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NET MULTIPLIERS AVOID EXAGGERATING IMPACTS: WITH A BI-REGIONAL ILLUSTRATION FOR THE DUTCH TRANSPORTATION SECTOR*

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ABSTRACT. Industries often promote their interests by arguing that they have a big impact on the rest of the economy. This poses the question of how to measure the importance of an activity. To answer this, the literature often uses (regional) input-output analysis. This paper critically reviews the traditional use of multipliers in such cases. To avoid double-counting impacts and to solve related conceptual problems, the net multiplier concept is introduced. This net multiplier is illustrated empirically for the Dutch transport sector using a Type II biregional input-output model for the Netherlands.

1. INTRODUCTION

Arguments for state aid and state intervention in favor 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 when decisions about large infrastructure projects have to be taken, especially in small open economies. In the Netherlands, both lines of reasoning are combined and used by special interest groups to 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. In addition, 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. Generally, the arguments are not based primarily 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 (cf. Oosterhaven, Eding, and Stelder, 2001).

To substantiate such claims consultants and academics traditionally multiply direct employment or some other kind of size indicator by a sector- or project-specific employment or value-added multiplier. The result is presented as an estimate of the total impact, direct plus indirect plus induced plus

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whatever other impacts one can think of—in the case of plant closedowns, see Cole (1988) discussed in Jackson, Madden, and Bowman (1997), and Oosterhaven (2000). The main problem with this traditional approach is the claim that each and every sector is economically more important than its own share in total employment or value added indicates. Naturally, this cannot be true. When the claims of all sectors in an economy are added an (implicit) estimate of the total size of the economy will result that is many times larger than its actual size.

In Section 2 we discuss the theoretical delusion that is responsible for this outcome in more detail. Section 3 presents a new concept, the *net multiplier*. When this net multiplier is applied to all sectors, the estimated total of all impacts will aggregate to the correct size of the whole economy. In Section 4, we illustrate the working of this net multiplier empirically for the Dutch transportation sector using the recent Dutch bi-regional input-output tables. Finally, Section 5 summarizes the theoretical and empirical results, and extrapolates the discussion from the present sectoral framework into the issue of the importance of investments in transport infrastructure.

2. THE SIN OF EXAGGERATING SECTORAL IMPACTS

The direct economic importance of a certain sector can, seemingly easily, be measured by some kind of size indicator, preferably by its direct contribution to the gross regional or gross national product (GRP or GNP), or else by its direct contribution to total regional or national employment. However, even this simple way of measuring the direct impact is not without problems, as will become clear.

The line of reasoning and the calculation of the indirect economic importance of a sector usually begins with the making of an inventory of its relations with other actors in the economy. It is important 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. The difference is that the first concept is causally neutral, whereas the second implies causality. 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.

A sector may have large backward and forward linkages, but that does not tell us whether that sector is (passively) receiving impulses from other sectors or (actively) sending impulses to other sectors. 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 for example, Schultz, 1977). To be labeled a key sector, a second criterion has to be satisfied. The sector at hand, besides (1) having large linkages to pass on growth impulses, also needs (2) to generate these growth impulses itself. Thus, the growth in this sector needs to be considered as (largely) exogenous from the rest of the economy (see Beyers, 1976, and Oosterhaven, 1981, chapter 5, for further discussion).

If we look at the standard Leontief model, final demand for sectoral outputs **f** is exogenous, and the causality of the model runs as follows. Any change in final as well as 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 **A x** as well as the endogenous demand for primary inputs, such as value added and imports. The model solution for total value added v is the following

$$v = \mathbf{v}_c' \, \mathbf{x} = \mathbf{v}_c' \, (\mathbf{I} - \mathbf{A})^{-1} \, \mathbf{f} = \mathbf{v}_c' \, \mathbf{L} \, \mathbf{f} \tag{1}$$

where $\mathbf{v}_c'$ represents a row with value-added coefficients, **A** the matrix with intermediate input coefficients, and **L** the Leontief-inverse (see Oosterhaven, 1981, chapter 2, or Miller and Blair, 1985, chapter 2, for details).

From Equation (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**. Multiplying by **x** unavoidably leads to the overestimation of the importance of the sector at hand. The reason is that Equation (1) assumes that the intermediate part of total output (**A x**) is endogenously determined by the size of (mainly the other sectors') total output. Multiplying the total of **x** by the value-added multipliers $\mathbf{v}_c' \, \mathbf{L}$ results in double counting of the endogenous part ($\mathbf{x} - \mathbf{f}$). When calculating the importance of Schiphol airport for Dutch national employment, for instance, BCI/NEI (1997, Table 5.1) forget that part of the backward-employment effect actually occurs within the aviation industry that was already included in the direct (platform-tied) employment at Schiphol that was assumed exogenous, but is not, at least not entirely. As a consequence, that part of backward employment is double counted.

