# On the Use of Gross versus Net Multipliers,
## with a bi-regional application on Dutch transportation

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## Abstract

The Dutch transportation sector promotes its proposals for new infrastructure by emphasising the strategic economic importance of The Netherlands as a European distribution-hub. This poses the question about the importance of the transport and distribution sector for the regional and the national economy. To answer such a question the literature often takes refuge with (regional) input-output analysis in order to estimate the economic impacts of the sector at hand. This paper produces such estimates for the Dutch transportation sector by using new bi-regional input-output data for the northern part of the Netherlands versus the whole of the Netherlands.

Simultaneously, this paper critically reviews the economic meaning of the traditional use of (gross) multipliers in these cases. To avoid double-counting of impacts and to solve the conceptual problems involved, the paper introduces the new concept of the *net* multiplier, and calculates the regional and national values for the northern part and for the whole of the Netherlands. Besides, it proposes an equal-handed method to calculate the cumulative importance of a regional or a national sector for the national balance of trade. Finally, it indicates a more appropriate approach for dealing with the infrastructure impacts' question.

## Keywords

Transportation sector, multipliers, forward and backward linkages, balance of trade, The Netherlands.

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## 1. Introduction: the problem of exaggerated impacts

Arguments for state aid and state intervention in favour of certain sectors of industry are often based on their assumed economic importance for the region or nation at hand. The same argument is used, especially in small open economies, when decisions about large infrastructure projects have to be taken. In the Netherlands, both lines of reasoning are combined by special interest groups that argue in favour of state support in the case of extensions of the port of Rotterdam and of Schiphol airport, which are considered to function as the motors of the Dutch economy. But also in the case of more peripheral regions, such as the northern Netherlands, transport and distribution activities and infrastructure investments are considered to be of great importance for the economic development of such regions (see Henstra, Krolis and Oosterhaven, 1999). Mostly, the arguments are not primarily based on the own size and the direct impact of the sector or project at hand, but on its assumed indirect importance for the regional or national economy.

To substantiate such claims consultants, but also academics, traditionally multiply direct employment or some other kind of size indicator with a sectoral or project-specific employment or other multiplier. The result is an estimate of the total direct plus indirect plus induced plus whatever other impacts one can think of (see in the case of plant closedowns, Cole, 1988, discussed in Jackson, Madden & Bowman, 1997, and in Oosterhaven, 2000). Basically, this traditional approach is wrong. This can easily be shown empirically, since applying the same approach to all sectors of a certain economy will result in an (implicit) estimate of the size of that economy that is many times larger than its actual size.

In section 2 we will discuss the theoretical delusion that is responsible for this outcome and we will present a new concept, the *net multiplier*, that results in a correct estimate of the size of the whole economy. In section 3, we will present empirical results for the Dutch transportation sector based on the new Dutch bi-regional input-output tables (see Eding *et al.* 1999). And, we will compare the outcomes of using the traditional (gross) multiplier approach with those of using our new *net* multiplier concept for four different subsectors of the transportation industry and for both the northern Netherlands and the whole of the country.

Besides the importance of a sector or a project for the gross national product, policy-makers in small open economies are often also interested in the importance of that sector or project for the national balance of trade. In that case, the gross versus net multiplier distinction, though theoretically still important, does not play such an important role in an empirical sense. Instead it is important whether or not an equal-handed treatment of exports and imports is followed. This is especially true when indirect exports and imports are included in the comparison. Section 4 shows how this indirect trade impact issue can be treated in a fair way by means of using a non-biased combination of the supply-driven and the demand-driven input-output model, provided that one does not interpret the results in a causal way. Again the four Dutch northern and national transportation subsectors serve to illustrate the argument empirically.

Finally, section 5 summarises the theoretical and empirical results, and extrapolates the discussion from the present static framework into the dynamic issue of the importance of investments in transport infrastructure for the growth of a regional or national economy.

## 2. Gross versus net multiplier effects: the theory

From here on we will forget about infrastructure projects and concentrate on the economic importance of a certain sector. The *direct* economic importance of a certain sector, seemingly easily, can be measured by some kind of size indicator, preferably by its direct contribution to GRP or GNP, or else its direct contribution to total regional of national employment. There are, however, pitfalls that will become clear when the question of the indirect economic importance is posed.

The line of reasoning and calculation of the *indirect* economic importance of a sector normally starts with its relations with other actors in the economy. Here we will concentrate mainly on its relations with other sectors. It is of importance to make a sharp distinction between the concept of relation or linkage, on the one hand, and the concept of effect or impact, on the other hand. The difference being that the first concept is causally neutral and essential static, whereas the second concept implies causality and is essentially dynamic. Clearly, when the issue of the indirect economic importance of a certain sector is concerned, one is, or at least one should be interested in causality.

