¹

$$I_r = S_r - (G_r - T_r) - (X_r - M_r) \quad (1)$$

where:

- I_r - private investment in region r ;
- S_r - private saving of region r ;
- G_r - government spending in region r ;
- T_r - taxes levied in region r ;
- X_r - export of goods and services and transfer of incomes from region r to other regions;
- M_r - import of goods and services and transfer of incomes from other regions to region r .

All variables in the model are *real* quantities (fixed general price level).

The government spending G_r is supposed to be fully autonomous. The analysis does not change fundamentally if G_r partly depends on the geographic product of region r , Y_r . For the sake of simplicity, regional income is assumed to be proportional to the geographic product.

Taxes consist of direct and indirect taxes (omitting index r):²

$$T = T_d + T_i \quad (2)$$

The direct taxes T_d are assumed to be partly dependent on income and partly autonomous:

$$T_d = \tau_d Y + T_{da} \quad (3)$$

where :

τ_d – marginal rate of direct taxes;
 T_{da} – direct autonomous taxes.

The indirect taxes T_i are assumed to be partly dependent on value added, partly dependent on the number of kilometres driven (for instance excises on fuels) and partly autonomous (for instance fixed road tax and tax on the ownership of vehicles):

$$T_i = \tau_i Y + t d + T_{ia} \quad (4)$$

where :

τ_i – marginal rate of indirect taxes;
 t – real levy per kilometre driven;
 d – number of kilometres driven;
 T_{ia} – indirect autonomous taxes.

Regional (private) saving S is a function of disposable income:

$$S = \sigma (Y - T_d) \quad (5)$$

where σ presents the propensity to save.

Substitution of (2) and (5) into (1) gives:

$$I = \sigma Y - G + (1 - \sigma) T_d + T_i - (X - M) \quad (6)$$

MOBILEC has largely a logarithmic-linear structure. To incorporate (6) in the model, this equation is transformed into:

$$I = \sigma Y \Gamma \quad (7)$$

where Γ is a parameter ($\Gamma \geq 0$).

It follows from (7) by substitution of (3), (4) and (6):

$$\Gamma = 1 + \left(\frac{1}{\sigma} - 1 \right) \tau_d + \frac{1}{\sigma} \tau_i + \frac{\frac{1}{\sigma} t d + \left(\frac{1}{\sigma} - 1 \right) T_{da} + \frac{1}{\sigma} T_{ia} - \frac{1}{\sigma} G - \frac{1}{\sigma} (X - M)}{Y} \quad (8)$$

With the help of (8), we can calculate the effects of a levy on mobility and the spending of its revenues on an increase of government spending and a decrease of taxes.

When the indirect tax rate decreases, the entrepreneurs will reduce their sales prices as a consequence of competitive pressure. The price reduction depends on the elasticity of the demand and the supply curve. If the entrepreneurs are able to keep a part of the tax reduction for themselves by not completely passing on into the sales prices, they will expand the use of labour and productive mobility. See the *Appendix to section 4.1* for a mathematical explanation.

4.2 Options of spending

If the levy on mobility does not change, we assume that Γ_r is constant. This assumption requires in (8) a constant direct and indirect tax rate (τ_d and τ_i) and the last term being constant. A sufficient condition for a constant value of this last term is that the growth rates of the revenues $t.d$, the autonomous taxes T_{da} and T_{ia} , the (autonomous) government spending G and the regional balance of payments $X - M$ are equal to the growth rate of the regional product Y . In reality, the last term will be more or less constant in a balanced growing economy.

Assume a new levy on mobility in the whole country. The national revenues of the new levy are allocated to the regions by the national (federal) government. We distinguish the following options for spending the revenues.

Increase of government spending:

option 1: increase of government consumption;

option 2: improvement of transport infrastructure;

option 3: decrease of the employers' contribution to social security in the gross wage rate.

Tax reductions:

option 4: decrease of direct autonomous taxes;

option 5: decrease of indirect autonomous taxes;

option 6: decrease of the direct tax rate;

option 7: decrease of the indirect tax rate.

The effect of a spending option on Γ_r is calculated with the help of (8). A new levy on mobility means an increase of t . Using the MOBILEC model, we calculate d and Y in (8). The spending of the revenues of the levy implies an increase of G or a decrease of τ_d , τ_i , T_{da} and T_{ia} , but it does not influence Y (as output of the production function) and consequently neither d in the *current* period. The new values of all these variables can lead to a change of Γ_r , which influences the investment in the current period, according to (7), and consequently the stock of capital goods at the beginning of the next period.³ Table 1 shows in the second column the effect of a spending option on Γ_r in (8). See *Appendix to section 4.2* for the mathematical derivation.

