The RAS Structural Decomposition Approach

Erik Dietzenbacher and Rutger Hoekstra*

Erik Dietzenbacher: University of Groningen, Faculty of Economics/SOM Research Institute, P.O. Box 800, NL-9700 AV Groningen, The Netherlands, e-mail: e.dietzenbacher@eco.rug.nl

Rutger Hoekstra: Department of Spatial Economics, Faculty of Economics and Econometrics, Vrije Universiteit Amsterdam, De Boelelaan 1105, NL-1081 HV Amsterdam, The Netherlands, e-mail: rhoekstra@econ.vu.nl

Abstract. This paper uses a structural decomposition to analyze the effects of technological change and trade on the sectoral outputs in the Netherlands. A novel RAS decomposition is implemented, so that the technological change may be split up into its components: average substitution, average intermediate input intensity and cell-specific effects. An ordinary structural decomposition is used to examine the trade effects as present in the changing final demands. The constant price European interregional tables for 1975 and 1985 that were used for this chapter, allow for analyzing the influence of trade with Germany, France, Italy, Denmark, Belgium, with the other European Union (EU) members, and with non-EU nations. The results show that the change in output is largely due to a shift in the export towards EU countries at the expense of the non-EU nations of the world. The main exception to this trend is the diminishing role of Germany, being the primary trading partner of the Netherlands. When viewing the results at sector level, the technological effects play an important role in explaining the output increases.

Keywords. Structural decomposition, RAS, technological change, European trade

* We would like to thank Jeroen van den Bergh, Alex Hoen, Jan van der Linden, Bart Los and Jan Oosterhaven for their comments, suggestions and help with the data.

1. Introduction

Technology and trade are widely considered to be significant driving forces of economic growth and have been subject to numerous studies. The input-output framework is a useful tool in this respect, because it coherently integrates information on the production technologies of the sectors and on the import and export relations. Input-output tables for different years, therefore may provide insight into how these economic processes have affected the economic structure and growth.

Technological change may be divided into a number of separate components. First, substitution of one intermediate input for another may occur. One might think of the general tendency in the past to replace metals by plastics in many production processes. Another phenomenon that has been widely observed is that less goods are used as intermediate inputs, while the use of services (and service-related products such as office machines) increases. Although it is, in general, not the case that goods are actually replaced by services, also these sort of changes will be referred to as substitution effects. Second, another type of technological improvement that may occur is the substitution of intermediate inputs for primary inputs. A rise in the share of intermediate inputs relative to the primary inputs, implies a productivity increase with respect to the primary inputs because a smaller quantity of primary input is used per unit of output. Due to the ambiguity of the primary inputs in the data we have used,[1] this effect will be referred to as the intermediate input intensity effect, rather than using the term productivity effect. That is, per unit of output more intermediate inputs are used.

Van der Linden and Dietzenbacher (1995, 2000) developed a method for decomposing the change in the input coefficients into these two types of technological

[1] Primary inputs refer to all cost categories, except for intermediate goods and services. Next to payments for labor and capital, they also include indirect taxes minus subsidies, the operating surplus and non-competitive imports. Our data set only allows to distinguish between non-competitive imports and other primary inputs.

changes and an additional cell-specific effect, using the RAS approach. This chapter utilizes this method in the setting of a structural decomposition analysis to assess the influence of technological change on the output of the Netherlands for the period 1975-1985. Its empirical application is characterized by large technological shifts due to the price shocks induced by the oil crises of the mid- and late 1970s.

The Netherlands are a small and very open economy with a longstanding tradition as a trading nation. They have been a member of the European Union (EU) and its predecessor, the EEC, since the foundation in 1958. Together with Belgium, the Netherlands have the largest degree of integration in the EU, in terms of their dependence on imports from and exports to the other member states (see e.g. Dietzenbacher *et al*., 1993, and Dietzenbacher and van der Linden, 1997). It is clear that changes in the exports may crucially affect the Dutch production levels. The structural decomposition analysis above, is therefore also used to examine how the sectoral outputs in the Netherlands have been affected by changes in the final demands, which includes the effects of the changing trade relationships (see Oosterhaven and van der Linden, 1997, and Oosterhaven and Hoen, 1998, for decomposition analyses at the EU level). Factors that are distinguished in this part of the decomposition analysis are the following. Changes in the overall level of the final demands. Changes in the destination of the final demands (or the distribution over the final demand categories), covering for example the substitution of exports to Germany for exports to Belgium. Changes in the composition (or product mix) of the final demands, such as the substitution of energy for food products in the exports to Germany. The way in which each of these three factors affect the outputs is termed the level effect, the category effect, and the product mix effect, respectively.

The availability of input-output tables and detailed trade data enable us to get some insight into the effects of changes in both technology and trading relationships on output growth. The plan of this chapter is as follows. Section 2 introduces structural decomposition analyses. In section 3, the method proposed by Van der Linden and

Dietzenbacher (1995, 2000) is illustrated, while in Section 4 the decomposition of the final demand categories is set out. This chapter uses constant price interregional data which will be discussed in Section 5. In Section 6, the empirical results are presented which are followed by some concluding remarks in Section 7.

2. Structural decomposition analysis

Structural decomposition analysis (SDA) is a comparative static method to assess the structural changes in an economy using input-output data. Based on the idea that the change over time in some variable is decomposed into the changes in its determinants, it is widely used as a tool to quantify the underlying sources of the change. For recent applications see Oosterhaven and van der Linden (1997), Cabrer *et al.* (1998), Cronin and Gold (1998), Oosterhaven and Hoen (1998), Wier (1998), Albala-Bertrand (1999), Alcala *et al.* (1999), Mukhopadyay and Chakraborty (1999), Wier and Hasler (1999), Casler (2000), Dietzenbacher (2000), Dietzenbacher *et al*. (2000), Hitomi *et al*. (2000), Jacobsen (2000), and Milana (2000), while Rose and Casler (1996) give a detailed overview.

In this paper we analyze the changes in the outputs. The standard Leontief model is given by $\mathbf{x} = \mathbf{Ax} + \mathbf{f}$, where $\mathbf{x}$ denotes the vector of sectoral outputs, $\mathbf{A}$ the $n \times n$ matrix of input coefficients and $\mathbf{f}$ the vector of final demands. The input coefficients are obtained from the matrix $\mathbf{Z}$ of intermediate deliveries. They denote the input of good i per unit of output of good j, that is, $a_{ij} = z_{ij} / x_j$ or $\mathbf{A} = \mathbf{Z}\hat{\mathbf{x}}^{-1}$ in matrix notation, where $\hat{\mathbf{x}}$ denotes the diagonal matrix with the outputs on its main diagonal and all other entries equal to zero. The solution for the Leontief model is given by $\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{Lf}$, where $\mathbf{L} \equiv (\mathbf{I} - \mathbf{A})^{-1}$ denotes the Leontief inverse. For the decomposition of the changes in the outputs, several equivalent forms may be used. Examples are:

$$\Delta\mathbf{x} = (\Delta\mathbf{L})\mathbf{f}_1 + \mathbf{L}_0(\Delta\mathbf{f}) \qquad (1)$$

$$\Delta\mathbf{x} = (\Delta\mathbf{L})\mathbf{f}_0 + \mathbf{L}_1(\Delta\mathbf{f}) \qquad (2)$$

$$\Delta\mathbf{x} = (\Delta\mathbf{L})\mathbf{f}_1 + \mathbf{L}_1(\Delta\mathbf{f}) - (\Delta\mathbf{L})(\Delta\mathbf{f}) \qquad (3)$$

$$\Delta\mathbf{x} = (\Delta\mathbf{L})\mathbf{f}_0 + \mathbf{L}_0(\Delta\mathbf{f}) + (\Delta\mathbf{L})(\Delta\mathbf{f}) \qquad (4)$$

Each of the forms (1) and (2) adopts different weights for the changes, while each of the forms (3) and (4) uses the same weights but includes a so-called interaction term. It is clear that the decomposition form is not unique and the number of equivalent forms increases rapidly when the number of determinants exceeds two (as in the present case). Dietzenbacher and Los (1997, 1998) have analyzed the sensitivity across decomposition forms and found that the average of all the forms they considered could be approximated very well by the average of the so-called polar forms. In the present case this means taking the average of the forms (1) and (2) (which equals the average of (3) and (4) only in the two determinant case). This results in the following decomposition formula:

$$\Delta\mathbf{x} = \tfrac{1}{2}(\Delta\mathbf{L})(\mathbf{f}_0 + \mathbf{f}_1) + \tfrac{1}{2}(\mathbf{L}_0 + \mathbf{L}_1)(\Delta\mathbf{f}) \qquad (5)$$

The first term on the right hand side gives the changes in the outputs if the input coefficients had changed (implying a change $\Delta\mathbf{L}$ in the Leontief inverse) while the final demands had been unchanged. In the same way, the second term reflects the contribution of changes in the final demands by measuring what the output changes would have been if final demands had changed while technology (reflected by the input matrix **A**) had remained constant.