As regards relations with other sectors, traditionally a distinction is made between the *forward linkages* with downstream, processing industries and the *backward linkages* with upstream, supplying industries. These two causally neutral concepts find their origin in theories of unbalanced sectoral development (Hirschman, 1958) and unbalanced regional development (Myrdal, 1957). In those theories, however, they are already used in a very causal way, in the sense that they are viewed as important channels through which growth impulses are passed on, starting from companies, industries or regions that are considered to function as the (causal) growth engines of the economies at hand. With these authors the causality issue is solved externally by means of labelling certain sectors as exogenous and others as endogenous.

This does not mean, however, that a causal interpretation may be given to the concept of linkages itself. This is because one and the same linkage between a supplying sector *i* and a processing sector *j* may be the vehicle of both a causal forward effect and a causal backward effect. A *forward effect* occurs when, *e.g.*, the productivity increases of industry *i*, through lower output prices, are passed on to industry *j*. A *backward effect* occurs when, *e.g.*, output increases of industry j, through increases in the demand for inputs, are passed on to industry *i*. Hence, the existence of large forward or backward linkages, as such, does not tell anything about the direction of causality. The industry at hand may either be (passively) receiving impulses from other sectors or it may (actively) be sending impulses to other sectors. Moreover, when the impulses are negative, having large linkages actually does not represent a merit but a vice, either for the (receiving) industry at hand or for the (receiving) rest of the economy.

Consequently, the existence of large forward and backward linkages, without further information, does not imply that the sector at hand can be considered a key sector for regional of national development, despite the fact that this is regularly done in empirical development economics (see Schultz, 1977). To be labelled a *key sector*, a second criterion has to be satisfied. The sector at hand, besides having large linkages to pass on growth impulses, also needs to generate these growth impulses itself, *i.e.* the growth in this sector needs to be considered as (largely) exogenous from the rest of the economy (see Beijers, 1976, and Oosterhaven, 1981, ch. 5, for a further discussion).

The practical upshot of the above discussion is that, in order to get a clear interpretation, forward and backward *linkages* are best measured by means of the *direct size* of those linkages themselves, without relying on any (implicit) model of the economy. This leads to using:

- the shares of intermediate sales in total sales as a measure of the *direct forward* linkages per sector (*i.e.* the row sums of the matrix of intermediate output coefficients, $\mathbf{B}\,\mathbf{i}$), and
- the share of intermediate purchases in total costs as a measure of the *direct backward* linkages per sector (*i.e.* the column sums of the matrix with intermediate input coefficients, $\mathbf{i}'\,\mathbf{A}$).

Both measures and their underlying matrices **A** and **B** can be derived from regional or national input-output tables in the usual manner (see Oosterhaven, 1981, or Miller & Blair, 1985).

Instead of direct linkages, the standard approach mostly uses measures for the *total* of direct and indirect linkages, *i.e.*

- the row sums of the Ghosh-inverse as a measure of the *cumulative forward* linkages per sector (*i.e.* $\mathbf{G}\,\mathbf{i} = (\mathbf{I} - \mathbf{B})^{-1}\,\mathbf{i}$), and
- the column sums of the Leontief-inverse as a measure of the *cumulative backward* linkages per sector (*i.e.* $\mathbf{i}'\,\mathbf{L} = \mathbf{i}'\,(\mathbf{I} - \mathbf{A})^{-1}$).

Unfortunately, these last two measures are equal to the *multipliers* of, respectively, the supply-driven input-output model (Ghosh, 1958) and the traditional demand-driven input-output model. Hence, they do not represent causally neutral linkages, but forward and backward *causal effects* that are based on specific causal relationships and a specific designation of model variables as being either exogenous or endogenous. Since the underlying models represent two mutually contradictory extremes, wrong interpretations of these so-called cumulative linkages are almost unavoidable (see Oosterhaven, 1988, 1996, for details).

To illustrate the double-counting of impacts and the over-estimation of the economic importance of a certain sector that is the consequence of this confusion, we will first summarise the causality and the exogenous/endogenous distinction in the standard demand-driven Leontief model. In this model, the final demand **f** for sectoral outputs is exogenous. Any change in whatever part of total demand for sectoral outputs is matched, without supply constraints, by endogenous sectoral production **x**. Sectoral production, in its turn, determines the endogenous intermediate demand for sectoral outputs as well as the endogenous demand for primary inputs, such as value added *v* and imports *m*. The model solution for value added is the following:

$$v = \mathbf{v_c}'\ \mathbf{x} = \mathbf{v_c}'\ (\mathbf{I} - \mathbf{A})^{-1}\ \mathbf{f}\ = \mathbf{v_c}'\ \mathbf{L}\ \mathbf{f} \qquad (1)$$

where $\mathbf{v_c}'$ represents the row with value added coefficients (see Oosterhaven, 1981, or Miller & Blair, 1985, for details).