Problems are compounded when ad hoc estimates of causal forward effects are added to the so-called direct effect, the total of which is then multiplied with standard employment or value-added multipliers in order to estimate the so-called backward effects of a certain industrial complex of project. This procedure leads to triple counting of effects. In addition to the double counting of part of the direct effect with part of the backward effects, adding ad hoc forward effects 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, for instance, Knight Wendling (1992) 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 overestimation and double counting is simple: multipliers are used outside the context of the model from which they are derived. However, the simple remedy "don't do it", is too naive. Practitioners will continue to need simple devices like multipliers, which they will want to simply multiply by total direct employment or value added.

3. THE REMEDY: USE NET MULTIPLIERS

So, the standard input-output multipliers may only be multiplied with (exogenous) final demand. When they are multiplied with total sectoral value added or employment, they actually operate as 'gross multipliers' because this misuse will result in over estimating the economic importance of the sector at hand. Therefore, we will use the new label *net multiplier* to indicate any multiplier that may rightfully be multiplied with total sectoral output, value added, or employment without resulting in an over estimation of that sector's economic importance.

More precisely, in the case of total sectoral output, we define the Type I net total output multipliers as $\mathbf{i}' (\mathbf{I} - \mathbf{A})^{-1} <\mathbf{f}_c>$, with $\mathbf{i}' (\mathbf{I} - \mathbf{A})^{-1}$ being the standard total output multipliers and $<\mathbf{f}_c>$ a diagonal matrix with the fractions of total sectoral output that may rightfully be considered exogenous, that is, f_j / x_j.

In the case of value-added and employment multipliers, the corresponding net multipliers need to be multiplied by total sectoral value added or employment, and not by total output. This means that the gross value-added and gross employment multipliers first need to be standardized (cf. Oosterhaven, 1981, chapter 4; Miller and Blair, 1985, chapter 4) before the corresponding net multiplier can be formulated. This leads to the following definition of the Type I net value-added multipliers

$$\mu_{\mathbf{I}}' = \mathbf{v}_c' (\mathbf{I} - \mathbf{A})^{-1} <\mathbf{v}_c>^{-1} <\mathbf{f}_c> \tag{2}$$

In Equation (2) $<\mathbf{f}_c>$ is again the diagonal matrix with the sectoral final output ratios (of Type I) that secures the net character of the multipliers, whereas $<\mathbf{v}_c>^{-1}$ represents the diagonal inverse of the sectoral value-added ratios that secures the standardization with respect to sectoral value added.

When the standard Leontief model is extended with endogenous household consumption expenditures (cf. Oosterhaven, 1981, chapter 6, or Batey, 1985), the *Type II net value-added multipliers* are defined as

$$\mu_{\mathbf{II}}' = \mathbf{v}_c' (\mathbf{I} - \mathbf{A} - \mathbf{Q})^{-1} <\mathbf{v}_c>^{-1} <\mathbf{f}_c^*> \tag{3}$$

In Equation (3) q_{ij} from $\mathbf{Q}$ indicates the endogenous consumption expenditures on products from sector i paid for from incomes earned in sector j per unit of output in sector j, and $<\mathbf{f}_c^*>$ now represents what may be called the Type II final output ratios, which are derived from $\mathbf{f}^* = \mathbf{f} - \mathbf{Qx}$.[1] Consumption is now also endogenous, so only $\mathbf{f} - \mathbf{Qx}$ remains as exogenous final demand.

Type I and Type II net employment multipliers are defined analogously by replacing, in Equation (2) and (3), $\mathbf{v}_c$ with $\mathbf{e}_c$, containing the sectoral employment-output ratios.

[1]The 14 Dutch biregional input-output tables have columns of consumption expenditures differentiated per region (Eding et al., 1999). These are used for constructing the $\mathbf{Q}$ matrix for labor incomes in the empirical section (see Oosterhaven, 1981, chapter 6, for the interregional generalization).

If we denote the extended Leontief inverse $(\mathbf{I} - \mathbf{A} - \mathbf{Q})^{-1}$ in Equation (3) with $\mathbf{L}^*$, standard input-output analysis tells us that the usual Type II multipliers based on $\mathbf{L}^*$ are larger than the usual Type I multipliers based on $\mathbf{L}$ (provided of course that $\mathbf{Q} > \mathbf{0}$). However, in the case of the net multipliers, no such systematic relation can be found. This follows from the following property.