As was indicated in the introduction, the aim of this paper is twofold. First, to analyze how the changes in the input matrix **A** have affected the outputs (the methodology for which is explained in Section 3). Second, to get some insight in the importance of export relations and the changes therein for a small, open economy like the Netherlands (see Section 4 for the methodological aspects).

3. Applying the RAS technique

The decomposition form in (5) will be further developed into a nested form. That is, in this section the first term will be further decomposed into the underlying sources of the changes in the input coefficients. Note that $\Delta\mathbf{L} = \mathbf{L}_0(\Delta\mathbf{A})\mathbf{L}_1 = \mathbf{L}_1(\Delta\mathbf{A})\mathbf{L}_0$ and thus

$$\Delta\mathbf{L} = \tfrac{1}{2}\mathbf{L}_0(\Delta\mathbf{A})\mathbf{L}_1 + \tfrac{1}{2}\mathbf{L}_1(\Delta\mathbf{A})\mathbf{L}_0 \quad (6)$$

Next the changes $\Delta\mathbf{A}$ in the input coefficients are further decomposed. For this purpose we follow the approach developed in Van der Linden and Dietzenbacher (1995, 2000). Changes in the input coefficients are decomposed into column-specific changes indicating the change in a sector's intermediate input intensity (or productivity as discussed in the introduction), row-specific changes reflecting the average substitution of intermediate inputs between sectors, and cell-specific changes (i.e. the changes that are not explained by the row and column changes).

Column-specific changes imply that the entire column in $\mathbf{A}_0$ for sector *j* is multiplied by s_j. It is thus assumed that structural changes of this type leave the mix of intermediate inputs unaffected. Due to a process innovation or economies of scale, for example, a unit of output is now produced using the same percentage less of each intermediate input.

It is clear that at the aggregation level of most datasets (including our own), many different forms of structural changes take place simultaneously within a single sector *j*. The multipliers s_j should therefore be viewed as reflecting average column-specific effects. Yet, it may not be expected that such multipliers can provide an adequate description of all the structural changes that have occurred.

Due to the row-specific changes, the entire row *i* in $\mathbf{A}_0$ is multiplied by r_i. For example, a product innovation may imply that each sector uses the same percentage less of intermediate input *i*. In the same way, some other input may be used more in each sector. Again, the effects described by the multipliers r_i are average substitution effects and it is not to be expected that all types of substitution follow such a simple pattern. All changes that are not captured by the uniform row and column multiplications are accounted for by the cell-specific changes, as we will see shortly.

Since the changes in the intermediate input intensities and the average substitution effects occur simultaneously, the matrix $\mathbf{A}_0$ is affected as follows.

$$\tilde{a}_{ij}^1 = r_i a_{ij}^0 s_j \qquad \text{or} \qquad \tilde{\mathbf{A}}_1 = \hat{\mathbf{r}}\mathbf{A}_0\hat{\mathbf{s}} \tag{7}$$

where $\hat{\mathbf{r}}$ and $\hat{\mathbf{s}}$ are the diagonal matrices with the multipliers r_i and s_j.

As mentioned before, it may not be expected that the column-specific and the row-specific changes alone are able to provide a full description of all the changes that have taken place. In other words, $\mathbf{A}_1$ will differ from $\tilde{\mathbf{A}}_1$. These differences are the cell-specific changes that cannot be captured by column-specific and row-specific changes alone. Hence the cell-specific changes are defined as

$$\varepsilon_{ij} = a_{ij}^1 - \tilde{a}_{ij}^1 = a_{ij}^1 - r_i a_{ij}^0 s_j \qquad \text{or} \qquad \boldsymbol{\varepsilon} = \mathbf{A}_1 - \tilde{\mathbf{A}}_1 = \mathbf{A}_1 - \hat{\mathbf{r}}\mathbf{A}_0\hat{\mathbf{s}} \tag{8}$$

Next we have to find the multipliers r_i and s_j. Since both the column-specific and the row-specific changes are average effects, it is required that they yield the correct result on average. That is, it is required that the matrix of intermediate deliveries corresponding to $\tilde{\mathbf{A}}_1$ (i.e. $\tilde{\mathbf{A}}_1\hat{\mathbf{x}}_1$) has the correct column and row sums. Let $\mathbf{e}$ denote the n-element summation vector, i.e. $\mathbf{e}'$ = (1,…,1) where a prime is used to indicate transposition. The correct row sums are given by $\mathbf{Z}_1\mathbf{e} = \mathbf{A}_1\mathbf{x}_1 \equiv \mathbf{u}_1$ and the correct column sums by $\mathbf{e}'\mathbf{Z}_1 = \mathbf{e}'\mathbf{A}_1\hat{\mathbf{x}}_1 \equiv \mathbf{v}_1'$. The requirements to be fulfilled by the multipliers r_i and s_j are then as follows.

$$\tilde{\mathbf{A}}_1\mathbf{x}_1 = \hat{\mathbf{r}}\mathbf{A}_0\hat{\mathbf{s}}\mathbf{x}_1 = \mathbf{u}_1 \qquad \text{and} \qquad \mathbf{e}'\tilde{\mathbf{A}}_1\hat{\mathbf{x}}_1 = \mathbf{e}'\hat{\mathbf{r}}\mathbf{A}_0\hat{\mathbf{s}}\hat{\mathbf{x}}_1 = \mathbf{v}_1' \tag{9}$$

The problem of finding the multipliers r_i and s_j under the restrictions in (9) may be solved iteratively by the well-known RAS method as developed in Stone (1961). This method was developed for updating matrices of intermediate deliveries (or input matrices) given their row and column totals. A detailed description is given in Miller and Blair (1985), while more technical aspects are dealt with in Bacharach (1970) and MacGill (1977). It should be mentioned that the economic background of the RAS technique, i.e. interpreting the column multipliers as intermediate input intensity effects and the row multipliers as substitution effects, has been criticized in e.g. Lecomber (1975) and Miernyk (1977). Also the performance of the RAS method for purposes of updating has been questioned, e.g. by Allen and Gossling (1975) and Lynch (1986). Van der Linden and Dietzenbacher (2000), however, refute this critique by arguing that the row-specific and the column-specific multipliers should not be considered as the sole determinants of the changes. Once the cell-specific changes are taken into account, the RAS method may well be used for descriptive purposes. The results then indicate how much of the actual changes that have taken place can be explained from (column-specific) changes in intermediate intensities and (row-specific) average substitution effects alone. For other recent contributions see Golan *et al*. (1994), de Mesnard (1994, 1997), Polenske (1997), Dietzenbacher and Hoen (1998), Toh (1998), Gilchrist and St. Louis (1999), Andréosso-O'Callaghan and Yue (2000), and Jalili (2000).