Table 1 Effects of ways of spending the revenues of a new levy on mobility, with a spending in region r amounting to D (omitting index r)

<i>Way of spending</i>	<i>Value of $\Gamma(a)$</i>	<i>Other variables</i>
Increase of government spending:		
(1) increase G , consumptive	$\Delta\Gamma = 0$	
(2) improvement infrastructure	$\Delta\Gamma = 0$	decrease travel time/distance
(3) decrease contribution social security	$\Delta\Gamma = 0$	decrease wage rate
Tax reductions:		
(4) decrease T_{da}	$\Delta\Gamma = D / Y$	increase of travel time
(5) decrease T_{ia}	$\Delta\Gamma = 0$	
(6) decrease τ_d	$\Delta\Gamma = D / Y$	increase of travel time
(7) decrease τ_i	$\Delta\Gamma = 0$	decrease of sales prices

(a) $\Delta\Gamma$ represents the difference between the value of Γ as a result of the new levy and the value of Γ without the new levy.

According to (7), a higher Γ leads to more investment, *ceteris paribus*, and consequently to a higher economic growth. Preferring a higher economic growth, we conclude *on the basis of $\Delta\Gamma$* :

- 1st preference: options 4 (decrease of the direct autonomous taxes) and 6 (decrease of the direct tax rate);
- 2nd preference: options 1, 2, 3, 5 and 7 (remaining options).

Some ways of spending have not only effects on Γ but trigger additional effects (third column of table 1):

- Option 2. An improvement of infrastructure leads to a lower travel time and, in case of new infrastructure, to a lower travel distance and consequently to a higher national product.
- Option 3. A decrease of the employers' contribution to social security in the gross wage rate leads to a lower wage rate and consequently to a higher national product.
- Options 4 and 6. Lower direct taxes lead to a higher disposable income, *ceteris paribus*, to a higher consumptive mobility and commuter traffic (which do not contribute to national product via the production function) and so to a higher utilization of the road capacity, to a longer travel time and consequently to a lower national product.
- Option 7. A lower indirect tax rate leads, in general, to lower sales prices, to a higher use of production factors (because of the *partial* passing on of the tax reduction into the sales prices) and consequently to a higher national product.

The consequences of these additional effects are that options 4 and 6 fall and options 2, 3 and 7 rise in the order of preference. It is quite conceivable that the options 4 and 6 ultimately get a lower preference than the options 2, 3 and 7. A more detailed ranking is possible after simulating some cases with the help of the model (see section 5.2).

Other additional effects are conceivable, for instance a decrease of the interest rate, but we leave them aside in our analysis. In reality, the final ranking of the ways of spending is also based on non-economic judgments. These judgments can lead to a mix of spending options.

5 Empirical analysis

Our empirical analysis refers to Belgium. The same type of methodology can be performed for other countries.

5.1 Scenario analysis

We make a scenario analysis to estimate the effects on the economy and mobility in the 43 Belgian regions (*arrondissements*) of a levy on mobility. For that purpose, we use MOBILEC-Belgium.

All scenarios are based on the following assumptions:

- technological development of 1.75 % per period (a period in the model contains 3 years); because of differences in innovation, this percentage has been reduced to 1.5 % or raised to 2 % for some regions;
- rise of the share of labour-intensive industries (especially the services sector) in the regional product in a period of 3 years corresponding with $\frac{3}{4}$ of the rise of this share in the preceding period;
- rise of the real wage rate of 1.2 % per year;
- decrease of the average number of passengers by car with 0.3 % by year and increase of the average load by lorry, train and ship with 0.7 % per year.⁴

The following additional assumptions are made for the *reference scenario*:

- constant capacity of the roads;
- constant real travel-distance cost by kilometre;
- constant travel time by train and ship.

As alternatives, we formulate several *levy scenarios* where a new levy per kilometre driven is introduced. We examine seven ways of spending, resulting in seven levy scenarios. These levy scenarios are compared with the reference scenario. Option 2 has been concretised firstly by an extension of the *road* capacity in dependence of its utilization (= option 2a). See *Appendix to section 5.1* for the estimation of the parameters connected with the spending options.

The existing levy on mobility is an excise on fuel. We assume a new levy on mobility of 0.04 euro (price level 2003) per kilometre driven by lorry and car from the year 2003. Busses have been exempted from the new levy. Consequently, the travel-distance costs per kilometre increases for lorry and car with 0.04 euro. See *Appendix to section 5.1 (bis)* for the calculation of the revenues of the levy.

5.2 Quantitative results

We aggregate the quantitative results by *arrondissement* to Total Belgium. The results are presented in table 2.

