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PRODUCTION CHAINS

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Summary

Triangularization of input-output tables is the normal method to determine the hierarchy of industries in the production process. The present paper formalizes the notion of production chains in order to obtain an alternative method with considerable conceptual and computational advantages. Production chains are sequences of transformations of products by successive industries. These can be calculated from input-output tables because each term of the Taylor series representation of the Leontiev inverse corresponds with one transformation. The degree to which a transformation is major or minor can be operationalized by measuring the amounts of value or employment per unit of output added in each transformation. In addition, both the numbers transformations through which each industry's inputs go (backward transformations) and that of its outputs (forward transformations) may be calculated. Using these concepts, the much too restrictive hierarchy obtained by triangularization can be replaced by a number of other characteristics like the 'distances' between industries, the distance from an industry to consumption and that to primary inputs.

1. Introduction

Each industry has its own place in the economy. An industry purchases goods and services from other industries and vice versa (for short we will use most of times the term goods when we mean goods and services). Besides, frequently an industry will also supply to final demand categories. A good that has been used by an industry could be considered as being embodied in the products of that industry, even though we can no longer identify it as such. Would we follow a good on its path through the various stages of production processes we would notice that it is repeatedly embodied in a product before it finally "arrives" at its destination, the final demand categories. This progressive advance we will call a production chain .

It has been often suggested that by triangularizing IO-tables the existence of a production chain can be made visible. This is based on the assumption that a lower placed industry will supply to a higher placed one while the reverse will not be true. Analyzing a production structure by triangularizing the IO-table has its drawbacks:

1. triangularizing is nothing more than ordering the industries;
2. the ordering depends on the dimensions of the table and therefore does not give fixed characteristics of the industries;
3. the method is instable when the values of a number of cells are close to zero;
4. the calculations demand the utmost of computer time (for any increase in the number of industries computer time growth with $n^2.n!$);
5. the ordering is very sensitive to relative changes in prices;
6. circularity - the direct or indirect delivery by an industry to itself - cannot be taken into account.

Besides these drawbacks one might also wonder on what base the triangularization should be carried out. Should we take the value in dollars, the cumulated coefficients or even apply other standards? Each option has its own peculiarities while their respective results are difficult to compare and their differences are hard to interprete. An extensive appraisal of these problems can be found in Wessels[1].

In studies on this subject quite often Leontief[2] is cited: "The triangularization of a real input-output table - that is, the discovery of its peculiar structural properties - is a challenging task". In our opinion the analysis of the economic structure is emphasized here, for which triangularization is a tool. Chenery and Watanabe[3] applied this method to compare productions structures of several countries. Anjac and Masson[4] tried to avoid the problem of the many potential permutations by creating a linear ordering, based on the principle of the "most important purchaser".

To minimize the influence of the final demand categories Simpson and Tsukui[6] used the input coefficients as basis for their triangularization; small coefficients were simply neglected. When they compared tables of different countries they noticed that between industries fundamental inter-dependences could be recognized. Korte and Oberhofer[7] studied the mathematical backgrounds. They presume that the ordering by means of triangularization yields such a unique result that this ordering will best represent the industrial hierarchy. Helmstädter[8-11] has published many articles on triangularization. In one of them he wonders how long the distances - measured in time - between the various industries would be. In the case of perfect linearity this question is easy to solve, but when circularity is involved the situation becomes very complicated. He also touches on the relation between the time of investing and the lag till the expected growth of the consumption. Lamel et al.[12] use triangularization to compare the production structure of different countries and confirm the assumption that there exists a relation between the level of development of a country and the different forms of interdependence between industries. Dubek[13] compared the production structures between Austria and Czechoslovakia and concluded that the influence of technology on triangular properties of the table is not big and that, when one wants to look at possible technological similarities between countries, this technique should be used with the greatest restraint.

The purpose of this article is to develop a method which will enable us to "see" a kind of hierarchical structure between industries. This method will be much less troubled by the above-mentioned drawbacks than triangularization. It is also less sensitive to differences in classifications and to different levels of aggregation. We have also, more or less, succeeded in eliminating the influence of different relative prices.