THEOREM 1: *The output-weighted average of all sectoral net multipliers equals unity*

Proof. With $x = \mathbf{i}' \mathbf{x}$, the economy-wide total output, which equals total input, this follows for the Type I net value-added multipliers from

$$\mu_{\mathbf{I}}' (\mathbf{x}\, x^{-1}) = \mathbf{v}_c' \,\mathbf{L} <\mathbf{v}_c>^{-1} <\mathbf{f}_c> \mathbf{x}\, x^{-1} = \mathbf{v}_c' \,\mathbf{L} <\mathbf{f}> <\mathbf{v}>^{-1} \mathbf{x}\, x^{-1} = \mathbf{v}' <\mathbf{v}>^{-1} \mathbf{x}\, x^{-1} = 1$$

The proof for the Type II net multipliers $\mu_{\mathbf{II}}'$ is analogous with $\mathbf{L}$ and $\mathbf{f}$ being replaced by $\mathbf{L}^*$ and $\mathbf{f}^*$. The proofs for the net employment multipliers is analogous with $\mathbf{e}_c$ instead of $\mathbf{v}_c$. The proof for the net total output multipliers is also analogous but without the $\mathbf{v}_c$ matrices and vectors. Q.E.D.

The theorem above is the reason for developing the concept of the net multiplier. As a consequence, the net multipliers avoid the double counting of impacts, as follows from the next property.

THEOREM 2: *When each sectoral net multiplier is multiplied by its appropriate sectoral total and then summed over all sectors, the total for the whole economy will result*

Proof. For the Type II net value added multipliers this follows from

$$\mu_{\mathbf{II}}' \,\mathbf{v} = \mathbf{v}_c' \,\mathbf{L}^* <\mathbf{v}_c>^{-1} <\mathbf{f}_c^*> \mathbf{v} = \mathbf{v}_c' \,\mathbf{L}^* <\mathbf{f}^{ex}> <\mathbf{v}>^{-1} \mathbf{v} = \mathbf{v}' <\mathbf{v}>^{-1} \mathbf{v} = \mathbf{v}' \,\mathbf{i} = v$$

Again, the proof for the other net multipliers is analogous. Q.E.D.

From Theorems 1 and 2 it follows that sectors with net multipliers smaller than unity will be more dependent on other sectors than those other sectors are dependent upon them. The most extreme case being sectors that have a net multiplier equal to zero. Given the above, the interpretation of this extreme case is simple and precisely signifies why the concept of the net multiplier was developed. Such sectors have an (exogenous) final output equal to zero, which signifies that they are not able to generate exogenous growth impulses themselves. This does not imply that these sectors are not important, but rather that their growth is entirely dependent upon the impulses they receive from and through other sectors.[2]

[2]One of the referees correctly pointed out that an exogenous final demand impulse will increase the final output ratio of the sector at hand (f_j/x_j) and thus its net multiplier. Moreover, the indirectly increased output in all (other) sectors will result in decreases of their final output ratios and their net multipliers. However, in the new equilibrium both theorems will still hold. The fact that in equilibrium (most probably) the net multiplier of the primarily affected sector will increase and all others will decrease is precisely what the net multiplier concept intends to pick up. The fact that the standard multipliers do not change again indicates that they are not the proper tool to use

4 AN APPLICATION TO DUTCH TRANSPORTATION

Before illustrating the net multiplier concept empirically, the traditional way of 'proving' the importance of a certain sector is illustrated. This is done for the Dutch transportation sector using the recent bi-regional input-output table for the North and the Rest of the Netherlands (derived from RUG/CBS, 1999, see also Eding et al. 1999). Using bi-regional input-output data enables the analyst to present the regional as well as the national economic importance of a certain sector within one consistent modeling framework. The two regions used relate to the total of the three northern provinces (the North), and the total of all twelve Dutch provinces (the Nation).

The following subdivision of the transportation sector is used (1) public passenger transport, (2) road freight transportation, (3) air, sea and inland shipping, and (4) other transport services (travel agencies and auxiliary freight services).