Finally, it should be noted that the solution of (9) is not unique. That is, if the multipliers r_i and s_j satisfy (9), also the multipliers λr_i and s_j / λ do, for any arbitrary value λ. To overcome this problem the results are scaled such that the sum of all average substitution effects r_i is zero. In other words, the total use of intermediate inputs is the same with substitution as it would have been without substitution. This yields

$$(\mathbf{r}'\mathbf{A}_0\hat{\mathbf{s}}\mathbf{x}_1)/(\mathbf{e}'\mathbf{A}_0\hat{\mathbf{s}}\mathbf{x}_1) = 1 \quad (10)$$

From (8) we may now write $\Delta\mathbf{A} = \hat{\mathbf{r}}\mathbf{A}_0\hat{\mathbf{s}} + \boldsymbol{\varepsilon} - \mathbf{A}_0$. Using the same averaging procedure that led to (5), we may now decompose $\Delta\mathbf{A}$. Note that $\mathbf{A}_0$ may be written as $\hat{\mathbf{r}}_0\mathbf{A}_0\hat{\mathbf{s}}_0$ with $\hat{\mathbf{r}}_0 = \hat{\mathbf{s}}_0 = \mathbf{I}$. This yields

$$\Delta\mathbf{A} = \tfrac{1}{2}(\hat{\mathbf{r}} - \mathbf{I})\mathbf{A}_0(\hat{\mathbf{s}} + \mathbf{I}) + \tfrac{1}{2}(\hat{\mathbf{r}} + \mathbf{I})\mathbf{A}_0(\hat{\mathbf{s}} - \mathbf{I}) + \boldsymbol{\varepsilon} \quad (11)$$

Substituting (11) into (6), and substituting the resulting expression for $\Delta\mathbf{L}$ into (5) implies that its term $\tfrac{1}{2}(\Delta\mathbf{L})(\mathbf{f}_0 + \mathbf{f}_1)$ can be decomposed into the following three terms.

$$\tfrac{1}{8}[\mathbf{L}_0(\hat{\mathbf{r}} - \mathbf{I})\mathbf{A}_0(\hat{\mathbf{s}} + \mathbf{I})\mathbf{L}_1 + \mathbf{L}_1(\hat{\mathbf{r}} - \mathbf{I})\mathbf{A}_0(\hat{\mathbf{s}} + \mathbf{I})\mathbf{L}_0](\mathbf{f}_0 + \mathbf{f}_1) \quad (12a)$$

$$\tfrac{1}{8}[\mathbf{L}_0(\hat{\mathbf{r}} + \mathbf{I})\mathbf{A}_0(\hat{\mathbf{s}} - \mathbf{I})\mathbf{L}_1 + \mathbf{L}_1(\hat{\mathbf{r}} + \mathbf{I})\mathbf{A}_0(\hat{\mathbf{s}} - \mathbf{I})\mathbf{L}_0](\mathbf{f}_0 + \mathbf{f}_1) \quad (12b)$$

$$\tfrac{1}{4}[\mathbf{L}_0\boldsymbol{\varepsilon}\mathbf{L}_1 + \mathbf{L}_1\boldsymbol{\varepsilon}\mathbf{L}_0](\mathbf{f}_0 + \mathbf{f}_1) \quad (12c)$$

Equation (12a) gives the changes in the outputs due to the changes in the intermediate input intensities (i.e. column-specific changes). Expression (12b) describes the consequences of the average substitution effects (i.e. row-specific changes), and equation (12c) indicates the effects due to cell-specific changes.

4. Decomposing the final demands

In this section we further decompose the second term in equation (5). We distinguish between changes in the level of final demands, changes in the categorical distribution and changes in the product mix of final demands (see also Lin and Polenske, 1995). The level of final demands is given by the scalar g which measures the total amount of all expenditures for final demands. The empirical application in Section 6 is based on an input-output table that records 24 sectors and that allows to distinguish the following nine final demand categories. Exports to Germany, Belgium, France, Italy and Denmark, exports to other members of European Union, exports to the rest of the world, consumption by households, and other final demands. The categorical distribution is given by the vector $\mathbf{d}$ and its element d_k denotes the part of the total final demand expenditures that is spent by category k (=1,…,9), with $\Sigma_k d_k = 1$. The product mix within the final demand categories is given by the 24×9 bridge matrix $\mathbf{B}$. Its element b_{ik} gives the part of the final demands in category k that is spent on products of sector i. Note that the column sums of the bridge matrix add to one. The final demand vector $\mathbf{f}$ can now be written as $g\mathbf{Bd}$. Note that the separate final demand categories can be singled out by using $g\mathbf{B}\hat{\mathbf{d}}$ instead, in which case the final demand vector is obtained as $\mathbf{f} = g\mathbf{B}\hat{\mathbf{d}}\mathbf{e}$. Following Dietzenbacher and Los (1998) the two polar decompositions of $\Delta\mathbf{f}$ are as follows

$$\Delta\mathbf{f} = (\Delta g)\mathbf{B}_0\hat{\mathbf{d}}_0\mathbf{e} + g_1(\Delta\mathbf{B})\hat{\mathbf{d}}_0\mathbf{e} + g_1\mathbf{B}_1(\Delta\hat{\mathbf{d}})\mathbf{e}$$

$$\Delta\mathbf{f} = (\Delta g)\mathbf{B}_1\hat{\mathbf{d}}_1\mathbf{e} + g_0(\Delta\mathbf{B})\hat{\mathbf{d}}_1\mathbf{e} + g_0\mathbf{B}_0(\Delta\hat{\mathbf{d}})\mathbf{e}$$

Substituting the average of these two expressions into equation (5) implies that its second term $\frac{1}{2}(\mathbf{L}_0 + \mathbf{L}_1)(\Delta\mathbf{f})$ can be decomposed further into the following three components.

$$\tfrac{1}{4}(\mathbf{L}_0 + \mathbf{L}_1)(\Delta g)(\mathbf{B}_0\hat{\mathbf{d}}_0 + \mathbf{B}_1\hat{\mathbf{d}}_1)\mathbf{e} \tag{13a}$$

$$\tfrac{1}{4}(\mathbf{L}_0 + \mathbf{L}_1)[g_1(\Delta\mathbf{B})\hat{\mathbf{d}}_0 + g_0(\Delta\mathbf{B})\hat{\mathbf{d}}_1]\mathbf{e} \tag{13b}$$

$$\tfrac{1}{4}(\mathbf{L}_0 + \mathbf{L}_1)(g_1\mathbf{B}_1 + g_0\mathbf{B}_0)(\Delta\hat{\mathbf{d}})\mathbf{e} \tag{13c}$$

Equation (13a) gives the level effect, i.e. the change in the outputs due to the change in the level of the final demands. The category effect in expression (13b) shows how changes in the categorical distribution of the final demands affect the outputs. The product mix effect in equation (13c) indicates the effects of changes in the product mix of the final demands on the outputs.

It should be mentioned that the RAS method could have been applied also for the decomposition of the final demands. In that case, let **F** denote the 24×9 final demand matrix, with **f** = **Fe**. The RAS technique then yields $\tilde{\mathbf{F}}_1 = \hat{\boldsymbol{\rho}}\mathbf{F}_0\hat{\boldsymbol{\sigma}}$. The row-specific multiplier ρ_i again reflects the average substitution between products and the column-specific multiplier σ_j covers the category effect, assuming that the product mix within this category remains constant. Cell-specific changes are obtained from $\mathbf{F}_1 = \tilde{\mathbf{F}}_1 + \boldsymbol{\delta}$ and $\Delta\mathbf{f}$ in (5) is given by $\hat{\boldsymbol{\rho}}\mathbf{F}_0\boldsymbol{\sigma} + \boldsymbol{\delta}\mathbf{e} - \mathbf{F}_0\mathbf{e}$. The typical constraints in (9) are for the present case given by $\hat{\boldsymbol{\rho}}\mathbf{F}_0\boldsymbol{\sigma} = \mathbf{F}_1\mathbf{e}$ and $\boldsymbol{\rho}'\mathbf{F}_0\hat{\boldsymbol{\sigma}} = \mathbf{e}'\mathbf{F}_1$, respectively. The scaling similar to (10) yields $(\boldsymbol{\rho}'\mathbf{F}_0\boldsymbol{\sigma})/(\mathbf{e}'\mathbf{F}_0\boldsymbol{\sigma})$ = 1.