Our starting point is the existence of production chains of different lengths; every industry is the central link of its production chain. The

length of a chain is determined by the number of production steps; an intermediate delivery from one industry to another is considered as one step. Later the steps will be subjected to weighting, based on value added and employment. In principle a production chain is stretched out from scratch to consumption.

The method has been applied to a special Dutch IO-table with 317 entries; the results will be published on a level of 179 industries.

One of the by-products of the calculations is a matrix which represents the "numbers of (weighted) steps" between industries. Since every industry is the central link of its own production chain one cannot simply add or subtract positions on the various chains. The direction is of great influence: comparing two indusries A and B the difference between A B and B A could be very large indeed.

2. The total input-output table

The purpose of our analysis is to establish the length of the production chains that links original inputs to their final destination. This cannot be done with the standard IO-table, since the latter contains a number of categories of primary costs that do not contain original inputs, as well as categories of final expenditure that are not the true final destination.

Thus the categories of primary costs can be broken down as

1. net value added;
2. imports;
3. consumption of fixed capital.

Of these, only net value added represents inputs that have not gone through previous transformation. Consumption of fixed capital reflects the using-up of the past investments thatare the result of earlier flows through the production chain. Imports consist of goods and services that have passed through production chains abroad and, frequently, at home as well. Clearly we would underestimate the length of the production chain if we ignore the fact that consumption of fixed capital and imports are based on earlier flows through the production chain. Hence the chains underlying these two categories have to be incorporated in the IO-table we are to employ. Thus this table has to be adjusted.

The original primary category of imports is broken down in a separate table of imports, that are competitive with the corresponding Dutch industries. For those goods which cannot be produced by Dutch industries additional rows and columns have been created. The columns have the input structure of the countries of origin. In a similar way rows and columns for different types of capital goods are introduced. The rows of these "pseudo-industries" contain the depreciations, the columns the relative contributions of the industries that produced the particular baskets of capital goods. In this way we have constructed a new table that contains a row $v^{*'}$ with the net value added and an intermediate matrix

$$A^* = A_d^* + A_m^* \tag{1}$$

Here A_d^* is the domestic intermediate matrix with the added pseudo-industries, while A_m^* represents the matrix of imported products, broken down according to their Dutch counterparts and extended with rows and columns for the non-competitive imports.

The matrix A^* represents total intermediate deliveries, i.e. including those abroad and over time (capital), corresponding to the original final deliveries of the Dutch IO-table. However, the production totals of the original table should be supplemented by the production totals of the newly created "industries" for non-competitive imports and capital consumption. The vector obtained in this way allows the determination of a matrix of input coefficients

$$\tilde{A}^* = A^* \hat{t}^{*-1} \tag{2}$$

The matrix $\tilde{A}^*$ may be called the matrix of "total input coefficients". It shows the total input structure associated with the Dutch intermediate and final demand: the usual domestic input structure supplemented with that of imports and capital consumption. The only primary input is value added. All production chains underlying the other original inputs have been incorporated in this matrix.

The original final demand categories are:

1. consumption of households and government,
2. gross investments;
3. inventory changes;
4. exports.

Only the first one is a bona-fide final destination. Investment goods will be employed in future production processes and so will contribute to future production chains. Inventories and exports will not become final commodities until they are absorbed by domestic or foreign consumption, directly or by entering foreign or domestic production chains again. Thus we should actually analyse the deliveries to consumption only and eliminate the other categories. This requires modifications of the intermediate deliveries and primary costs both: their deliveries attributable to these categories of final expenditure must be removed. This can only be achieved by first calculating the cumulated input coefficients and then multiplying these with the consumption vector. In this way we obtain the primary costs and intermediate deliveries connected with consumption only.

We can now calculate the total production belonging to a closed economy with an input structure that closely resembles the Dutch one. We obtain

$$t_c^* = (I - \tilde{A}^*)^{-1} c^* \qquad (3)$$

where c^* is the consumption vector.

We call the economy closed because it contains all production steps from scratch to final consumption. Thus it can be considered as being closed in both time and space.