Table 2 Average growth per year (%) of the real domestic product, employment and transport of goods and passengers by transport mode in Belgium in the period 2000-2030, according to the reference scenario and seven levy scenarios (a)

	Reference scenario	Levy scenarios options 1, 5	option 2a	option 3	options 4, 6	option 7
Domestic product	1.95	1.94	2.02	2.08	1.99	1.97
Employment	.67	.66	.73	.84	.70	.69
Transport of goods						
• by lorry	1.36	1.32	2.24	1.43	1.36	1.35
• by train	1.50	1.49	1.54	1.60	1.52	1.52
• by ship	1.81	1.80	1.87	1.91	1.83	1.83
Transport of passengers						
• by car	.38	.21	1.23	.25	.23	.22
• by train	.16	.20	-.11	.21	.20	.20
• by bus (b)	-.34	-.20	.82	-.22	-.21	-.20

(a) Transport growth has been calculated on the basis of the number of passengers or quantities of tons.

(b) Including tram and metro.

Reference scenario

The reference scenario shows an average economic growth in Belgium of 1.95 % per year in the period 2000-2030. It is accompanied with an average growth of employment of 0.67 % per year. The transport of goods by train and ship grows more than that by lorry. The transport of passengers by car and train increases and by bus (including tram and metro) decreases.

Levy scenarios, options 1 and 5

The results of the options 1 (increase of government consumption) and 5 (decrease of indirect autonomous taxes) are equal, what is consistent with table 1 in section 4.2. The levy raises the travel distance-costs of the lorry and car, what has a negative effect on the growth of the regional product, employment and transport by lorry and car. Because of the somewhat lower economic growth, the transport of goods by train and ship also decreases. The growth of transport of passengers by train and bus increases; the negative effect of economic growth is smaller than the positive effect of substitution (shift in the modal split). These two options show the lowest growth of transport by lorry and car in comparison with all other scenarios.

Levy scenarios, options 2a, 3 and 7

The results of the options 2a (improvement of road infrastructure), 3 (decrease of the employers' contribution to social security in the gross wage rate) and 7 (decrease of the indirect tax rate) stem from the negative effect of the levy on economic growth and the positive effect of the spending of the revenues on economic growth. The positive effect runs through an increased use of labour and/or productive mobility:

- in option 2a as a result of the reduction of the real prices of productive mobility.
- in option 3 as a result of the reduction of the employers' contribution to social security in the gross wage rate;
- in option 7 as a result of the *partial* passing on of the tax reduction into sales prices.

On balance, the economic growth increases in the three options. Option 3 shows the highest growth of the regional product and employment and option 2a the highest growth of the transport by lorry and car. In the options 3 and 7, the growth of transport by car is lower than in the reference scenario. The growth of transport by lorry is only lower in option 7.

Levy scenarios, options 4 and 6

The results of the options 4 (decrease of direct autonomous taxes) and 6 (decrease of the direct tax rate) are equal (see also table 1 in section 4.2) and stem from the negative effect of the levy on economic growth and the positive effect of the spending of the revenues on economic growth. The positive effect runs through more investment as a result of more private saving by tax reduction.

On balance, the economic growth increases in the two options. The growth of the transport by car is lower than in the reference scenario. The growth of transport by lorry is the same as in the reference scenario.

Ranking of the options

We can now refine the rough ranking of the options in the general analysis in subsection 4.1. Preferring a higher economic growth, we conclude:

- 1st preference: option 3 (decrease of the employers' contribution to social security in the gross wage rate);
- 2nd preference: option 2a (improvement of road infrastructure);
- 3rd preference: option 4 (decrease of direct autonomous taxes) and 6 (decrease of the direct tax rate);
- 4th preference: option 7 (decrease of the indirect tax rate);
- 5th preference: options 1 (increase of government consumption) and 5 (decrease of the indirect autonomous taxes).

If we exclude the options with a lower economic growth and a higher growth of transport by car compared with the reference scenario, we have left in decreasing preference: options 3, 4, 6 and 7. These options show a lower total utilization of the road infrastructure by lorry, car and bus in terms of passenger-car equivalent in comparison with the reference scenario. If we require in addition a lower or equal growth of transport by lorry, the option 4, 6 and 7 remain.

5.3 Spending on public transport

Option 2 treats the spending of the revenues of a levy on an improvement of infrastructure. This option has been concretised in the scenario analysis by an extension of the road capacity (= option 2a). It is also possible to spend the revenues of a levy on an improvement of the infrastructure of public transport and on other measures promoting public transport (= option 2b). Since the costs of these measures are not known in general terms, we cannot transform the revenues of a levy into a public-transport scenario.