From (1) it is clear that the value added multipliers $\mathbf{v_c}'\mathbf{L}$ may only be multiplied with exogenous final demand **f** and not with endogenous total output **x**. When the latter is done, this unavoidably leads to an over-estimation of the importance of the sector at hand. The reason being that (1) assumes that the intermediate part of total output is endogenously determined by the size of (mainly the other sectors') total output. Multiplying the total of **x** with the value added multipliers $\mathbf{v_c}'\mathbf{L}$ results in double-counting, because this procedure assumes this endogenous part ($\mathbf{x} - \mathbf{f}$ ) to be exogenous. When calculating the importance of Schiphol airport for national employment BCI/NEI (1997, table 5.1), for instance, forget that part of the backward employment effect actually occurs in the aviation industry that was already included in the direct (platform-tied) employment at Schiphol that was assumed exogenous.

Things get even more wrong when ad hoc estimates of causal forward effects are added to the so-called direct effect, which total is then multiplied by standard employment or value added multipliers in order to estimate the so-called backward effects of a certain sector of project. This procedure easily leads to triple-counting of effects. Besides the above mentioned double-counting of part of the direct effect with part of the backward effects, this will also lead to double-counting of part of both the direct and the backward effects with the forward effects. When evaluating the economic impact of a rail freight line from the port of Rotterdam to the Ruhr-area Knight Wendling (1992), for instance, added the backward effects of the Rotterdam port industries on inland freight transport to the forward effects of the freight line on the Rotterdam port industries.

The principal reason for all this over-estimation and double-counting is simple: multipliers are used outside the context of the model from which they are derived.

The simple remedy "don't do it", however, is too naive. Practitioners, will continue to need simple devices like multipliers, which they will unavoidably want to multiply simply with total output, total employment or total value added. Therefore, we propose to label the old, standard multipliers as *gross* multipliers, which may only be multiplied with (exogenous) final demand. Next to this, a new so-called net multiplier is needed that can simply be multiplied with the total of a certain sector in order to get the impact of that sector on the economy.

In the case of total output, the new *net total output multipliers* will be equal to the old (gross) output multipliers $\mathbf{i}'\mathbf{L}$ times $<\mathbf{f_c}>$, that is, times the diagonal matrix with the fractions of total sectoral output that may be considered exogenous (*i.e.* $f_j / x_j$).

In the case of value added and employment multipliers, the corresponding net multipliers need of course to be multiplied with total sectoral value added or total sectoral employment. This means that, just as with the old (gross) multipliers, the new net value added and employment multipliers need to be standardised. This leads to the following definition of the *standardised net value added multipliers*:

$$\mathbf{SNVAM\text{-}I}' = \mathbf{v_c}'\ (\mathbf{I} - \mathbf{A})^{-1}\ <\mathbf{f_c}>\ <\mathbf{v_c}>^{-1} \qquad (2)$$

Where $<\mathbf{f_c}>$ is the matrix with the sectoral final output ratios that secures the *net* character of the multipliers, and $<\mathbf{v_c}>^{-1}$ represents the diagonal inverse of the sectoral value added ratios that secures the standardisation with respect to sectoral value added. The above net multipliers represented the so-called Type I net multipliers that are derived from the basic Leontief model.

In the next empirical section, however, we will use so-called *Type II standardised net* employment and net value added *multipliers*:

$$\mathbf{SNVAM\text{-}II}' = \mathbf{v_c}'\ (\mathbf{I} - \mathbf{A} - \mathbf{Q})^{-1}\ <\mathbf{f_c}^{ex}>\ <\mathbf{v_c}>^{-1} \qquad (3)$$

Where $q_{ij}$ from **Q** indicates the endogenous consumption expenditures on products from sector *i* paid from labour incomes in sector *j* per unit of output in sector *j*, and where $\langle \mathbf{f_c^{ex}} \rangle$ represents the exogenous final output ratios. These Type II multipliers are derived from the following extended input-output model (see Oosterhaven, 1981, for its interregional generalisation used in the next section):

$$v = \mathbf{v_c}' \, (\mathbf{I} - \mathbf{A} - \mathbf{Q})^{-1} \, \mathbf{f^{ex}} = \mathbf{v_c}' \, \mathbf{L^{ex}} \, \mathbf{f^{ex}} \qquad (4)$$

Where $\mathbf{f^{ex}} = \mathbf{f} - \mathbf{Q} \, \mathbf{x}$, and where $\mathbf{L^{ex}}$ stands for the extended Leontief-inverse.