Multiplying (3) with the input coefficients we obtain the intermediate matrix of the closed economy

$$A_c^* = \tilde{A}^* \hat{t}_c^* \qquad (4)$$

The next step is the calculation of the vector of the coefficients of the net value added

$$\tilde{v}^* = v^* \hat{t}^{*-1} \qquad (5)$$

The net value added of the closed economy becomes

$$v_c^* = \tilde{v}^* \hat{t}_c^* \qquad (6)$$

In nearly the same way we can calculate vectors for other effects like employment

$$l_c^* = l^* \hat{t}^{*-1} \hat{t}_c^* \tag{7}$$

So, proceeding from a specified consumption - in our case the Dutch consumption - we have constructed the intermediate matrix A^*, which completely describes all the necessary production processes. There are no imports and the consumption is the only final output. The consumption of capital goods has completely been taken into account. One consequence of the addition of pseudo-industries to A^* is that - when we track a good in its path trough the various production processes - a step via a capital good has to be considered as a double step: first a delivery to a pseudo-industry and then one to the industry that in reality will consume that particular good. We can justify this by taking the view that the installation of a capital good and the production of a good with the de facto help of that capital good can be seen as two separate actions.

Suppose we have a matrix A, partitioned in 4 submatrixces A_{11}, A_{12}, A_{21} and A_{22}. We define A as

$$A = \begin{pmatrix} A^* & c^* \\ 0 & 0 \end{pmatrix} \tag{8}$$

We find the Leontief inverse

$$(I - \tilde{A})^{-1} = \begin{pmatrix} (I - \tilde{A}_c^*)^{-1} & (I - \tilde{A}_c^*)^{-1} c^* \\ 0 & 0 \end{pmatrix} \tag{9}$$

Like the standard Leontief inverse here every column represents the cumulated input of an industry. However, in (9) we find in the last column the cumulated input of the final demand category consumption, which implies that this column is treated like any other industry. Of course the other industries do not contain inputs from the final column, which is why the bottom row of both (8) and (9) contains nothing but zero's.

From now on we will call the last column of (8), c^* extended with an element zero, the consumption vector c. In the same way we construct the vectors v and l. For t the added element is the column total of c. The coefficient vectors $\tilde{v}$ and $\tilde{l}$ are obtained by

$$\tilde{v} = v\ \hat{t}^{-1} \tag{10}$$

$$\tilde{l} = l\ \hat{t}^{-1} \tag{11}$$

Finally we obtain the matrix with input coefficients

$$\tilde{A}_i = A\ \hat{t}^{-1} \tag{12}$$

and with output coefficients

$$\tilde{A}_o = \hat{t}^{-1}\ A \tag{13}$$

The importance of these matrices will become clear in the next chapters.

3. The number of forward transformations

The cumulated output coefficients (i,j) in the Leontief inverse $(I - \tilde{A}_o)^{-1}$ indicate which part of the output of industry i is, ultimately, embodied in the products of industry j. The diagonal element must be at least equal to one, since all output of industry i is by definition a product of industry i whereas, in addition to this, part of i's products are embodied in other industries' output which in its turn may be embodied in i's output once again. Since the total IO-table treats consumption as an industry its coefficients are equal to one: all output of this "industry" is embodied in its "products" and none in that of other industries.

The Leontief inverse $(I - \tilde{A}_o)^{-1}$ represents the ultimate result of an infinite number of steps in the production process. The steps may be made ecplicit by means of the Taylor expansion of the inverse

$$(I - \tilde{A}_o)^{-1} = I + \tilde{A}_o + \tilde{A}_o^2 + \tilde{A}_o^3 + \ldots\ldots$$

$$= \sum_{k=o}^{\infty} \tilde{A}_o^k \tag{14}$$

The various terms of (14) can be regarded as succesive steps in a continuous production process. After each step part of the output, newly embodied in one product or another is "siphoned" off to consumption.