The reason we have not adopted the RAS approach in decomposing the final demands, is that the assumption underlying the interpretation of the row-specific multipliers ρ_i is questionable. It means that (on average) each category changes the use of good *i* by the same percentage. In other words, this change is assumed to hold for consumption by Dutch households, for exports to each destination,[2] and for other purposes (including government consumption, domestic investments and inventory stock changes). Given the large diversity of these categories, we feel that assuming a uniform change in the entire row of **F** is much less plausible than it is for the input matrix **A**. It is unlikely that Dutch consumers, investors, the government and importers in each of the distinguished destinations, all have a similar pattern of average substitution between products.

5. Description of the data

The empirical application in the next section is a decomposition of output growth in the Netherlands between 1975 and 1985. Since we want to focus on two aspects, *viz*. a further breakdown of the changes in the input coefficients and the effects of a changing trade pattern, the data need to satisfy certain criteria. For the decomposition of the input matrix it is required that the data are in constant prices because otherwise changes in input coefficients reflect price changes as well as technical changes. To analyze the effects of changes in the trade pattern it is important to have sufficiently detailed information on the exports. To this end we have adapted the intercountry input-output tables for the European Union (EU).

[2] Note that exports are used for various purposes, such as foreign consumption, investments and as intermediate inputs in foreign production processes.

These intercountry input-output tables have been constructed at the University of Groningen on the basis of the Eurostat harmonized national input-output tables (see Eurostat, 1979) and harmonized international trade data (Eurostat, 1990). Details on the construction are given in van der Linden and Oosterhaven (1995), van der Linden (1998) and Hoen (1999). We have used the tables for 1985 and for 1975 in constant prices (in ECUs) of 1985. The tables give all trade flows within and between six members of the European Union (The Netherlands, Germany, France, Belgium, Italy and Denmark) for a 25-sector classification scheme (see Appendix A). Final demands consist of “household consumption”, “government consumption”, “capital stock formation”, “inventory stock changes”, “exports to non-included EU members” and “exports to other countries”.

In this analysis we will only be focussing on the Netherlands and we therefore have to adapt the data accordingly. The matrix **Z** gives the domestic intermediate deliveries (i.e. within the Netherlands). The final demands consist of domestic household consumption, exports to each of the five included EU members (covering the deliveries to production sectors and to final demand categories), total exports to non-included EU members, total exports to other countries, and other domestic final demands (i.e. government consumption, capital stock formation and inventory stock changes in the Netherlands). The above setup is also known as the input-output table *without* imports (see Konijn, 1994). By constructing the data in this way we are in fact assuming that all imports are non-competitive, i.e. that the imported goods have been produced in a different way than the domestic goods.

As a check of the results we also ran the decomposition using the input-output table *with* imports. In this case, all imports are assumed to be competitive and are added to the intermediate input matrix **Z**. To keep the table balanced the imports have to be subtracted from the final demand and we therefore get *net* exports (export minus imports) for all the trading partners specified. The results of the decomposition for this so-called competitive imports case are given in Appendix B.

Due to data problems we had to aggregate the sectors 8 (“office and data processing machines”) and 9 (“electrical goods”) into a single sector for the calculations in the text. The calculations displayed in Appendix B for the competitive imports case did not require this additional aggregation.

A remarkable entry in the data, is the negative diagonal element (-3057) in the matrix of intermediate deliveries for the Netherlands in 1985, for sector 17 (“recovery, repair services, wholesale and retail trade”). Negative elements do occur sporadically in the final demand categories of the official input-output statistics, in which case they are attributable to the accounting of (transport or trade) margins. Also the row of indirect taxes minus subsidies in input-output tables occasionally records negative entries when sectors are highly subsidized. Inclusion of negative elements in the intermediate deliveries, however, is economically nonsense because it implies that a negative amount of an input is required in the production technology of the sector. To overcome this problem, we have compared the column elements of the sector in question to those in other countries. It turned out that the production technology (excluding the negative diagonal element) used in the Netherlands was very similar to that of Denmark and France. An estimate of the Dutch diagonal element (1300) was then obtained on the basis of the French and Danish technologies in 1985 and was inserted into the Dutch table. Although no adaptation would be entirely satisfactory, it should be noted that adjustments of this figure influence the outcomes only marginally, as was indicated by a sensitivity analysis. It is obvious that, as a consequence of this adaptation, any specific result for this sector should be interpreted only with great care.

6. Empirical results

The implementation of the decomposition described in Sections 3 and 4, was applied to the Dutch part of the intercountry input-output tables for the EU for the period 1975-1985. Table 1 provides an overview of the final demand categories in both years. The first two columns give the absolute amounts of the exports of Dutch goods and services to each of the other five member countries, to the rest of the EU, and to the rest of the world (ROW), and the Dutch expenditures for household consumption and for other final demand purposes (government consumption, domestic capital stock formation and inventory stock changes). In order to get an impression of the Dutch trade relationships, the last four columns give the corresponding import figures.

INSERT TABLE 1

The table clearly shows the Dutch economy's dependence on exports (particularly with Germany) which comprise over 40% of the total final demand in both years. The single most important final demand category in Table 1, however, is the delivery of products to consumers, which accounts for over a third of the total. Taking a closer look at the exports over the 1975-1985 period, we note two opposite shifts. First, the share of exports going to other EU countries has substantially increased, which is consistent with the increasing economic integration in this period. The second change is the decreasing importance of Germany and of the ROW as destinations for the exports. Despite the fact that in absolute terms the exports remain approximately constant, their share in the total has diminished significantly. Another remarkable feature in Table 1 is the regional spread of the imports. Whereas the ROW plays a relatively modest role as far as Dutch exports are concerned, it is by far the most important origin of Dutch imports (almost 60%). Also note that, in contrast to the export figures, the import shares are remarkably stable over time. The table shows that the Netherlands have had very large trade surpluses with all European trading partners (amounting to 29117 in 1975 and 45068 in 1985), but run a trade deficit with the rest of the world (2994 and 13020, respectively).

The results of the decomposition of technical changes using the RAS technique are presented together with the total effect of final demand changes in Table 2. The total technology effects and the total final demand effects are obtained by applying equation (5). The further decomposition of the total technology effects follows equations (12). That is, the substitution effects are given in equation (12b), the intermediate input intensity effects in (12a), and the effects of cell-specific changes in (12c). The percentages in brackets are the shares of the effects relative to the row total. Note that a positive (negative) percentage indicates that the corresponding effect has the same (respectively the opposite) sign as the total output change, be it an increase or decrease. The complete sector classification is given in Appendix A.

INSERT TABLE 2

The results in Table 2 show that, consistent with most SDA literature, the total final demand effects (79%) are far greater than the total influence of changes in the technology (21%). Nevertheless, the influence of changes in technology is still quite sizeable when compared to SDA literature over similar time periods. Note that 82% of all output changes due to the technology effects, takes place in the services sectors (17-25).

Looking at the column totals, the overall substitution effect is negligible, as might have been expected. Due to the scaling in equation (10), the average input coefficient is not affected by substitution. As a consequence, it is likely that the corresponding effect on total output is negligible. Also the total effect of the cell-specific changes is extremely small, which even holds for almost all sectors separately. This implies that the decomposition of input coefficient changes, into row-specific substitution effects and column-specific intermediate input intensity effects, provides a most adequate description of the actual changes. This reinforces the conclusion in Van der Linden and Dietzenbacher (1995, 2000) that the RAS method may be a useful tool for descriptive purposes.

The changes in the intermediate input intensities have led to a considerable increase of the total output. At the overall macro level, it appears that the use of domestic intermediate deliveries per unit of output has increased by 15% from 0.307 in 1975 to 0.353 in 1985. A quick calculation in which the economy is assumed to be made up of only a single sector, yields an increase in the (scalar) Leontief inverse $(1/1-a)$ from 1.443 in 1975 to 1.546 in 1985. Multiplying the difference by the average of the total final demands (which are 167316 in 1975 and 214197 in 1985) gives an output increase due to the intermediate input intensity change of 19570, which is extremely close to the result in Table 2. In answering the question what has caused this change in the intermediate input intensity, it turns out that the gross value added per unit of output fell by 9% from 0.517 in 1975 to 0.472 in 1985. This implies that the imports per unit of output have been more or less constant (i.e. 0.176 and 0.175, respectively). So, at least at the overall level, it is not the case that the intermediate input intensity has increased because domestic intermediate goods have been substituted for imported intermediate goods.