The first row of Table 1 first shows the employment share of total transportation in the North to be 4.2 percent, with road freight transportation being the largest subsector. The share for the Netherlands as a whole is larger at 5.2 percent. The difference is caused by the larger share of commercial transportation, which is related to the international transhipment function of the two 'mainports' in the western part of the country. On the other hand, public passenger transport is relatively more important in the less densely populated North. Per subsector, the value added and the employment shares are comparable, except for the capital-intensive air and water transportation where the value added share is far larger, and the more labor-intensive other transportation where the employment share is much larger. In fact, in terms of employment, northern air and water transportation is the same size as other transportation but in terms of value added it contributes more than twice as much to the regional economy.

The middle part of Table 1 gives the standard Type II multipliers for employment and value added. In the case of the North these multipliers are calculated by means of a Type II biregional input-output model, which is based on the recent set of rectangular Dutch biregional make and use tables (see Eding et al. 1999). The biregional nature of the model means that the national impact of the northern transportation sector can be decomposed into an intraregional northern part and a spillover part that for the rest of the country (see Oosterhaven, 1981, chapter 4; Miller and Blair, 1985, chapter 3). 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.[3]

Looking at the multipliers, first note that the employment multipliers of air and water transportation are relatively large, which is caused by their relatively small direct employment coefficients (i.e., the large $<\mathbf{e}_c>^{-1}$ in the multiplier

when measuring the importance of a sector for the regional or national economy, after a final demand impulse.

[3]All input-output calculations in this section are made with the Interregional Input-Output Software (IRIOS) package of the University of Groningen (see www.REGroningen.nl).

TABLE 1: The Traditional View on the Importance of the Transport Sector

	Public Transport		Road Freight Transport		Air/Sea/Inland Shipping		Other Transport Services		Total	
Type of Importance	North	Nation	North	Nation	North	Nation	North	Nation	North	Nation
Direct Employment (%)	1.2	0.8	1.9	2.3	0.5	0.8	0.5	1.3	4.2	5.2
Direct Value Added (%)	1.0	1.2	2.0	1.9	1.3	2.9	0.2	0.6	4.5	6.7
Regional Standard Employment Multiplier	1.54	—	1.51	—	2.29	—	1.22	—		
National Standard Employment Multiplier	1.88	1.70	1.86	1.56	3.36	2.88	1.32	1.72		
Regional Standard Value Added Multiplier	1.48	—	1.49	—	1.41	—	2.00	—		
National Standard Value Added Multiplier	1.76	1.65	1.80	1.68	1.74	1.76	2.52	2.19		
Employment Importance (%)	1.8	1.4	2.9	3.7	1.2	2.3	0.6	2.2	6.6	9.5
Value Added Importance (%)	1.5	2.0	3.1	3.3	1.8	5.1	0.3	1.4	6.7	11.8

formula). Next, note that a comparable explanation holds for the relatively large value-added multipliers of other transportation. However, note that the national employment multipliers for the northern subsectors are larger than those in the rest of country. In the case of air and water transportation this is understandable in view of the smaller value added per worker in the North (compare the upper part of Table 1). In the case of the remaining two northern subsectors (public passenger transport and road freight transport) smaller foreign import leakages partially explain the larger size of the multipliers. For the exception of the smaller northern employment multiplier for the other transportation, the larger cluster linkages within the rest of the Netherlands are the main explanation (see also Oosterhaven, Eding, and Stelder, 2001).

The lower part of Table 1 shows the result of multiplying the upper part of the direct economic importance, by the regional and national multipliers from the middle part. Thus measured, 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 percent of public transportation in the North, which is significantly larger than the corresponding national importance of 1.4 percent. This systematic difference is explained by the interregional spillovers to the rest of the country, which are ignored when the importance of a regional sector for the regional economy is calculated. The systematic differences are particularly large in the case of air and water transportation and other transportation. In both cases, the intraregional multipliers of the northern subsectors are considerably smaller than 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 psychological threshold of 10 percent. Thus, the lobbyist will use that number to claim that at least 12 percent of the Dutch economy is dependent on the transport sector. *At least,* because the above calculations still exclude the forward economic impact of the transport sector on, for instance, the location decisions of international industrial and service activities. The lobbyist will claim that such activities will locate in the Netherlands because of the presence of its "excellent cluster" of international transport and distribution services. This way of thinking is popularized in the public debate by using the phrase "without transportation, everything stands still." However, competing lobbyists, will use the same type of reasoning to underscore the importance of their sectors. Indeed, in our modem age "without energy, everything stands still" too, whereas Marxists rightfully claim that "without the mighty arm of labor" everything stands still. What is omitted from the equation is the fact that dependence is a two-sided phenomenon. Not only are all other sectors dependent upon transport services, but the transportation sector is dependent upon the demand and demand growth of all these other sectors. The way to quantify this two-sided nature of dependence, is to use net multipliers instead of the standard multipliers, as was argued in Section 2.