If we limit ourselves to consumption, we can easily determine how many production steps (from now on we will call them transformations) on the average were needed before one unit of output has "reached" consumption. We only need to multiply every fraction which is siphoned to the consumption with the number of transformations. Performing this operation we obtain

$$\begin{aligned} \tilde{H} &= 1\tilde{A}_o + 2\tilde{A}_o^2 + 3\tilde{A}_o^3 + \ldots \\ &= \sum_{k=0}^{\infty} k\, \tilde{A}_o^k \\ &= (I - \tilde{A}_o)^{-1} \{ (I - \tilde{A}_o)^{-1} - I \} \end{aligned} \tag{15}$$

What is the interpretation of the non-consumption elements of $\tilde{H}$? In every term of the series expansion a characteristic element (i,j) represents the output of industry i, delivered to industry j, as a fraction of the total output of i, weighted with the number of observed transformations.

It is possible that, because of circularity, a fraction of output of one industry more than one time will be delivered to one another industry. In this case the fraction will each time be accounted for, but each time weighted with the matching number of transformations. So an element (i,j) of $\tilde{H}$ contains the fraction of tne cumulated output i which flows through j, multiplied with the number of observed transformations. Of course this is also true for the consumption column of $\tilde{H}$ but, since the cumulated output which 'flows' through the consumption, is equal to one by definition, we find only the average number of transformations until consumption is reached.

A matrix which is easier to interprete can be obtained by dividing $\tilde{H}$ element-wise by that fraction of the cumulated output of i, which has been delivered to j,

$$\tilde{H}_f = \tilde{H} \oslash \{ (I + \tilde{A}_o)^{-1} - I \} \tag{16}$$

Here we define the operation

$$Q = R \oslash S \quad \Leftrightarrow \quad q_{ij} \begin{cases} = r_{ij}/s_{ij} & , |s_{ij}| > 0 \\ = 0 & , r_{ij} = s_{ij} = 0 \end{cases} \tag{17}$$

This implies that for all elements of R an S with the same indices we should have:

$$s_{ij} > 0 \quad \vee \quad s_{ij} = r_{ij} = 0 \tag{17a}$$

Since the elements of $\tilde{A}_o$ usually are at least equal to zero, and taking the series expansions in (14) and (15) into account one can easily realize that the condition in (17a) is met.

The matrix $\tilde{H}_f$ may be designated the "transformations matrix". Its characteristic element (i,j) represents the average number of transformations of each unit of i that eventually passes through j, directly and indirectly. If each transformation by each industry would require the same period of time (Helmstädter[10] mentions three months, Hack[14] arrives at the same results) the elements of the transformations matrix are directly proportional to the average time that lapses between production by i and the passing through j.

When two industries are to a large degree interdepent, e.g. when i supplies j with a very large fraction of its output the number of transformations will be small; the reverse need not to be true! When one travels from London to Amsterdam the distance is very short. However travelling from Amsterdam to London and continuing in the same direction the distance becomes very large indeed!

4. Forward en backward transformations

When we introduced the transformation concept in section 3 we started with the inputs as they arrive at an industry and considered how they are transformed, first by the industry itself and next by succeeding industries. The first of these transformations may be called the industry's "own transformation", the next ones its "forward transformation" since they are obtained by looking forward from the industry. This immediately suggests that one could also look backward, i.e. consider the number of transformations through which each

industry's inputs have gone prior to reaching it. In addition to the two concepts of the industry's own transformation and its forward transformation this yields the concept of backward transformations. All three concepts can also be considered in terms of deliveries between industries (or for that matter from industries to consumption), because each transformation is followed by a delivery. All deliveries of an industry are represented in the total input-output table. Thus we define industry's j own transformation as the delivery of its complete output to other industries or consumption. Given this definition the number of the own transformation equals one and is just the first term of an expansion of (16) in a power series of $\tilde{A}_o$. The pure forward transformations are the indirect deliveries of j to other industries or consumption; they are given by the remaining part of (16). Analogously, the number of backward transformations should be defined as the number of times that the input of j from any industry i has been delivered or any industry (or, equivalently, incorporated in any industry's output) prior to reaching j.

It is useful to illustrate these concepts by means of an example. Consider figure 1. where the simplified stituation is shown in which there are just

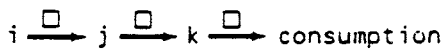

Figure 1. Pure three-industry filière, value added created only in te first industry.

three industries i, j and k, with i delivering to j only, j to k only and k to consumption only. This situation is commonly refered to as a pure 'filière'. In figure 1. the situation is simplified further by assuming that just industry i creates value added and has no other inputs; this is indicated by he rectangles above the arrows. In this case the delivery from i to j is i's "own transformation" and those from j to k and k to consumption are its forward transformations. Similarly, the deliveries from i to j and j to k are the backward transformations of k. For all three industries, the length of the production chain is the same, v.z. three transformations.