At the sectoral level, the picture is much more varied of course. The substitution effects can easily be traced back to the row-specific multipliers r_i, which are listed in Table 3. The substitution effect is positive whenever $r_i > 1$, and negative if $r_i < 1$. It should be noted that the figures in Table 2 present absolute changes. When these changes are taken as a percentage of the sector's total output, their pattern appears to be much in line with the pattern of the r_i's.

INSERT TABLE 3

Explaining the intermediate input intensity effects at the sectoral level is much more complex. For a single sector *j*, it certainly is insufficient to consider just the multiplier s_j. Only when the sector's diagonal element is very dominant, this may provide an adequate explanation. Most sectors, however, require a much more intricate explanation. For example, for agriculture (sector 1) it turns out that the diagonal element of the matrix **A** is only 0.06 in 1975, while the input into the food industry (sector 11) yields an input coefficient of 0.29. Since the food industry reduces its intermediate input intensity itself and since it delivers a large amount to final demand categories, this certainly contributes substantially to the large negative effect found for agriculture. In the same way, the small s_j for agriculture is important for the negative intermediate input intensity effects on the food industry, because the inputs from the food industry into agriculture yield an input coefficient of 0.21. Another interesting sector in this respect is lodging (sector 18), which had the smallest s_j. Still, the effects of changing intermediate input intensities on its output are positive and even amount to 10% of its 1975 output. It turns out that this sector's diagonal element is zero and all the other input coefficients in its row are positive, although fairly small. When considering the intermediate input intensity effects, however, almost all of these input coefficients increase, which explains why the resulting output change for lodging is positive.

A particularly interesting sector to examine in the period under consideration is the energy sector (2 – "fuel and power products"). The price shocks that accompanied the oil crises of the 1970's are the most likely reasons for the shifts in production technologies over this period. The influence of the oil shocks is clearly visible in the results at sector level, the decrease in the output of the energy sector (by 12% from 45722 in 1975 to 40313 in 1985) is most striking. The results show that the substitution effect is very large, i.e. the overall substitution trends in the economy have resulted in a large decrease in the use of energy as an input. Clearly the energy price increases and price changes in the sectors that are highly dependent on energy inputs (such as metals, 3; minerals, 4; and inland transport, 19) are consistent with these substitution effects. The large intermediate input intensity effects on the output of the energy sector, reflect that almost each sector depends on energy at least to some extent (the average input coefficient in row 2 was 0.06 in 1975 and 0.04 in 1985). Since 19 out of 24 sectors use more intermediate inputs, this affects the output of the energy sector considerably.

In explaining the results of Table 2, we have used the multipliers r_i and s_j which are presented in Table 3. For most of the sectors it is found, at least to some extent, that s_j is larger than one if the input coefficients in column *j* have increased. Using the column sums of the matrix **A** of input coefficients for this purpose, this relationship is observed for 19 out of 24 sectors (exceptions are the sectors 1, 2, 5, 11, and 18). In the same way, if the input coefficients in row *i* increase, one might expect r_i to be larger than one. On the basis of the row sums of **A**, this holds for 18 sectors (exceptions are the sectors 6, 12, 14, 16, 20, and 21). Clearly, these relationships are far too simple to give a full explanation, because they neglect the fact that row and column changes occur simultaneously. The RAS method takes full account of this simultaneous nature of the changes. As a consequence, however, explaining the observed outcomes for the multipliers r_i and s_j often requires the cumbersome task to consider the (changes in the) entire rows and columns, instead of just focusing on summary statistics such as the row and column totals.

The column-specific multipliers s_j in Table 3 show that five sectors (1, 11, 13, 18, and 20) have decreased their (domestic) intermediate input intensity between 1975 and 1985. For "paper and printing products" (sector 13) and "maritime and air transport services" (sector 20), this involves a substitution towards the use of imported intermediate inputs. The import coefficients of these two sectors increase from 0.18 to

0.22 and from 0.38 to 0.52, respectively. The row-specific multipliers r_i indicate the substitution patterns amongst the intermediate inputs. It should be borne in mind that we have applied a scaling such that the overall substitution effect for the entire economy is zero. Table 3 shows substitution away from energy (sector 2) and minerals (4), away from heavy manufacturing such as metal products (6) and heavy machinery (7), away from all three transport sectors (19-21), and away from some of the services sectors (22, 23). This is counterbalanced by substitution towards the "computer" sector (8+9), towards the food industry (11), towards lodging (18), and towards two of the largest service sectors (24, 25).

INSERT TABLE 4

The results for the decomposition of the final demands are presented in Table 4. The level effects are obtained from equation (13a), the category effects from (13b), and the product mix effects from (13c). Since the final demand block consists of seven export vectors, one household consumption vector and a vector with other final demands, the full representation of results would be given by 27 vectors of sectoral output changes. The figures in Table 4 provide the total output changes obtained from summing the sectoral outcomes.

Looking at the column totals in Table 4, it turns out that the level effects explain almost the entire output changes that are due to final demand changes. Note that both the category effects and the product mix effects describe the consequences of reshuffling the total final demand, between categories and between products respectively. Therefore, one might have expected the contribution of these two effects to be relatively close to zero, at the overall level.

The results for the category effects clearly reflect the observations we made on the basis of Table 1. The final demand share of the exports to Germany and to the rest of the world, and the share for other final demand purposes all declined. In contrast, the share of the exports to the rest of the EU and to Belgium, and the share of household consumption increased. The findings for the product mix effects indicate to what extent the total output has been affected by the change in the products supplied to the nine final demand categories. At first sight, it seems as if this product substitution is particularly strong for the products that households consume. Closer inspection, however, shows that the product mix effect of household consumption is only very moderate when the size of this consumption (see Table 1) is taken into account. When the figures are corrected for size, it appears that the product mix effect of the exports to Denmark and to the rest of the EU are the largest.

A comparison with the competitive imports case

When the results above for the non-competitive imports case are contrasted with those in Appendix B for the competitive imports case (i.e. where all imports are considered to be competitive), a number of clear-cut differences arise. The most important is the increase of the intermediate input intensity effects, the total of which nearly doubles due to the shift of imports from the primary inputs to the intermediate inputs. The total technology effect also increases significantly, from 21% to 35%, which is largely due to the fact that the imports have been subtracted from the final demand categories and have therefore reduced the final demand effects. Note that the inputs coefficients matrix **A** becomes larger and therefore also the Leontief inverse **L**. Although the final demands decline, the increase in **L** more than compensates this, due to the non-linear nature of inversion.

To give an impression, we carry out some "notepad calculations" again for the case where all sectors are aggregated into one. The input coefficient was 0.307 in 1975 and 0.353 in 1985, under the non-competitive imports assumption. When all imports are assumed to be competitive, the single input coefficient a raises to 0.483 in 1975 and

0.528 in 1985. The corresponding scalar Leontief inverses become 1.934 and 2.119, respectively. The increase in the Leontief inverse between 1975 and 1985 was 0.103 under the non-competitive imports assumption and amounts to 0.185 under the competitive imports assumption. As a consequence, the total final demand effect yields 63509 and the total technology effect[3] amounts to 25926. For the non-competitive imports case, the total effects in Table 2 were fairly close to the calculations for the single-sectored economy. In the competitive imports case this no longer holds. The explanation is that for some products the final demands have become negative now that exports are net exports. These negative final demands have a considerable impact on the sectoral results, while the outcome of the "notepad calculation" is comparable to sectoral calculations with average, and thus positive, final demands.

At the sector level, one of the more surprising results is the change in sign of the substitution effect for the sectors 8 ("office and data processing machines") and 9 ("electrical goods") when the results in Table 2 are compared with those in Table B.1 in Appendix B. A negative substitution effect seems counterintuitive for these "computer" sectors which one would have expected to be expanding already in that period.