Comparing (1) with (4) shows that the Type I gross multipliers $\mathbf{v_c}'\mathbf{L}$ are smaller than the Type II gross multipliers $\mathbf{v_c}'\mathbf{L^{ex}}$, whereas Type I final output **f** is larger than Type II exogenous final output $\mathbf{f^{ex}}$ (provided of course that $\mathbf{Q} > \mathbf{0}$). In case of the net multipliers, however, no such systematic relation can be found. In fact, the output-weighted average of both the Type I and the Type II *net* multipliers equals unity. With $x = \mathbf{i}' \, \mathbf{x}$, the economy-wide total output, this follows from:

$$\textbf{SNVAM-I}' \, \mathbf{x} \;\, x^{-1} = \mathbf{v_c}' \, \mathbf{L} \, \langle \mathbf{f_c} \rangle \, \langle \mathbf{v_c} \rangle^{-1} \, \mathbf{x} \;\, x^{-1} = \mathbf{v_c}' \, \mathbf{L} \, \langle \mathbf{f} \rangle \, \langle \mathbf{v} \rangle^{-1} \, \mathbf{x} \;\, x^{-1} = \mathbf{v}' \, \langle \mathbf{v} \rangle^{-1} \, \mathbf{x} \;\, x^{-1} = 1 \qquad (5)$$

The proof for the Type II net multipliers runs analogous with $\mathbf{L^{ex}}$ and $\mathbf{f^{ex}}$.

The above property is, of course, precisely the reason for developing the concept of the net multiplier. It also avoids the double-counting of impacts. This means that when each sectoral *net* multiplier is multiplied with its appropriate sectoral total (output, employment, whatever), the total for the whole economy will result instead of some multiple of it. For the Type II net value added multipliers this follows from:

$$\textbf{SNVAM-II}' \, \mathbf{v} = \mathbf{v_c}' \, \mathbf{L^{ex}} \, \langle \mathbf{f_c^{ex}} \rangle \, \langle \mathbf{v_c} \rangle^{-1} \, \mathbf{v} = \mathbf{v_c}' \, \mathbf{L^{ex}} \, \langle \mathbf{f^{ex}} \rangle \, \langle \mathbf{v} \rangle^{-1} \, \mathbf{v} = \mathbf{v}' \, \langle \mathbf{v} \rangle^{-1} \, \mathbf{v} = \mathbf{v}' \, \mathbf{i} = v \qquad (6)$$

The proof for the Type I net multipliers again runs parallel.

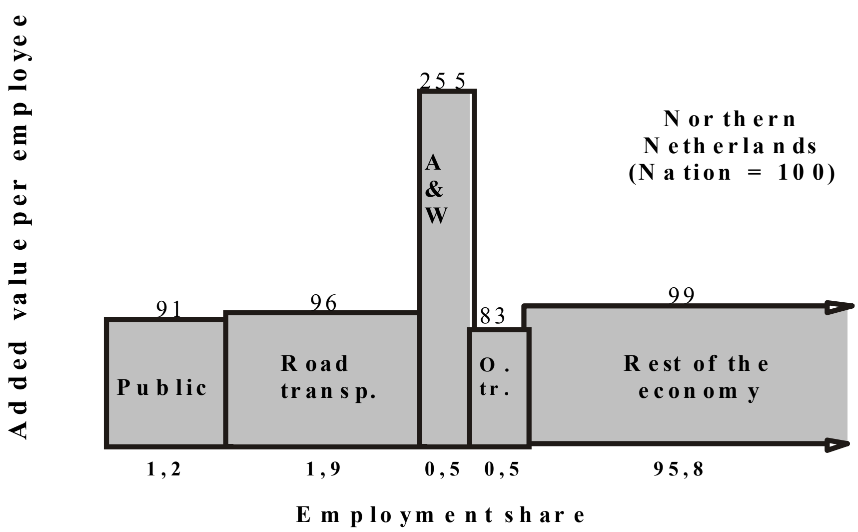
## 3. Application to the northern and the national Dutch transport sectors

Before discussing these net multipliers empirically, first, the traditional way of ‘showing’ the direct economic importance of a sector is presented graphically in Figure 1 and Figure 2. They relate to, respectively:
- the total of the three northern provinces (the North) and
- the Netherlands as a whole (the Nation),

and they show results for the following subdivision of the transportation sector:
- public passenger transport (National Accounts’ sectors 71-72.2),
- road freight transportation (NA- sectors 72.3/4),
- air, sea and inland shipping (“A&W”; NA-sectors 73-75), and
- travel agencies & auxiliary freight services (“other transport services”; NA-sector 76).

Figure 1, horizontally, shows the employment share of total transportation in the North to be 4.2% (1,2% + 1,9% + 0,5% +0,5%), with road freight transport being the largest subsector. The vertical axis shows that the value added per transportation worker is close to the national average, except for the capital-intensive water and air transport services where it is far higher, and except for the more labour-intensive “other transport services” where it is lower than average. Multiplying the horizontal and vertical axis gives the rectangular surfaces, which represent the value added shares of the subsectors. Thus, for example, in terms of employment, northern air and water transport is of the same size as “other transport services” but in terms of value added it contributes more than twice as much to the regional economy.