In figure 2. the situation differs from that in figure 1. in one respect only: all ndustries now create value added, in equal amounts. For industry i the situation remains the same as in figure 1.: apart from its own transformation its output goes through two forward transformations, yielding a total lenght of the production chain of three. However, for k the situation

differs. There are two contributions to k's output: k's inputs from j and k's own contribution to value added. A part of k's inputs from j has been created in i and has undergone one additional transformation, yielding two backward transformations, while the other part has undergone one backward transformation.

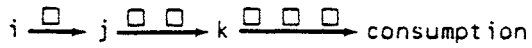

Figure 2. Pure three-industry filière, all industries create equal amounts of value added.

The own contribution of k goes through its own transformation only. Thus we find

$$1/3 \cdot 2 + 1/3 \cdot 1 + 1/3 \cdot 0 = 1$$

backward transformation for k's output. Thus the total length of the production chain for k's output equals 2 transformations, i.e. one backward and one own transformation, whereas this was 2 backward and one own transformation in case of figure 1.

The difference between figures 1 and 2 with respect to the length of k's production chain shows that it depends on the composition of k's <u>total</u> inputs. An industry's 'total inputs' consist of a bundle of physical goods and services, each of which have a different origin. To determine the number of steps through which the 'total inputs' have gone, one has to define a weighting schee for the components of the physical bundle first. In figure 2 these weights were value added. Instead, one might also consider employment as a yardstick, replacing the squares in figure 2 by the amounts of employment added by each industry. In general this generates different chain lengths.

Both forward and backward transformation may be given a "physical" interpretation if a number of simplifying assumptions are made. As was made clear above, they are descibed in terms of deliveries between industries, but the rationale for their definitions lies in the physical interpretations. In the forward case, suppose that each industry produces just one homogeneous product. Then the number of forward transformations from i to consumption is simply the number of times i's products are, on the average, incorporated in other products before they are consumed. Analogously, suppose in the backward case that there is only one homogeneous primary input, dubbed physical value

added for convenience. Then the total number of backward transformations of industry j is the number of times that the average unit of physical value added contained in its input has been incorporated in the products of preceding industries in the production chain, including its original creation. The industry's own transformation can, combining these two cases, be interpreted as the physical transformation of inputs into the industry's own product.

In the forward case, the above interpretation may be thought to hold true if the input-output table is so disaggregated that each industry is defined as producing just one product. In the backward case the interpretation is purely hypothetical, since in reality the case of one homogeneous primary input does not occur. Instead, however, one may replace the purely physical interpretation of backward transformation by that of the number of times a monetary unit of value added is incorporated in products prior to reaching a particular industry. That a monetary unit of value added created in different industries, or in a single industry for different purposes, has a different physical counterpart does not really matter.

5. Ordering of industries

In section 4 we defined the number of backward transformations between the industries i and j in the direction of the flows from i to j, as the number of times that one unit of input created in i is delivered to the industries of the successive production steps, until reaching j. Naturally, this number is also the number of times one unit of output of i is delivered to those industries until reaching j. Consequently, the bilateral number of backward transformations between i and j equals the number of forward transformations from i to j plus one, viz. i's own transformation. This number is found in matrix $\bar{H}_f$.

The discussion of figure 2. in section 4 demonstrated that, in order to obtain the total number of backward transformations of k, the bilateral numbers have to be weighted; in the case of figure 2 this was done with the value added. Generalizing this way of weighting we have to know the flows of cumulated value added from each industry to each other industry. The matrix of cumulated value added coefficients is given by

$$\tilde{A}_v = \hat{\tilde{v}} \{ (I - \tilde{A}_i)^{-1} - I \} \tag{18}$$

The sum of the elements of a column of A_i equals that of A_v:

$$i' \tilde{A}_i = i' \tilde{A}_v \tag{19}$$

or

$$i' \tilde{A}_v + \tilde{v}' = i' \tag{20}$$

Thus the elements of row i of the matrix $\tilde{A}_v$ represent the value added each industry has to create in order to enable the production of one unit of output of the industry corresponding with column j. These are precisely the "flows" with which the numbers of bilateral transformations have to be weighted - analogously to our discussion of figure 2 - in order to arrive at the total number of backward transformations of each industry. A preliminary step thus is to multiply each element of $\tilde{A}_v$ with the corresponding element of $\bar{H}_f$:

$$\bar{H}_b = \tilde{A}_v \otimes \bar{H}_f \tag{21}$$

The operator $\otimes$ is defined such that for any three m x n - matrices Q, R and S holds

$$Q = R \otimes S \Leftrightarrow q_{ij} = r_{ij} \cdot s_{ij}, \{ \forall i,j; 0<i\leq m \wedge 0<j\leq n \} \tag{22}$$

For convenience, the left-hand side of (21) is written analogously to $\bar{H}_f$; however, unlike $\bar{H}_f$, the numbers of bilateral forward transformations, $\bar{H}_b$ is not the matrix of bilateral backward transformations. Instead, $\bar{H}_b$ is a matrix with relative contributions to the numbers of backward transformations. From it, the total length of the backward production chains is easily obtained by adding the cells per column

$$\bar{h}_b' = i' \bar{H}_b \tag{23}$$

Element j of $\bar{h}_b$ now gives industry j's total number of backward transformations. The total number of forward transformations of j is the "bilateral" number of forward transformations from j to consumption. This is the last column of the transformation matrix $\bar{H}_f$. It can be selected by means of a unit vector u with elements u(i)

$$u(i) = o, \quad (i < n); \qquad u(n) = 1 \tag{24}$$

Consequently, the total number of forward transformations of industry j is given by element j of

$$\bar{h}_f = \bar{H}_f \, u \tag{25}$$

Of course it is also possible to look at both bench-marks simultaneously. Adding both vectors we obtain a vector which might be called the total production path

$$\bar{h}_s = \bar{h}_b + \bar{h}_f \tag{26}$$

We now look at the relative position $\bar{q}$ on this path

$$\bar{q} = (\bar{h}_b + 0.5 \; i) : \bar{h}_s \tag{27}$$

In this way we have acquired a new ordering (adding 0.5 i to $\bar{h}_b$ does justice to the fact that the relative position of an industry is defined at half way its "own" transformation). While for triangularization in principle only one kind of ordering exists, we are here confronted with three possibilities. Each of them has its own merits and we cannot conclude that there is a "best" ordering. If we want to characterize industries, it should be based on at least both backward and forward transformations.

6. Characterizing a basket of goods and services

Until now we have characterized industries by means of their numbers of transformations. But we could also have said that in this way we have characterized the goods and services of an industry. Obviously we can extend this to a basket of goods at servies, e.g. imports, exports and consumption. Of course we would like to compare the various baskets. For backward transformations we had chosen to weight the products with their value. For the baskets we will do the same.

We introduce the following scalars

$$s_b^z = z' \, \bar{h}_b \; / \; z' \, i \tag{28}$$

$$s_f^z = z' \, (\bar{h}_f - i) / \; z' \, i \tag{29}$$

where z is a vector containing various products (in value). For z we could substitute m, x or c (imports, exports or consumption, respectively). The substraction by i in (28) is needed because $\bar{h}_f$ still contains the transformation of the industry which produced the goods.

We now define the total chain length and the share of the backward chain respectively:

$$s_s^z = s_b^z + 1 + s_f^z \tag{30}$$

$$s_q^z = (s_b^z + 0.5) \; / \; s_s^z \tag{31}$$

With the help of these four scalars we can determine the number of transformations which were or are expected to be carried out on a product. Applying this to imports and exports should be especially rewarding. It is possible to develop a measure for the share of raw materials in a country's trade or for the extent to which it trades consumer durables. For raw materials the share of the backward chain is low, for durables high. However, one should be very careful in interpreting these figures: Investment goods have a relatively low share of the backward chain, because they undergo forward 'transformations' as they are used. The difference with raw materials, that also go through many forward transformations, becomes clear if one looks at the number of backward transformations instead of the share of this number in the total chain.