The final demand effects in Table B.2 cannot be directly compared to the effects in Table 4 because of the adjustment for imports. This means that the export effects of all the trading partners are now the effects of changes in the *net* exports (i.e. the difference between the exports and the imports). Some of the final demand changes are therefore negative (notably the net exports to Germany and to the rest of the world). The outcomes for the category effects in Table B.2 are in line with the observations in Table 1 whenever net exports (and in particular the contribution of each category to the total net exports) are considered.

[3] For a single-sectored economy, the substitution effect and the effect of a cell-specific change are both zero.

The assumption of all imports being either competitive or non-competitive is unrealistic. Unfortunately the present data set does not distinguish between the two types of import. What would be necessary for a satisfactory decomposition of the technology and trade would be knowledge of the actual competitive and non-competitive imports of the Netherlands.

7. Conclusions

In this chapter we have demonstrated that the RAS decomposition of technology (as suggested in Van der Linden and Dietzenbacher, 1995, 2000) can be implemented in a structural decomposition analysis and have applied it to the technological changes over the period 1975-1985 for the Netherlands. The results show that the total technological effect is quite significant particularly for the results of the input-output table *with* imports. The oil crises and energy price shocks are likely explanations for these large shifts in production technologies and the substitution effect away from energy is particularly large. The cell-specific effects are generally very minor which indicates that, in a period of such extreme technological change, the average substitution and average intermediate input intensity effects provide an adequate description of the technological effects.

The decomposition of the final demand effects showed that the changes in the exports to Germany and to the countries outside the EU have decreased output, while the growth in exports to other EU nations has spurred output.

Improvement of the data is required to distinguish between competitive and non-competitive imports. This would allow for a more appropriate decomposition of the *technical* coefficients instead of decomposing the (domestic) *input* coefficients as was done in this study. If such data were available, the intermediate input intensity effect could in fact be directly related to the productivity effect (with respect to the primary inputs).

References

Albala-Bertrand, J.M. (1999) Structural change in Chile: 1960-90, *Economic Systems Research*, 11, pp. 301-319.

Alcala, R., Antille, G. & Fontela, E. (1999) Technical change in the private consumption converter, *Economic Systems Research*, 11, pp. 389-400.

Allen, R.I.G. & Gossling, W.F. (eds) (1975) *Estimating and Projecting Input-Output Coefficients* (London, Input-Output Publishing Company).

Andréosso-O'Callaghan, B. & Yue, G. (2000) An analysis of structural change in China using biproportional methods, *Economic Systems Research*, 12, pp. 99-111.

Bacharach, M. (1970) *Biproportional Matrices and Input-Output Change* (Cambridge, Cambridge University Press).

Cabrer, B., Contreras, D. & Sancho, A. (1998) Prices revisited: their effects on industrial structure, *Economic Systems Research*, 10, pp. 31-43.

Casler, S.D. (2000) Interaction terms and structural decomposition: an application to the defense cost of oil, in: M.L. Lahr & E. Dietzenbacher (eds) *Input-Output Analysis: Frontiers and Extensions* (London, MacMillan), forthcoming.

Cronin, F.J. & Gold, M. (1998) Analytical problems in decomposing the system-wide effects of sectoral technical change, *Economic Systems Research*, 10, pp. 325-336.

Dietzenbacher, E. (2000) An intercountry decomposition of output growth in EC countries, in: M.L. Lahr & E. Dietzenbacher (eds) *Input-Output Analysis: Frontiers and Extensions* (London, MacMillan), forthcoming.

Dietzenbacher, E. & Hoen, A.R. (1998) Deflation of input-output tables from the user's point of view: a heuristic approach, *Review of Income and Wealth*, 44, pp. 111-122.

Dietzenbacher, E., Hoen, A.R. & Los, B. (2000) Labor productivity in Western Europe (1975-1985): an intercountry, interindustry analysis, *Journal of Regional Science*, 40, forthcoming.

Dietzenbacher, E. & van der Linden, J.A. (1997) Sectoral and spatial linkages in the EC production structure, *Journal of Regional Science*, 37, pp. 235-257.

Dietzenbacher, E., van der Linden, J.A. & Steenge, A.E. (1993) The regional extraction method: applications to the European Community, *Economic Systems Research*, 5, pp. 185-206.

Dietzenbacher, E. & Los, B. (1997) Analyzing decomposition analyses, in: A. Simonovits & A.E. Steenge (eds) *Prices, Growth and Cycles* (London, MacMillan), pp. 108-131.

Dietzenbacher, E. & Los, B. (1998) Structural decomposition techniques: sense and sensitivity, *Economic Systems Research*, 10, pp. 307-323.

Eurostat (1979) *European System of Integrated Economic Accounts, ESA*, 2nd edition (Luxembourg, Eurostat).

Eurostat (1990) *External Trade Statistics: User's Guide* (Luxembourg, Eurostat).
Gilchrist, D.A. & St Louis, L.V. (1999) Completing input-output tables using partial information, with an application to Canadian data, *Economic Systems Research*, 11, pp. 185-193.
Golan, A., Judge, G. & Robinson, S. (1994) Recovering information from incomplete or partial multisectoral economic data, *Review of Economics and Statistics*, 76, pp. 541-549.
Hitomi, K., Okuyama, Y., Hewings, G.J.D. & Sonis, M. (2000) The role of interregional trade in generating change in the multiregional economies of Japan, 1980-1990, *Economic Systems Research*, 12, forthcoming.
Hoen, A.R. (1999) *An Input-Output Analysis of European Integration* (Capelle a/d IJssel, Labyrint Publication, Ph.D. thesis).
Jacobsen, H.K. (2000) Energy demand, structural change and trade: a decomposition analysis of the Danish manufacturing industry, *Economic Systems Research*, 12, forthcoming.
Jalili, A.R. (2000) Comparison of two methods of identifying input-output coefficients for exogenous estimation, *Economic Systems Research*, 12, pp. 113-129.
Konijn, P.J.A. (1994). *The make and use of commodities by industries: On the compilation of input-output data form the national statistics* (Faculteit Bestuurskunde, Universiteit Twente, Enschede, the Netherlands, Ph.D. thesis).
Lecomber, J.R.C. (1975) A critique of methods of adjusting, updating and projecting matrices, in: R.I.G. Allen & W.F. Gossling (eds) *Estimating and Projecting Input-Output Coefficients* (London, Input-Output Publishing Company), pp. 43-56.
Lin, X. & K.R. Polenske (1995) Input-output anatomy of China's energy-demand change, *Economic Systems Research*, 7, pp. 67-84.
Linden, J.A. van der (1998) *Interdependence and Specialisation in the European Union* (Capelle a/d IJssel, Labyrint Publication, Ph.D. thesis).
Linden, J.A. van der & Dietzenbacher, E. (1995) The nature of changes in the EU cost structure of production 1965-1985: an RAS approach, in: H. Armstrong & R. Vickerman (eds) *Convergence and Divergence among European Regions* (London, Pion), pp. 124-139.
Linden, J.A. van der & Dietzenbacher, E. (2000) The determinants of structural change in the European Union: a new application of RAS, *Environment and Planning A*, forthcoming.
Linden, J.A. van der & Oosterhaven, J. (1995) Intercountry EC input-output relations: construction method and main results for 1965-1985, *Economic Systems Research*, 7, pp. 249-269.
Lynch, R.G. (1986) An assessment of the RAS method for updating input-output tables, in: I. Sohn (ed.) *Readings in Input-Output Analysis: Theory and Applications* (New York, Oxford University Press), pp. 271-284.
MacGill, S.M. (1977) Theoretical properties of biproportional matrix adjustments, *Environment and Planning A*, 9, pp. 687-701.
Mesnard, L. de (1994) Unicity of biproportion, *SIAM Journal on Matrix Analysis and Applications*, 15, pp. 490-495.
Mesnard, L. de (1997) A biproportional filter to compare technical and allocation coefficient variations, *Journal of Regional Science*, 37, pp. 541-564.

Miernyk, W.H. (1977) The projection of technical coefficientsfor medium-term forecasting, in: W.F. Gossling (ed.) *Medium-Term Dynamic Forecasting, The 1975 London Input-Output Conference* (London, Input-Output Publishing Company), pp. 29-42.