*Figure 1. The direct regional importance of the regional transport sector.*




Comparing Figures 1 and 2, it appears that the direct national importance of the transportation sector in terms of employment to be larger than that in the North, namely 5.2% (0,8% + 2,3% + 0,8% + 1,3%) versus 4.2%. The difference is caused by the larger share of commercial transportation (road freight transport, air and water transport, travel agencies & auxiliary freight services), that is related to the international transhipment function of the two 'mainports' in the western part of the country. Public passenger transport, on the other hand, is of more importance, relatively speaking, in the less densely populated North than the commercial transport services.

*Figure 2. The direct national importance of the national transport sector.*

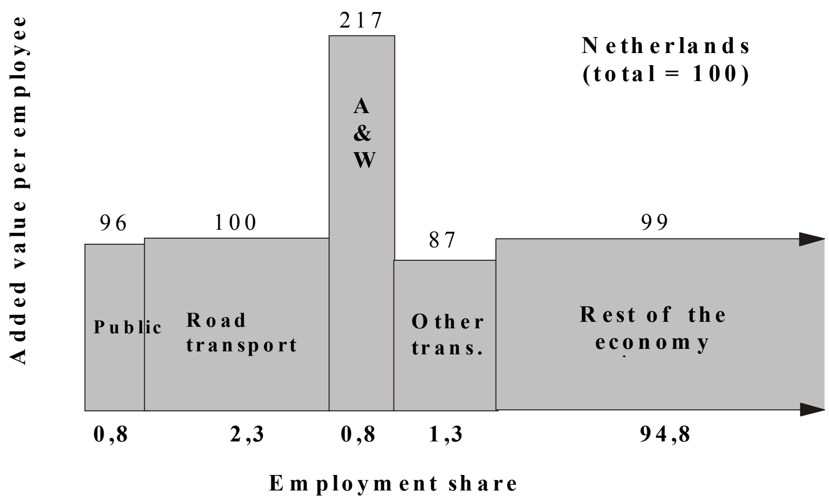



Table 1 represents the traditional (gross) view on the economic importance of a certain sector for the national or regional economy. The upper part summarises the information on the direct economic impact of the Dutch transportation sector from Figures 1 and 2.

The middle part gives the traditional type II standardised (gross) multipliers for employment and value added. In the case of the North these multipliers are calculated by means of a Type II *bi-regional* input-output model, which is based on the new set of rectangular Dutch bi-regional make and use tables (RUG/CBS, 1999). The bi-regional nature of the model means that the national impact of the northern transportation sector can be decomposed into an intra-regional northern part and an interregional spillover part which regards the rest of the Netherlands (see Oosterhaven, 1981, or Miller & Blair, 1985). For the Netherlands as a whole, for consistency reasons, a straight aggregation of the bi-regional model for the North into a national Type II input-output model is used.

Interestingly, except for "other transport services", the national employment multipliers for the northern subsectors are larger than those for the corresponding national subsectors. In the case of air and water transport, this is understandable in view of the much higher value added per worker in the North (compare Figures 1 and 2). This also shows up in the very large intra-regional employment multiplier of 2.29, which is caused by the very small direct employment coefficient of air and water transport (that is by $<\mathbf{v}_e>^{-1}$ in the multiplier formula). In the case of the remaining two northern subsectors (public passenger transport and road freight transport) smaller foreign import leakages explain part of the larger size of the multipliers. In the case of the smaller northern employment multiplier for the "other transport services", the larger cluster linkages within the rest of the Netherlands are the main explanation.

*Table 1. The traditional, gross view on the importance of the transport sector.*

| Type of importance | Public transport | | Road freight transport | | Air/sea/inland shipping | | Other transport s. | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | North | Nation | North | Nation | North | Nation | North | Nation | North | Nation |
| Direct EM (%) | 1.2 | 0.8 | 1.9 | 2.3 | 0.5 | 0.8 | 0.5 | 1.3 | **4.2** | **5.2** |
| Direct VA (%) | 1.0 | 1.2 | 2.0 | 1.9 | 1.3 | 2.9 | 0.2 | 0.6 | **4.5** | **6.7** |
| Regional SG EM M | 1.54 | | 1.51 | | 2.29 | | 1.22 | | | |
| National SG EM M | 1.88 | 1.70 | 1.86 | 1.56 | 3.36 | 2.88 | 1.32 | 1.72 | | |
| Regional SG VA M | 1.48 | | 1.49 | | 1.41 | | 2.00 | | | |
| National SG VA M | 1.76 | 1.65 | 1.80 | 1.68 | 1.74 | 1.76 | 2.52 | 2.19 | | |
| EM importance (%) | 1.8 | 1.4 | 2.9 | 3.7 | 1.2 | 2.3 | 0.6 | 2.2 | **6.6** | **9.5** |
| VA importance (%) | 1.5 | 2.0 | 3.1 | 3.3 | 1.8 | 5.1 | 0.3 | 1.4 | **6.7** | **11.8** |

EM= employment, VA= value added, SG = standardised gross, M = multiplier.