For the analysis of a basket the characterization of the consumption should be taken as a bench-mark. This is especially important when we want forward transformations, since consumption is considered to be the end of the production chain. Admittedly this does not hold true for every basket that has the same composition as the consumption basket. It might be conceivable that part of the contents of such basket will be shipped to consumption, part of it to other industries. That's why we find

$$s_f^z > 0 \tag{32}$$

Therefore we can only attribute a meaning to the difference $s_f^z - s_f^c$

7. Transformations weighted with the net value added

When we calculated the numbers of transformations in (15) we assigned to every transformation the same weight. Intuitively we would want to distinguish between industries that do not drastically change their inputs and those that do. Furthermore there are industries which execute more than one transformation where the (outsider) statistician is not able to register them (blast furnaces are a notorious example, smelting, melting and rolling, and where to draw the line?). In these cases the only solution seems to assigndifferent weights to different combinations of transformations.

The importance of the contribution to output by the various industries can best be measured by their value added. So (15) can be transformed to (32.a)

$$\tilde{H}^V = \hat{\tilde{v}}\,\tilde{A}_o + \hat{\tilde{v}}\,\tilde{A}_o^2 + \hat{\tilde{v}}\,\tilde{A}_o^3 \ \ldots + \tag{32.a}$$

$$+ \tilde{A}_o\,\hat{\tilde{v}}\,\tilde{A}_o + \tilde{A}_o\,\hat{\tilde{v}}\,\tilde{A}_o^2 + \tilde{A}_o\,\hat{\tilde{v}}\,\tilde{A}_o^3 + \ldots + \tag{32.b}$$

$$+ \tilde{A}_o^2\,\hat{\tilde{v}}\,\tilde{A}_o + \tilde{A}_o^2\,\hat{\tilde{v}}\,\tilde{A}_o^2 + \tilde{A}_o^2\,\hat{\tilde{v}}\,\tilde{A}_o^3 + \ldots + \tag{32.c}$$

$$+ \ldots$$

which demonstrates how the value added, formed in a particular industry is distributed among various destinations; (32.b) shows the value added to a unit of output after the first round of distributions and the way the newly formed value added has been distributed among those destinations. The third round (32.c) is a repetition of the second one with the understanding that the unit of output now has been distributed for the third time. We are allowed to rearrange the infinite series as

$$\tilde{H}^V = \hat{\tilde{v}}\,\tilde{A}_o + (\hat{\tilde{v}}\,\tilde{A}_o^2 + \tilde{A}_o\,\hat{\tilde{v}}\,A_o) +$$

$$+ (\hat{\tilde{v}}\,\tilde{A}_o^3 + \tilde{A}_o\,\hat{\tilde{v}}\,\tilde{A}_o^2 + \tilde{A}_o^2\,\hat{\tilde{v}}\,A_o) + \ldots \tag{33}$$

Looking at (15) it is easy to see the analogy. Another way to represent the series expansion is

$$\tilde{H}^V = \sum_{i=o}^{\infty} \tilde{A}_o^i\,\hat{\tilde{v}}\,\sum_{k=1}^{\infty} \tilde{A}_o^k$$

$$= (I - \tilde{A}_o)^{-1}\,\hat{\tilde{v}}\,\{(I - \tilde{A}_o)^{-1} - I\} \tag{34}$$

Substituting the diagonal matrix of value added with the identity matrix in (34) we can easily work our way back to (15). The matrix v now weights the various transformations, while the identity matrix assigned the same weight to every transformation.

The next step is to norm the transformations for the cumulated output

$$\bar{H}_f^v = \tilde{H}^v \oslash \{(I - \tilde{A}_o)^{-1} - 1\} \tag{35}$$

Analogous to (25) we obtain the vector with the weighted numbers of forward transformations

$$\bar{h}_f^v = \bar{H}_f^v \, u \tag{36}$$

We now want to know the value added that was formed before a certain transformation. This value is equal to the sum of all inputs. So the vector of the weighted backward transformations can be represented by

$$\bar{h}_b^v = i - \tilde{v} \tag{37}$$

The total length is, analogous to (26) found by

$$\bar{h}_s^v = \bar{h}_b^v + \bar{h}_f^v \tag{38}$$

The relative position in the production chain is given by

$$\bar{q}^v = (\bar{h}_b^v + 0.5\ \tilde{v}) \oslash \bar{h}_s^v \tag{39}$$

Here the individual contribution of an industry to the value added is equal to its value added coefficient. Entirely analogous to ch. 6 we define the scalars $S_b^{z,v}$, $S_f^{z,v}$, $S_s^{z,v}$ and $S_q^{z,v}$ for a basket z.