Milana, C. (2000) The input-output structural decomposition analysis of “flexible” production systems, in: M.L. Lahr & E. Dietzenbacher (eds) *Input-Output Analysis: Frontiers and Extensions* (London, MacMillan), forthcoming.

Miller, R.E. & Blair, P.D. (1985) *Input-Output Analysis: Foundations and Extensions* (Englewood Cliffs, NJ, Prentice-Hall).

Mukhopadhyay, K. & Chakraborty, D. (1999) India’s energy consumption changes during 1973-74 to 1991-92, *Economic Systems Research*, 11, pp. 423-438.

Oosterhaven, J. & Hoen, A.R. (1998) Preferences, technology, trade and real income changes in the European Union: an intercountry decomposition analysis for 1975-1985, *Annals of Regional Science*, 32, pp. 505-524.

Oosterhaven, J. & Linden, J.A. van der (1997) European technology, trade and income changes for 1975-85: an intercountry input-output decomposition, *Economic Systems Research*, 9, pp. 393-411.

Polenske, K.R. (1997) Current uses of the RAS technique: a critical review, in: A. Simonovits & A.E. Steenge (eds) *Prices, Growth and Cycles* (London, MacMillan), pp. 58-88.

Rose, A. & Casler, S. (1996) Input-output structural decomposition analysis: a critical appraisal, *Economic Systems Research*, 8, pp. 33-62.

Stone, R. (1961) *Input-Output and National Accounts* (Paris, OECD).

Toh, M.-H. (1998) The RAS approach in updating input-output matrices: an instrumental variable interpretation and analysis of structural change, *Economic Systems Research*, 10, pp. 63-78.

Wier, M. (1998) Sources of changes in emissions from energy: a structural decomposition analysis, *Economic Systems Research*, 10, pp. 99-112.

Wier, M. & Hasler, B. (1999) Accounting for nitrogen in Denmark – a structural decomposition analysis, *Ecological Economics*, 30, pp. 317-333.

Appendix A: Sector Classification

1.	Agri	Agriculture, forestry and fishery products
2.	Ener	Fuel and power products
3.	Meta	Ferrous and non-ferrous ores and metals
4.	Mine	Non-metallic mineral products
5.	Chem	Chemical products
6.	MetP	Metal products except machinery and transport equipment
7.	AIMa	Agriculture and industrial machinery
8.	ODMa	Office and data processing machines
9.	ElGo	Electrical goods
10.	TrEq	Transportation equipment
11.	Food	Food, beverages and tobacco
12.	Text	Textiles and clothing, leather, footwear
13.	Pape	Paper and printing products
14.	Rubb	Rubber ad plastic products
15.	Oman	Other manufacturing products
16.	Buil	Building and constructing
17.	ReTr	Recovery, repair services, wholesale and retail trade
18.	Lodg	Lodging and catering services
19.	InTr	Inland transport services
20.	MATr	Maritime and air transport services
21.	Auxi	Auxiliary transport services
22.	Comm	Communication services
23.	Cred	Credit and insurance
24.	Omse	Other market services
25.	Pser	Non-market services

Appendix B: Results for the competitive imports case

In Tables 2 and 4 (in the main text), the decomposition is performed on the input-output table without imports, which means that only domestic inputs are included in the intermediate deliveries. Implicitly it is assumed that all imports are non-competitive, i.e. they are assumed to have a different production technology than the domestic products. In Tables B.1 and B.2 we present the equivalent results of Tables 2 and 4 under the assumption that all imports are in fact competitive and are included in the intermediate input matrix. To balance the table, the import quantities have to be subtracted from the final demand. When we decompose this new final demand vector, the result is an analysis of changes in the net exports (i.e. exports minus imports) to the trading partners on the sectoral outputs.

Table B.1. Specific technology and total final demand effects in the competitive imports case.

	TECHNOLOGY EFFECTS								FINAL DEMAND EFFECTS		TOTAL
	Total		Substitution		Intermediate input intensity		Cell Specific Substitution				
1 Agri	3311	(45%)	3611	(49%)	-268	(-4%)	-32	(0%)	4029	(55%)	**7340**
2 Ener	-3863	(71%)	-18560	(343%)	14460	(-267%)	237	(-4%)	-1546	(29%)	**-5409**
3 Meta	2211	(405%)	412	(76%)	1850	(339%)	-51	(-9%)	-1666	(-305%)	**545**
4 Mine	-165	(-125%)	-1315	(-996%)	1120	(848%)	30	(23%)	297	(225%)	**132**
5 Chem	1397	(19%)	-1316	(-18%)	3095	(43%)	-382	(-5%)	5771	(81%)	**7168**
6 MetP	501	(66%)	-832	(-110%)	1357	(179%)	-23	(-3%)	259	(34%)	**760**
7 AIMa	112	(90%)	-970	(-778%)	1107	(888%)	-25	(-20%)	13	(10%)	**125**
8 ODMa	-172	(-1445%)	-318	(-2672%)	175	(1470%)	-29	(-243%)	184	(1545%)	**12**
9 ElGo	190	(7%)	-899	(-33%)	1084	(40%)	4	(0%)	2552	(93%)	**2742**
10 TrEq	433	(115%)	-280	(-75%)	677	(180%)	37	(10%)	-58	(-15%)	**376**
11 Food	5420	(41%)	5799	(44%)	-372	(-3%)	-8	(0%)	7866	(59%)	**13286**
12 Text	-283	(69%)	-802	(197%)	575	(-141%)	-55	(14%)	-125	(31%)	**-408**
13 Pape	1249	(43%)	136	(5%)	1329	(46%)	-216	(-7%)	1672	(57%)	**2921**
14 Rubb	639	(78%)	52	(6%)	581	(71%)	5	(1%)	185	(22%)	**823**
15 Oman	-246	(616%)	-1083	(2712%)	907	(-2272%)	-71	(177%)	206	(-516%)	**-40**
16 Buil	2116	(156%)	244	(18%)	1439	(106%)	433	(32%)	-762	(-56%)	**1354**
17 ReTr	5103	(38%)	2383	(18%)	2655	(20%)	65	(0%)	8342	(62%)	**13445**
18 Lodg	769	(26%)	576	(19%)	272	(9%)	-78	(-3%)	2190	(74%)	**2959**
19 InTr	-969	(-204%)	-2223	(-469%)	1249	(264%)	5	(1%)	1443	(304%)	**474**
20 MATr	-1021	(-80%)	-1481	(-116%)	463	(36%)	-3	(0%)	2299	(180%)	**1277**
21 Auxi	195	(19%)	-379	(-38%)	541	(54%)	32	(3%)	806	(81%)	**1001**
22 Comm	680	(79%)	89	(10%)	571	(66%)	20	(2%)	183	(21%)	**862**
23 Cred	403	(17%)	226	(9%)	256	(11%)	-79	(-3%)	1986	(83%)	**2389**
24 Omse	10521	(66%)	8094	(51%)	2473	(16%)	-46	(0%)	5322	(34%)	**15843**
25 PSer	2837	(14%)	1698	(9%)	1140	(6%)	-1	(0%)	16834	(86%)	**19672**
Total	**31369**	**(35%)**	**-7136**	**(-8%)**	**38737**	**(43%)**	**-232**	**(0%)**	**58282**	**(65%)**	**89651**

Table B.2. Results of the final demand decomposition in the competitive imports case.

	LEVEL EFFECT		CATEGORY EFFECT		PRODUCT MIX EFFECT		TOTAL
Germany	7801	(-173%)	-12780	(283%)	468	(-10%)	**-4511**
France	1994	(56%)	1270	(36%)	294	(8%)	**3558**
Italy	1501	(35%)	2692	(62%)	143	(3%)	**4336**
Belgium	3034	(42%)	4739	(66%)	-565	(-8%)	**7208**
Denmark	608	(-51%)	-1962	(166%)	172	(-15%)	**-1182**
Rest EU	4013	(15%)	23920	(87%)	-585	(-2%)	**27348**
ROW	-3015	(16%)	-14733	(79%)	-876	(5%)	**-18625**
Consumption	30021	(96%)	8329	(27%)	-6982	(-22%)	**31368**
Other FD	17379	(198%)	-6524	(-74%)	-2073	(-24%)	**8783**
Total	**63335**	**(109%)**	**4951**	**(8%)**	**-10004**	**(-17%)**	**58282**

*Note that the final demand effects of the 7 trading partners are in fact *net* export (export minus import) effects and therefore have a different interpretation than the results in Table 2.