Table 3 shows the effects on transport and economy of such measures that the travel time of transport of passengers by train and bus/tram/metro falls by 1 % and 2 % respectively by year,

including waiting time. The working hypothesis is that the cost of each public-transport scenario equals the revenues of the levy.

Table 3 Average growth per year (%) of the real domestic product, employment and transport of goods and passengers by transport mode in Belgium in the period 2000-2030, according to the reference scenario and two public-transport scenarios (a)

	Reference scenario	Public-transport scenarios: decrease of travel time	
		1 % by year	2 % by year
Domestic product	1.95	1.95	1.96
Employment	.67	.67	.67
Transport of goods			
• by lorry	1.36	1.38	1.38
• by train	1.50	1.50	1.51
• by ship	1.81	1.82	1.82
Transport of passengers			
• by car	.38	.32	.27
• by train	.16	2.04	4.19
• by bus (b)	-.34	1.93	3.85

(a) Transport growth has been calculated on the basis of the number of passengers or quantities of tons.

(b) Including tram and metro.

We conclude that option 2b influences the economic growth to a small degree. For that reason, we estimate its ranking of preference between option 7 on the one hand and the options 1 and 5 on the other hand (in the ranking of subsection 5.2). Option 2b increases the growth of public transport to a considerable extent and it decreases the growth of transport by car to a much lesser degree.

6 Conclusions

The impact on freight and passenger transport and on the economy of a levy on mobility is strongly influenced by the way of spending the revenues of the levy. The revenues can be used for an increase of government spending, tax reductions and a decrease of the government deficit.

The following options for an increase of government spending have been examined:

option 1: increase of government consumption;

option 2: improvement of infrastructure

- option 2a: improvement of road infrastructure;

- option 2b: improvement of the infrastructure and other measures for public transport;

option 3: decrease of the employers' contribution to social security in the gross wage rate.

Option 1 leads to a decrease of the growth of transport by lorry and car, but it is accompanied with a lower economic growth. Options 2 and 3 have not this disadvantage, but the growth of transport by lorry increases. If option 2 is concretised by an improvement of road infrastructure, the growth of transport by car also increases, even to a considerable extent.

The following options for tax reductions have been examined:

option 4: decrease of direct autonomous taxes;

option 5: decrease of indirect autonomous taxes;
 option 6: decrease of the direct tax rate;
 option 7: decrease of the indirect tax rate.

Option 5 leads to a decrease of the growth of transport by lorry and car, but it is accompanied with a lower economic growth. Option 7 has not this disadvantage. Neither have the options 4 and 6 this disadvantage, but the growth of transport by lorry does not change.

Preferring a higher economic growth, we get the following ranking of the options:

- 1st preference: option 3 (decrease of the employers' contribution to social security in the gross wage rate);
- 2nd preference: option 2a (improvement of road infrastructure);
- 3rd preference: options 4 (decrease of direct autonomous taxes) and 6 (decrease of the direct tax rate);
- 4th preference: option 7 (decrease of the indirect tax rate);
- 5th preference: option 2b (improvement of the infrastructure and other measures for public transport);
- 6th preference: options 1 (increase of government consumption) and 5 (decrease of the indirect autonomous taxes).

If we exclude the options with a lower economic growth and a higher growth of transport by car compared with the reference scenario, we have left in decreasing preference: options 3, 4, 6, 7 and 2b. These options show a lower total utilization of the road infrastructure by lorry, car and bus in terms of passenger-car equivalent than the reference scenario. If we require in addition a lower or equal growth of transport by lorry, the option 4, 6 and 7 remains.

Finally, we note that the final ranking of the ways of spending is also based on non-economic judgments. These judgments can lead to a mix of spending options.

Appendix to section 4.1:

The relationship between the decrease of the indirect tax rate on the one hand and the use of labour and productive mobility on the other hand

The MOBILEC model teaches that the real wage rate determines the marginal labour productivity and the real price of productive mobility determines the marginal mobility productivity (section 3). When the indirect tax rate decreases, the entrepreneurs will pass it on partly into their sales prices as a consequence of the pressure of competition. Therefore, the equilibrium conditions for the marginal productivities must be adapted (omitting index r in τ_i and δ ; see below for the derivation):

$$\frac{\partial Y_r}{\partial N_r} = w_r \frac{1 + \tau_i + \Delta\tau_i}{1 + \tau_i + \delta \Delta\tau_i} \quad (9)$$

$$\frac{\partial Y_r}{\partial T p_{i_{sr}}} = p p_{i_{sr}} \frac{1 + \tau_i + \Delta\tau_i}{1 + \tau_i + \delta \Delta\tau_i} \quad (10)$$

$$\frac{\partial Y_r}{\partial T p_{1rs}} = p p_{1rs} \frac{1 + \tau_i + \Delta \tau_i}{1 + \tau_i + \delta \Delta \tau_i} \quad (11)$$

where:

- N_r - labour volume in region r;
- $T p_{i sr}$ - productive mobility of goods (number of tons) by lorry from region s to region r;
- $T p_{1 rs}$ - productive mobility of business traffic (number of passengers) by car from region r to region s and back to the region of origin r;
- w_r - wage rate in region r;
- $p p_{i sr}$ - price of productive mobility of goods by lorry from region s to region r;
- $p p_{1 rs}$ - price of productive mobility of passengers (business traffic) from region r to region s and back to the region of origin r
- δ - factor indicating the measure of passing on into sales prices of a change of the indirect tax rate.

The same types of equations apply to the marginal productivity of freight transport by train ($T p_{ii sr}$) and by ship ($T p_{iii sr}$) and to the marginal productivity of business traffic by train ($T p_{2 rs}$) and by bus/tram/metro ($T p_{3 rs}$). The factor δ depends on the elasticity of the demand and the supply curve. Full passing on into sales prices implies $\delta = 1$; the marginal factor productivities do not change. If the tax decrease will not be passed on, $\delta = 0$ and the marginal factor productivities are decreasing. The entrepreneurs implement the lower marginal factor productivities by increasing the use of labour and productive mobility, ceteris paribus.

Equation (9) is derived as follows. There are two situations: situation 0 is the point of departure and situation 1 shows a rise of the VAT compared with situation 0. It applies to situation 1 with regard to labour:

$$\left(\frac{\partial Y}{\partial N} \right)_1 = \frac{w_1'}{p_1} = w_1 \quad (12)$$

where:

- w_1' - nominal wage rate in situation 1;
- w_1 - real wage rate in situation 1;
- p_1 - price level of geographic product at factor costs in situation 1.

The price including VAT is represented by r. It applies $p(1 + \tau) = r$ where τ represents the VAT. On this basis, (12) can be rewritten as follows:

$$\left(\frac{\partial Y}{\partial N} \right)_1 = \frac{w_1' p_0}{p_0 p_1} = \frac{w_1' r_0}{p_0 r_1} \frac{1 + \tau_1}{1 + \tau_0} \quad (13)$$

The exogenous nominal wage rate is in both situations the same: $w_1' = w_0'$. Further is $\tau_0 + \Delta \tau_1 = \tau_1$. Finally, it applies $p_0(1 + \tau_0 + \delta \Delta \tau_1) = r_1$ where δ concerns the extent in which an increase of the VAT can be passed on into sales prices. Substitution of these equations into (13) gives:

$$\left(\frac{\partial Y}{\partial N}\right)_1 = \frac{w'_0}{p_0} \frac{p_0(1+\tau_0)}{p_0(1+\tau_0+\delta\Delta\tau_1)} \frac{1+\tau_0+\Delta\tau_1}{1+\tau_0} = w'_0 \frac{1+\tau_0+\Delta\tau_1}{1+\tau_0+\delta\Delta\tau_1} \quad (14)$$

Rewriting of (14) gives (9). Equations (10) and (11) are derived in the same way.

Appendix to section 4.2:

The effects on the parameter Γ of spending the revenues of a new levy on different ways

Suppose a new levy on mobility in the whole country. The national revenues of the new levy are R_N and the contribution of region r is R_r . The other regions are represented by region s ; the contribution of region s to the revenues is R_s . So $R_N = R_r + \Sigma R_s$. The spending of the revenues goes via the national (federal) government. The spending of the revenues in region r is D_r and in region s D_s . So $D_r + \Sigma D_s = D_N$ and $D_N = R_N$. It is assumed in the following analysis that $D_r > R_r$ and that the deficit of region r is financed by the surplus of the total of the other regions; it applies to region s : $D_s < R_s$. Other assumptions do not change the analysis fundamentally. We will analyse the effects of seven ways of spending on the parameters Γ_r and Γ_s .

Option 1. Spending the revenues of a new levy on mobility on an increase of government spending, especially government consumption.

Analysis.

$$\Delta(t_r d_r) = R_r, \quad \Delta(t_s d_s) = R_s, \quad \Delta G_r = D_r, \quad \Delta G_s = D_s, \quad \Delta X_s = R_s - D_s, \quad \Delta M_r = \Sigma(R_s - D_s)$$

It follows from (8):

$$\Delta\Gamma_r = [(1/\sigma_r) R_r - (1/\sigma_r) D_r + (1/\sigma_r) \Sigma(R_s - D_s)] / Y_r = 0$$

$$\Delta\Gamma_s = [(1/\sigma_s) R_s - (1/\sigma_s) D_r - (1/\sigma_s) (R_s - D_s)] / Y_r = 0$$

Option 2. Spending the revenues of a new levy on mobility on an improvement of infrastructure.