The lower, concluding part of Table 1 shows the result of multiplying the upper part, with the direct economic importance of the transportation subsectors, with the regional and national multipliers from the middle part. The direct, indirect and induced *regional importance* is found to be almost systematically smaller than the corresponding national importance. The only exception is the direct, indirect and induced employment importance of 1.8% of public transportation in the North, which is significantly larger than the corresponding national 1.4%. The systematic difference is explained by the interregional spillovers to the rest of the country, which are neglected when the importance of a regional sector for the regional economy is calculated. The systematic differences are, especially, large in the case of air and water transport and "other transport services". In both cases, the intra-regional multipliers of the northern subsectors are considerably below the national multipliers of the national subsectors.

Next, note that in terms of value added, the *national importance* of the transportation sector is above the psychologically important threshold of 10%. Thus, the lobbyist will use that number to claim that *at least* 12% of the Dutch economy is dependent on the transport sector. At least, because the above calculations still exclude the forward economic impact of the transportation sector on, especially, the location decisions of international industrial and service activities. Such activities, the lobbyist will claim, will especially locate in the Netherlands because of the presence of its "excellent cluster" of international transport and distribution services. This way of thinking is popularised in the public debate by using the phrase "without transportation, everything stands still".

Other lobbyists, however, will use the same type of reasoning to underscore the importance of their sectors. And indeed, in our modern age "without energy, everything stands still" too, while Marxists rightfully claim that "without the mighty arm of labour" everything also stands still. What is left out of the equation is the fact that *dependence* (mostly) is a *two-sided phenomenon*. Not only are all other sectors dependent upon transportation services; also, the transportation sector is dependent upon the demand and demand growth of all these other sectors. The way to quantify this other side of the coin, this "depending upon", is to use net multipliers in stead of the traditional (gross) multipliers, as was argues in section 2.

Table 2 shows the values of these *net multipliers* in case of the northern and the national Dutch transportation sectors. Not surprisingly, the net multipliers of public transportation are found to be smaller than 1.00. The reason is that only little of the output of public transport goes to exogenous final demand (see <$\mathbf{f_c}^{\mathbf{ex}}$> in the Type II net multiplier formula). Most of the outputs of public transport go to household consumption demand that is (mostly) endogenous in the Type II input-output model that is used in the calculations behind Table 2. In fact, only the public transportation by the elderly and other economically non-active parts of the population is exogenous, as our Type II model only reckons with endogenous *labour* incomes. The net employment multipliers of the northern "other transport services" are smaller than 1.00 too, as opposed to the net national multiplier that is exactly equal to 1.00. The reason is that the northern "other transport services" mainly cater for local households and businesses, whereas the national "other transport services" also serve international customers, whose demand is exogenous.

These empirical numbers illustrate two theoretical properties. First, net multipliers are model-specific as are gross multipliers. Second, as opposed to gross multipliers, net multipliers actually reduce the "importance" of certain sectors. Consequently, one does not easily "forget" that multipliers are model-specific and may not be used outside that context.

*Table 2. The alternative, net view on the importance of the transport sector.*

| | Public transport | | Road freight transport | | Air/sea/inland shipping | | Other transport s. | | Av. net/gross Correction; | |
|---|---|---|---|---|---|---|---|---|---|---|
| Type of importance | North | Nation | North | Nation | North | Nation | North | Nation | Resp. | **Total** |
| Regional SN EM M | 0.74 | | 1.36 | | 2.02 | | 0.76 | | 0.74 | |
| National SN EM M | 0.79 | 0.76 | 1.57 | 1.18 | 2.74 | 2.25 | 0.62 | 1.00 | 0.68 | |
| Regional SN VA M | 0.71 | | 1.34 | | 1.25 | | 1.16 | | 0.79 | |
| National SN VA M | 0.74 | 0.74 | 1.52 | 1.28 | 1.42 | 1.38 | 1.18 | 1.27 | 0.69 | |
| EM importance (%) | 0.9 | 0.6 | 2.6 | 2.8 | 1.1 | 1.8 | 0.4 | 1.3 | **4.9** | **6.5** |
| VA importance (%) | 0.7 | 0.9 | 2.8 | 2.5 | 1.6 | 4.0 | 0.2 | 0.8 | **5.3** | **8.2** |

EM= employment, VA= value added, SN = standardised net, M = multiplier.