Table 1. Summary of final demand and import changes in the period 1975-1985 for the Netherlands.

	Total final demands (1000 million ECU)		**Relative share in final demands**		**Relative share in exports**		**Imports (1000 million ECU)**		**Relative share of imports**	
	1975	**1985**	**1975**	**1985**	**1975**	**1985**	**1975**	**1985**	**1975**	**1985**
Germany	22409	22629	13%	11%	33%	25%	6566	8921	15%	15%
France	5643	7392	3%	3%	8%	8%	2516	2884	6%	5%
Italy	2858	4676	2%	2%	4%	5%	964	1122	2%	2%
Belgium	7307	12423	4%	6%	11%	14%	2874	4544	7%	8%
Denmark	1624	1212	1%	1%	2%	1%	206	368	0%	1%
Rest EU	7580	20831	5%	10%	11%	23%	5177	6255	12%	11%
ROW	21099	20825	13%	10%	31%	23%	24093	33845	57%	58%
Consumption	58513	77875	35%	36%						
Other FD	40284	46336	24%	22%						
Total	**167316**	**214197**	**100%**	**100%**	**100%**	**100%**	**42397**	**57938**	**100%**	**100%**

Table 2. Specific technology and total final demand effects at sector level for the Netherlands (1975-1985).

	TECHNOLOGY EFFECTS								FINAL DEMAND EFFECTS		TOTAL
	Total		Substitution		Intermediate input intensity		Cell-specific Substitution				
1 Agri	1947	(27%)	3872	(53%)	-1964	(-27%)	38	(1%)	5393	(73%)	**7340**
2 Ener	-7225	(134%)	-12178	(225%)	4931	(-91%)	22	(0%)	1816	(-34%)	**-5409**
3 Meta	262	(48%)	-185	(-34%)	440	(81%)	7	(1%)	283	(52%)	**545**
4 Mine	-266	(-201%)	-1221	(-925%)	938	(710%)	18	(14%)	398	(301%)	**132**
5 Chem	826	(12%)	540	(8%)	448	(6%)	-162	(-2%)	6342	(88%)	**7168**
6 MetP	-99	(-13%)	-1130	(-149%)	1024	(135%)	8	(1%)	858	(113%)	**760**
7 AIMa	-63	(-50%)	-460	(-369%)	386	(310%)	12	(9%)	187	(150%)	**125**
8 ODMa + 9 ElGo	1297	(47%)	1006	(37%)	409	(15%)	-118	(-4%)	1456	(53%)	**2754**
10 TrEq	357	(95%)	182	(48%)	144	(38%)	31	(8%)	19	(5%)	**376**
11 Food	3897	(29%)	6047	(46%)	-2215	(-17%)	65	(0%)	9390	(71%)	**13286**
12 Text	108	(-27%)	-11	(3%)	129	(-32%)	-9	(2%)	-516	(127%)	**-408**
13 Pape	359	(12%)	-309	(-11%)	809	(28%)	-141	(-5%)	2562	(88%)	**2921**
14 Rubb	128	(16%)	-144	(-18%)	292	(35%)	-19	(-2%)	695	(84%)	**823**
15 Oman	-34	(86%)	-486	(1217%)	498	(-1246%)	-46	(115%)	-6	(14%)	**-40**
16 Buil	1827	(135%)	-1170	(-86%)	2446	(181%)	551	(41%)	-473	(-35%)	**1354**
17 ReTr	4605	(34%)	3277	(24%)	1396	(10%)	-67	(0%)	8840	(66%)	**13445**
18 Lodg	824	(28%)	671	(23%)	219	(7%)	-66	(-2%)	2135	(72%)	**2959**
19 InTr	-655	(-138%)	-2170	(-458%)	1482	(313%)	33	(7%)	1129	(238%)	**474**
20 MATr	-26	(-2%)	-154	(-12%)	116	(9%)	12	(1%)	1303	(102%)	**1277**
21 Auxi	203	(20%)	-376	(-38%)	539	(54%)	39	(4%)	799	(80%)	**1001**
22 Comm	27	(3%)	-684	(-79%)	718	(83%)	-6	(-1%)	835	(97%)	**862**
23 Cred	-473	(-20%)	-4530	(-190%)	4083	(171%)	-27	(-1%)	2862	(120%)	**2389**
24 Omse	6823	(43%)	5122	(32%)	1790	(11%)	-89	(-1%)	9020	(57%)	**15843**
25 PSer.	4315	(22%)	3590	(18%)	703	(4%)	22	(0%)	15357	(78%)	**19672**
Total	**18965**	**(21%)**	**-901**	**(-1%)**	**19760**	**(22%)**	**106**	**(0%)**	**70685**	**(79%)**	**89651**

Table 3. Row and column multipliers and input coefficient totals.

	Multipliers		**Column totals**		**Row totals**	
	r	**s**	**1975**	**1985**	**1975**	**1985**
1 Agri	1.25	0.72	0.46	0.52	0.38	0.44
2 Ener	0.60	1.23	0.27	0.23	1.53	1.00
3 Meta	0.93	1.27	0.25	0.26	0.17	0.20
4 Mine	0.59	1.14	0.36	0.37	0.20	0.15
5 Chem	1.15	1.09	0.39	0.37	0.29	0.36
6 MetP	0.71	1.22	0.28	0.34	0.33	0.34
7 AIMa	0.69	1.35	0.25	0.34	0.16	0.14
8 ODMa + 9 ElGo	2.29	1.50	0.15	0.24	0.08	0.18
10 TrEq	1.27	1.33	0.32	0.41	0.07	0.13
11 Food	2.10	0.88	0.49	0.55	0.46	0.60
12 Text	0.97	1.26	0.21	0.29	0.11	0.11
13 Pape	0.90	0.88	0.42	0.40	0.47	0.42
14 Rubb	0.86	1.01	0.27	0.30	0.10	0.13
15 Oman	0.71	1.06	0.26	0.30	0.15	0.13
16 Buil	0.81	1.50	0.38	0.49	0.44	0.44
17 ReTr	1.57	1.63	0.27	0.37	0.57	0.96
18 Lodg	2.42	0.65	0.43	0.43	0.04	0.10
19 InTr	0.46	1.13	0.28	0.33	0.17	0.13
20 MATr	0.62	0.83	0.20	0.17	0.03	0.05
21 Auxi	0.71	1.23	0.19	0.29	0.09	0.14
22 Comm	0.76	1.03	0.10	0.13	0.19	0.18
23 Cred	0.82	1.17	0.78	0.80	0.79	0.73
24 Omse	2.19	1.56	0.13	0.20	0.37	0.90
25 Pser	2.43	1.11	0.18	0.25	0.15	0.43

Table 4. Results of the final demand decomposition.

	LEVEL EFFECT		CATEGORY EFFECT		PRODUCT MIX EFFECT		TOTAL
Germany	8386	(648%)	-8086	-(625%)	993	(77%)	**1294**
France	2454	(86%)	230	(8%)	176	(6%)	**2860**
Italy	1487	(50%)	1477	(50%)	-15	(0%)	**2950**
Belgium	3590	(48%)	4117	(55%)	-223	-(3%)	**7485**
Denmark	526	-(118%)	-1144	(257%)	173	-(39%)	**-446**
Rest EU	5010	(24%)	14764	(71%)	1017	(5%)	**20791**
ROW	7836	(2458%)	-8269	-(2594%)	752	(236%)	**319**
Consumption	25358	(91%)	4004	(14%)	-1527	-(5%)	**27835**
Other FD	15361	(202%)	-6675	-(88%)	-1088	-(14%)	**7598**
Total	**70008**	**(99%)**	**418**	**(1%)**	**258**	**(0%)**	**70685**