Analysis. The revenues are used for an increase of government spending, namely for financing an improvement of infrastructure. So the same method as in the analysis of option 1 can be followed. $\Delta\Gamma_r$ and $\Delta\Gamma_s$ are the same as in option 1.

Option 3. Spending the revenues of a new levy on a decrease of the employers' contribution to social security in the gross wage rate.

Analysis. The revenues are used for an increase of government spending, namely for financing the decrease of the employers' contribution to social security. So the same method can be followed as in the analysis of option 1. $\Delta\Gamma_r$ and $\Delta\Gamma_s$ are the same as in option 1.

Option 4. Spending the revenues of a new levy on mobility on a decrease of direct autonomous taxes.

Analysis.

$$\Delta(t_r d_r) = R_r, \quad \Delta(t_s d_s) = R_s, \quad \Delta T_{da(r)} = -D_r, \quad \Delta T_{da(s)} = -D_s, \quad \Delta X_s = R_s - D_s, \quad \Delta M_r = \Sigma(R_s - D_s)$$

It follows from (8):

$$\begin{aligned} \Delta \Gamma_r &= [(1/\sigma_r) R_r + (1/\sigma_r) (-D_r) - (-D_r) + (1/\sigma_r) \Sigma(R_s - D_s)] / Y_r = D_r / Y_r \\ \Delta \Gamma_s &= [(1/\sigma_s) R_s + (1/\sigma_s) (-D_s) - (-D_s) - (1/\sigma_s) (R_s - D_s)] / Y_s = D_s / Y_s \end{aligned}$$

Option 5. Spending the revenues of a new levy on mobility on a decrease of indirect autonomous taxes.

Analysis.

$$\begin{aligned} \Delta \Gamma_r &= [(1/\sigma_r) R_r + (1/\sigma_r) (-D_r) + (1/\sigma_r) \Sigma(R_s - D_s)] / Y_r = 0 \\ \Delta \Gamma_s &= [(1/\sigma_s) R_s + (1/\sigma_s) (-D_s) - (1/\sigma_s) (R_s - D_s)] / Y_s = 0 \end{aligned}$$

Option 6. Spending the revenues of a new levy on mobility on a decrease of the direct tax rate.

Analysis. Assuming region specific direct tax rates, $\Delta \tau_{d(r)} = -D_r / Y_r$ and $\Delta \tau_{d(s)} = -D_s / Y_s$. In that case:

$$\begin{aligned} \Delta \Gamma_r &= (1/\sigma_r) (-D_r) / Y_r - (-D_r) / Y_r + [(1/\sigma_r) R_r + (1/\sigma_r) \Sigma(R_s - D_s)] / Y_r = D_r / Y_r \\ \Delta \Gamma_s &= (1/\sigma_s) (-D_s) / Y_s - (-D_s) / Y_s + [(1/\sigma_s) R_s - (1/\sigma_r) (R_s - D_s)] / Y_s = D_s / Y_s \end{aligned}$$

The results are the same as in option 4.

If the direct tax rate is a national matter, then $\Delta \tau_d = -D_N / Y_N$. It implies:

$$\Delta \tau_d = \frac{-D_N}{Y_N} = \frac{-D_r - \sum D_s}{Y_N} = \frac{-D_r}{Y_r} \frac{Y_r}{Y_N} + \sum \frac{-D_s}{Y_s} \frac{Y_s}{Y_N} = \Delta \tau_{d(r)} \frac{Y_r}{Y_N} + \sum \Delta \tau_{d(s)} \frac{Y_s}{Y_N}$$

So, if $\Delta \tau_d = -D_N / Y_N$, then $\Delta \tau_{d(r)} = -D_r / Y_r$ and $\Delta \tau_{d(s)} = -D_s / Y_s$. It follows (see above):

$$\Delta \Gamma_r = D_r / Y_r \text{ and } \Delta \Gamma_s = D_s / Y_s.$$

The results are the same as in the case of region specific direct taxes.

Option 7. Spending the revenues of a new levy on mobility on a decrease of the indirect tax rate.

Analysis. The same method can be followed as in the analysis of option 4. $\Delta \Gamma_r$ and $\Delta \Gamma_s$ are the same as in option 5.

Appendix to section 5.1:

The estimation of the parameters connected with the spending options

The values of the parameters in the MOBILEC model are indicated in Van de Vooren (2004). Here we explain how the parameters connected with the spending options are estimated.