When the upper, direct importance part of Table 1 is multiplied with the upper, *net* multiplier part of Table 2, the concluding, lower part of Table 2 results. The basic feature of the lower part of Table 1 remains. The regional importance of the transport sector for the North is much smaller than the national importance of the national transport sector. In terms of value added the difference is as large as that between 5.3% and 8.2%. This remains so, despite the interesting fact that the *weighted average net/gross correction* for the North is smaller than that for the whole of the Netherlands, both for employment and for value added. A consideration of the properties (5) and (6), and the fact that the intra-regional gross multipliers are smaller than the corresponding national gross multipliers, explains this phenomenon. Being smaller, gross intra-regional multipliers exaggerate the (one-sided dependency) measurement of importance less. Hence, they need to be corrected less too. At the national level, however, the correction is larger. Instead of a national importance of almost 12% in terms of value added in Table 1, now only an importance of 8% remains.

## 4. Direct versus cumulative contribution to the balance of trade

The measurement of the importance of a certain sector for the national balance of trade is not without difficulties either. The problem here is simpler, as it most often comes down to an unbalanced use of information on exports as compared to imports. Examples are the statements of a sector's (relatively) large contribution total national exports, without a correction for the sometimes also large use of foreign imports. An example for The Netherlands is the chemical industry, which indeed has a large share in total Dutch exports, but also has a rather large share in total foreign imports. The only fair way to compare the direct contributions of sectors to the national balance of trade balance is to compare the *direct net contributions*. This can be done in essentially two different ways:

1. One can subtract the *own direct imports* of a certain sector from its own direct exports. Depending on the accounting conventions used, this most often leads to an (implicit) estimate of total imports that falls short to the actual imports of the economy at hand. The reason is that government and

households (statistically) also take part in foreign imports, whereas they (mostly) do not take part in foreign exports. The result is a systematic over-estimation of each sectors' contribution to the balance of trade. When commodity data are absent, the only refuge is to correct for the (implicitly estimated) export surplus. This will of course be 'forgotten', because of the theoretical and empirical complexities involved.

2. A better alternative is, therefore, to subtract *all competitive imports* of products of the sector at hand from its direct exports. This may best be done at the commodity level that is present in all make and use tables. When summed over all commodities using a make-use accounting framework, the total contribution to the national balance of trade will (almost) equal the size of the national balance of trade. The difference, of course, being the non-competitive imports that cannot be allocated to a domestic industry. In the case of an industry-by-industry framework, the same procedure can be used, but then a full matrix of foreign imports by sector of origin is needed.

Direct information from the recent Dutch bi-regional input-output tables (RUG/CBS, 1999) gives the net direct contributions of the transport sectors' products to the national balance of trade in Table 3. The difference with the earlier tables is that Table 3 compares the North with the rest of the Netherlands and not with the whole of the Netherlands[1]. Except for public transport, whose services are neither imported nor exported, except through foreign visitors to the Netherlands and vice versa, all transport subsectors show a considerable *net direct contribution*. Given the strong international position of the Dutch transportation sector this is not surprising.

Other sectors often complain about such numbers, as they do not reckon with the *indirect exports* of *e.g.* agricultural outputs through the food industry. Several ad hoc approaches are used to remedy this neglect; the most direct, but incorrect approach is to simply attribute the exports other (forwardly linked) sectors to the exports of the sector at hand and show how large the contribution of this combined export is. This procedure neglects that the exports of that the other sector are only possible thanks to numerous other inputs besides those of the sector at hand. In the case of agriculture, this applies to all non-agricultural inputs (including labour) that are also needed to produce the export of the food industry. Furthermore, such simply procedures (mostly) also neglect the fact that correcting for indirect exports logically implies that a fair and balanced comparison also requires a comparable correction for *indirect imports*.

Despite several theoretical drawbacks, we believe that only the combined use of the supply-driven input-output model (to measure indirect exports) and the demand-driven model (to measure indirect imports) will produce a fair and equal-handed comparison between sectors. As long as the result is not interpreted in any causal sense, but is used mainly as a descriptive device, the drawback will not be too severe (see Oosterhaven, 1988, 1996).

To measure cumulative (*i.e.* direct and indirect) imports the following *standardised gross (backward) import multipliers* may be used:

$$\mathbf{SGIM'} = \mathbf{m_c'}\ (\mathbf{I} - \mathbf{A})^{-1} <\mathbf{m_c}>^{-1} \tag{7}$$

Where $<\mathbf{m_c}>^{-1}$ indicates the diagonal inverse of the sectoral import ratios that secures the standardisation of the regular backward import multipliers $\mathbf{m_c'L}$.