Table 2 shows the values of these net multipliers in case of the northern and the national Dutch transport sectors. Not surprisingly, the net multipliers of public transport are found to be smaller than 1.00. The reason is that little of the output of public transport goes to exogenous final demand (see $<\mathbf{f}_c^*>$ in the Type II net multiplier formula). The major part of the outputs of public transport goes to household consumption that is mostly endogenous in the Type II input-output model used in the calculations behind Table 2. In fact, only the public transport consumed by the elderly and other economically nonactive parts of the population is exogenous, because the Type II model only deals with endogenous labor incomes. The net employment multipliers of northern other transportation are smaller than 1.00, too, as opposed to the net national multiplier that is exactly equal to 1.00. The reason is that northern other transportation mainly caters to local households and businesses, whereas national other transportation also serves international customers whose demand is exogenous.

TABLE 2: The Alternative, Net View on the Importance of the Transport Sector

	Public Transport		Road Freight Transport		Air/Sea/Inland Shipping		Other Transport Services		Total	
Type of Importance	North	Nation	North	Nation	North	Nation	North	Nation	North	Nation
Regional Net Employment Multiplier	0.74	—	1.36	—	2.02	—	0.76	—		
National Net Employment Multiplier	0.79	0.76	1.57	1.18	2.74	2.25	0.62	1.00		
Regional Net Value Added Multiplier	0.71	—	1.34	—	1.25	—	1.16	—		
National Net Value Added Multiplier	0.74	0.74	1.52	1.28	1.42	1.38	1.18	1.27		
Employment Importance (%)	0.9	0.6	2.6	2.8	1.1	1.8	0.4	1.3	4.9	6.5
Value Added Importance (%)	0.7	0.9	2.8	2.5	1.6	4.0	0.2	0.8	5.3	8.2

These results illustrate two theoretically important conclusions. First, net multipliers are model-specific, as are the corresponding standard multipliers. Second, in contrast to the standard 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.

When the *direct* importance part of Table 1 is multiplied by the *net* multiplier part of Table 2, the lower part of Table 2 results. The basic feature of the lower part of Table 1 remains. The importance of the overall transport sector to the North is much smaller than the importance of the overall transport sector to the nation. In terms of value added the difference was as large as that between 6.7 percent and 11.8 percent in Table 1. Now it is as large as that between 5.3 percent and 8.2 percent.

However, more interesting is the fact that the *weighted average net/ standard correction* for the North is smaller than that for the whole of the Netherlands, both for employment and for value added (see Table 3). A look at Theorem 1 and 2, and the fact that the standard intra-regional multipliers are smaller than the corresponding national multipliers, explains this phenomenon. Being smaller, standard intraregional multipliers exaggerate the (traditional one-sided dependency) measurement of importance less. Hence, they need to be corrected less too. Naturally, at the national level the correction is larger.

5. CONCLUSION: HOW ABOUT INFRASTRUCTURE IMPACTS?

Both the theoretical discussion and the empirical illustration show that claims of economic importance are often misleadingly high. This article introduces the concept of the net multiplier to remedy this systematic upward bias. The most appealing aspects of this new multiplier are that double counting is avoided, and when applied to all sectors the net multipliers add up to the national economy. Another interesting property of the net multiplier is that it can be smaller than unity, 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 the net multiplier concept are the same as the models behind the standard multipliers. This means that they also ignore price-volume interactions. Particularly when the discussion

TABLE 3: Net and Standard Impacts Measures of the Transport Sector Compared

	Employment		Value Added	
(in percentage shares of the economy)	North	Nation	North	Nation
Standard Impact Measure	6.6	9.5	6.7	11.8
Net/Standard Correction (%)	74	68	79	69
Net Multiplier Measure	4.9	6.5	5.3	8.2

centers on the evaluation of new infrastructure proposals, and not on the (backward) importance of sectors as such, input-output models are inadequate even when net multipliers are used. In those cases, spatial computable general equilibrium models are needed (see e.g. Bröcker, 1998; Oosterhaven and Knaap, 2002). Such models need to have an interindustry character in order to capture forward effects, which mostly start with sector-specific transport cost reductions. Besides, they need an interindustry character to capture backward effects, which mostly start with sector-specific transport demand effects. So, input-output data are still needed. 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. So, interregional input-output data are still needed. However, for the time being, we need net multipliers to give a more balanced evaluation of the regional and national economic importance of transportation and other economic sectors.

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