The parameter Γ_r in the base period, 1991-1993, is estimated with the help of (7). The values of I_r and Y_r are known in the base period. However, the values of S_r and σ_r are unknown. Assuming $\sigma_r = \sigma_N$ for all regions and approximating σ_N as $S_N/(Y_N - T_{d(N)}) = 0.14$ in the base period, the value of Γ_r can be derived from (7).

Option 2a

The question with regard to option 2a (improvement of road infrastructure) is to what extent the revenues of the new levy make possible an extension of the road capacity. To answer this question, we have to know the cost for extending the road capacity.

The cost of the extension of the road capacity is estimated as follows. It applies to any region r (omitting index r):

$$F_t = (V_t - V_{t-1}) f_t \quad (15)$$

where:

F_t - total construction cost in period t ;

V_t - capacity of the road infrastructure in period t ;

f_t - mean cost by unit of capacity of the road infrastructure in period t .

The mean cost by unit capacity depends on the degree of the development of the economy: the more the economy has been developed, the more additional construction works to the extending of the road capacity are necessary. Because of this empirical fact, the value of f_t is approximated with the help of:

$$f_t = (\mu Y_{t-1}) / V_{t-1} \quad (16)$$

where μ is a parameter ($0 < \mu < 1$). Substitution of (16) into (15) gives:

$$F_t = [(V_t - V_{t-1}) / V_{t-1}] \mu Y_{t-1} \quad (17)$$

We want to extend the road capacity in such a way that travel time of the road traffic does not rise in spite of the increasing road traffic. To that end, we equate the growth rate of the road capacity with the growth rate of the utilization of the road capacity in the preceding period:

$$\frac{V_t - V_{t-1}}{V_t} = \frac{U_{t-1} - U_{t-2}}{U_{t-2}} \quad (18)$$

However, (18) has two problems. Firstly, the revenues of the levy may be insufficient or too much to finance the whole extension of the road capacity. Secondly, the value of the growth rate of the utilization of the road capacity may be for some regions in some periods negative, especially in the period where the new levy is introduced. To prevail these problems, we reformulate (18) as follows:

$$\frac{V_t - V_{t-1}}{V_{t-1}} = \lambda_{t-1} \left[\frac{U_{t-1} - U_{t-2}}{U_{t-2}} - \left(\frac{U_{t-1} - U_{t-2}}{U_{t-2}} \right)_{\min} \right] \quad (19)$$

where:

U_t - utilization of the road capacity in period t , expressed in passenger-car equivalent;

λ_t - parameter in period t ($\lambda_t > 0$);

min - minimum value: the lowest value of $(U_{t-1}-U_{t-2}) / U_{t-2}$ of the 43 regions.

Substitution of (19) into (17) gives:

$$F_t = \lambda_{t-1} \left[\frac{U_{t-1} - U_{t-2}}{U_{t-2}} - \left(\frac{U_{t-1} - U_{t-2}}{U_{t-2}} \right)_{\min} \right] \mu Y_{t-1} \quad (20)$$

The parameter λ_{t-1} is assigned such a value that $F_{N(t)} = R_{N(t-1)}$. So λ_{t-1} is calculated as:

$$\lambda_{t-1} = R_{N(t-1)} : \sum_{r=1}^k \left[\frac{U_{r(t-1)} - U_{r(t-2)}}{U_{r(t-2)}} - \left(\frac{U_{r(t-1)} - U_{r(t-2)}}{U_{r(t-2)}} \right)_{\min} \right] \mu Y_{r(t-1)} \quad (21)$$

Equation (19) is applied to any region r . The model generates the time paths of U . The parameter λ is calculated using (21). Besides the time paths of U , the model generates the time paths of Y . Finally, we need an estimation of the value of μ .

We estimate μ with the help of the reference book about economic effects of infrastructure of the Dutch Ministry of Transport, Public Works and Water Management (1996). This reference book teaches that the construction of motorway with 2x2 lanes costs 19.5 ± 5.0 million guilders per kilometre in the period 1997-1999 (variant I, excluding additional constructions works, pp. 23 and 25): $f_{97-99} = 19.5 \pm 5.0$. $Y_{94-96} = 1,794,591$ (period 1994-1996, million guilders). The length of the Dutch motorway network amounts to 2173 km in 1995. Using (20), $\mu = 0.071 \pm 0.018$.