The cumulative (i.e. direct and direct) exports of a certain sector are measured analogously by means of *standardised gross (forward) export multipliers*:

$$\mathbf{SGEM} = <\mathbf{e_c}>^{-1} (\mathbf{I} - \mathbf{B})^{-1}\ \mathbf{e_c} \tag{8}$$

Where $<\mathbf{e_c}>^{-1}$ indicates the diagonal inverse of the sectoral export ratios that secures the standardisation of the regular forward export multipliers $\mathbf{G\ e_c}$.

It can be shown that the combined use of both multipliers will *almost* reproduce the aggregate national balance of trade to which the individual sectors' contributions are to be determined. This follows from:

[1] This is done for consistency reasons, as the import data detail on a regional level is not comparable to that on the national level (see RUG/CBS, 1999).

$$\mathbf{e' \; SGEM - SGIM' \; m = e' <e_c>^{-1} \; G \; e_c - m_c' \; L <m_c>^{-1} \; m = x' \; G \; e_c - m_c' \; L \; x} \quad (9)$$

The over-estimation on both sides of the balance of trade is comparable, since the Leontief-inverse **L** and the Ghosh-inverse **G** are both derived from the same matrix of intermediate transactions, and have the same weighted average value ($x / f = x / k$, with $k = \mathbf{i' \; k}$ = total primary cost, see Oosterhaven, 1996).

An exact fit is reached if the standardised *net import* and *net export multipliers* are used instead of the gross multipliers. The proof for imports runs analogous to that for value added in (6), with $\mathbf{i' \; m} = m$. Standardised net export multipliers are defined analogously, using $\mathbf{<k_c>}$ for the primary input ratios that secure the net character of the multipliers. The proof for the *exact reproduction of the balance of trade* then runs as follows:

$$\mathbf{e' \; SNEM - SNIM' \; m = e' <e_c>^{-1} <k_c> G \; e_c} - m = \mathbf{k' \; G \; e_c} - m = \mathbf{x' \; e_c} - m = e - m \quad (10)$$

Hence, using net multipliers as in (10) is again better than using gross multipliers as in (9), but here using gross multipliers is empirically acceptable as the over-estimation occurs on both sides of the balance of trade in the same way.

*Table 3. The net contribution of the transport sector to the national balance of trade*

| In %-points of total sectoral output | Public transport | Road freight transport | Air/sea/inland shipping | Other transport s. | Total |
|---|---|---|---|---|---|
| Northern Netherlands | | | | | |
| Direct net contribution | 1 | 36 | 71 | 23 | **37** |
| Cumulative contribution | - 12 | 23 | 69 | 12 | **27** |
| Rest of the Netherlands | | | | | |
| Direct net contribution | 2 | 35 | 66 | 28 | **42** |
| Cumulative contribution | - 8 | 26 | 63 | 20 | **35** |

The "cumulative contribution" rows of Table 3 show the result of using gross import and gross export multipliers in the case of the Dutch transport sectors. Clearly, the contribution of public transport is now negative, as no indirect exports of any significance are present, whereas a considerable amount of indirect imports is now reckoned with. For the other transport sectors, indirect imports are also more important than indirect exports, but the net contribution is still positive. The lower numbers, however, give a more balanced evaluation of the contribution of the transportation sectors to the Dutch balance of trade. Only for air and water transport, when correcting for indirect exports and imports, we hardly see a reduction of its contribution to the foreign balance of trade. In view of the strong transhipment function of the port of Rotterdam and Schiphol airport, which dominate this sector, this is not surprising either.

## 5. Conclusion: how about infrastructure impacts?

Both the theoretical discussion and the empirical illustration show that claims of economic importance are often misleadingly high. The paper introduces the concept of the *net multiplier* to remedy this systematic upward bias. The most appealing aspect of this new multiplier is that it can be smaller than 1.00, which gives a numerical expression to the notion that certain sectors may be more dependent on the rest of the economy than the rest of the economy is on them.

Nevertheless, the input-output models behind net multiplier concept developed in this paper are the same as the models behind the traditional (gross) multipliers. This means that they are equally (comparatively) static, while they also neglect price-volume interactions. Especially when the discussion centers on the evaluation of new infrastructure proposals, and not around the importance of sectors as such, input-output models are inadequate even when net multipliers are used. In those cases, computable spatial general equilibrium models are needed (see e.g. Bröcker, 1995, 1998). Such models need to have an inter-industry character in order to capture forward effects, which mostly start with transport cost reductions, and to capture backward effects, which mostly start with transport demand effects. Moreover, such models need to have an interregional character, as the same type of infrastructure will have a very different effect depending upon the regions where it is installed. Finally, for small open economies such models also need to incorporate the relevant neighbouring countries in order to capture international (re)location decisions to and from the country at hand.

For the time being, however, we anyhow will need net multipliers to give a more balanced evaluation of the regional and national economic importance of transportation and other economic sectors as such.

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