Option 2a concerns capacity extension of the *whole* road network. The question is, whether $\mu = 0.071 \pm 0.018$ also applies to the whole road network. The problem is that a value of f_t is not available for the whole road network. However, it can be demonstrated indirectly that $\mu = 0.071 \pm 0.018$ is not unlikely for the whole road network. The length of the whole paved road network in The Netherlands, open for four-wheel vehicles, amounts to 110,556 km in 1995, so that, using (16), $f_{97-99} = 384 \pm 97$ thousand guilders (price level 1995) per km. This seems to be a reasonable estimate for the whole road network. These figures do not contain additional constructions works. So $\mu = 0.071 \pm 0.018$ is a minimum estimate. We put $\mu = 0.1$, a value that we use for all regions and all years.

Option 3

In option 3 (decrease of the employers' contribution to social security in the gross wage rate), the revenues of the new levy are spent on a decrease of the employers' contribution in the next period. We assume that the national wage rate w_N^* (without the new levy) in the next period decreases with the same amount:

$$\Delta w_{N(t)} = - R_{N(t-1)} / N_{N(t-1)} \quad (22)$$

Assuming the same decrease of the wage rate in all regions in terms of percentage:

$$\Delta w_r / w_r^* = \Delta w_N / w_N^* \quad (23)$$

we calculate the decrease of the wage rate in region r (Δw_r) by substitution of (22) into (23):

$$\Delta w_{r(t)} = (w_{r(t)}^* / w_{N(t)}^*) (-R_{N(t-1)} / N_{N(t-1)}) \quad (24)$$

Options 4 and 6

The value of Γ_r changes as a result of the spending of the new levy in the options 4 (decrease of direct autonomous taxes) and 6 (decrease of the direct tax rate). For the calculation of $\Delta \Gamma_r$, we assume:

$$D_r = (Y_r / Y_N) R_N \quad (25)$$

Option 7

In option 7 (decrease of the indirect tax rate), we put $\delta = 0.5$ in (9), (10) and (11).

Appendix to section 5.1 (bis):

The calculation of the revenues of the new levy on mobility

The revenues of the new levy are calculated as follows:

$$R_N = \Delta t_{i_N} \sum_{r=1}^k \sum_{s=1}^n \frac{T p_{i_{sr}}}{b p_i} d_{i_{sr}} + \Delta t_{l_N} \sum_{r=1}^k \sum_{s=1}^n \left(\frac{T p_{l_{rs}}}{b p_l} + \frac{T c_{l_{rs}}}{b c_l} + \frac{T w_{l_{rs}}}{b w_l} \right) d_{l_{rs}} \quad (26)$$

where:

R_N - national revenues of the new levy on mobility;

Δt_{i_N} - new national levy on mobility by lorry per kilometre;

Δt_{l_N} - idem, by car;

$T c_{l_{rs}}$ - consumptive mobility (number of passengers) by car from region r to region s and back to the region of origin r;

$T w_{l_{rs}}$ - commuter traffic (number of passengers) by car from region r to region s and back to the region of origin r;

$b p_i$ - average load per lorry;

$b p_l$ - average number of passengers by car with regard to productive mobility;

$b c_l$ - idem, with regard to consumptive mobility;

$b w_l$ - idem, with regard to commuter traffic;

$d_{i_{sr}}$ - distance in Belgium by lorry from region s to region r;

$d_{l_{rs}}$ - distance in Belgium by car from region r to region s and back to the region of origin r;

summations: $n = 47$ regions, of which $k = 43$ Belgian arrondissements and $n-k = 4$ foreign countries (The Netherlands, Germany, Luxemburg and France).

Notes

1. It applies in an open economy: the identity $Y = C + S + T_d$ (i) and the equilibrium equation $Y + T_i = C + I + G + X - M$ (ii), where Y – national income, C – private consumption, S – private saving, T_d – direct taxes, T_i – indirect taxes, I – private investment, G – government spending, X – export and M – import. It follows from (i) and (ii): $I = S - (G - T) - (X - M)$, where $T = T_d + T_i$. So private investment corresponds to private saving reduced by the government deficit and the surplus of the balance of payments.

2. The variable T_d concerns a net amount: direct taxes and premiums for social security minus interest on government debt, social security benefits and other social benefits to the private sector. The variable T_i also concerns a net amount: indirect taxes minus subsidies.

3. The regional balance of payments $X - M$ is, for the sake of simplicity, not considered as an endogenous variable. It is assumed that its value is small in comparison with Y . However, $X - M$ changes in the model, if a part of the revenues of the levy in a region is spent in another region. The analysis does not change fundamentally, if $X - M$ partly depends on the regional product. See the Appendix to section 4.2 for a mathematical explanation.

4. This assumption can be deduced from a research for the period 1995-2020 by the Dutch Ministry of Transport, Public Works and Water Management (1997).

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