8. Norming of the unweighted transformations

A comparison between the lengths of the weighted and unweighted is not immediately possible, because both are measured in different units. In the weighted case the unit of measurement is such that the sum of the backward transformations and of the own transformations is one; in contrast, in the

unweighted case the unit of measurement is such that the number of the own transformation is one. Consequently, to obtain comparable concepts, either the weighted chains will have to be adjusted, or the unweighted ones. In the former case, the individual contributions of industries will have to be divided by the value added coefficients in order to standardize the number of (weighted) own transformations at one. But the value added coefficients can be very small, negative or zero. Therefore it is preferable to norm the unweighted chains.

In the weighted case the sum of the backward transformations and the individual contribution adds up to one (cf. (37)).

$$\bar{h}_b^v + \tilde{v} = i \tag{40}$$

We can adjust the unweighted production chains in the same way

$$\bar{h}_b^a + \tilde{a} = i \tag{41}$$

where

$$\tilde{a} = i \oslash (\bar{h}_b + i) \tag{42}$$

This implies

$$\bar{h}_b^a = \bar{h}_b \oslash (\bar{h}_b + i) \tag{43}$$

Thus $\bar{h}_b^a$ indicates, in case of element j, which part of the unweighted production chain up to and including the production of j's products occurs before industry j. Similarly we have

$$\bar{h}_f^a = \bar{h}_f \oslash (\bar{h}_b + i) \tag{44}$$

$$\bar{h}_s^a = \bar{h}_b^a + \bar{h}_f^a \tag{45}$$

$$\bar{q}^a = \bar{q} \tag{46}$$

We now can compare these "normed" unweighted production chains with the weighted chains.

9. Transformations weighted with employment

We will now pay special attention to the weighting with employment because it exemplifies a more general way of weighting. In general, the value added coefficients, which were used for weighting, have some unpleasant properties. They can fluctuate sharply in time, they can become negative and in general should be considered as anunreliable standard.

We can safely assume that when we weight with employment the coefficients will change much more gradually in time. Furthermore they will always be positive and seldom will be close to zero. Also the coefficients will be of much more interest to policy-makers.

In weighting with employment we look - for an industry - at the amount of employment needed to produce a certain quantity of goods that will contain one unit of cumulated employment. We call this relative quantity of employment the "added employment" coeffients. The cumulated coefficients are represented by

$$\tilde{l}' \ (I - \tilde{A}_i)^{-1} \tag{47}$$

Analogous to the way we calculated the value added coefficients we find the added employment coefficients to be the ratio of employment coefficients and cumulated employment coefficients

$$\tilde{w}' = \tilde{l}' \oslash \tilde{l}' \ (I - \tilde{A}_i) \tag{48}$$

We can now substiute $\tilde{w}$ for $\tilde{v}$ in (34) to obtain the weighted employment matrix

$$\tilde{\Pi}^l = (I - \tilde{A}_o)^{-1} \ \hat{\tilde{w}} \ \{(I - \tilde{A}_o)^{-1} - I\} \tag{49}$$

The normed matrix will become

$$\bar{\Pi}_f^l = \bar{\Pi}^l \oslash \{(I - \tilde{A}_o)^{-1} - I\} \tag{50}$$

Here again in the last column of $\bar{\Pi}_f^l$ the vector of the (for employment) weighted forward transformations can be found.

$$\bar{h}_f^l = \bar{H}_f^l \ u \tag{51}$$

In a similar way to the derivations in ch. 8 we obtain the vectors

$$\bar{h}_b^l = i - \tilde{w} \tag{52}$$

$$\bar{h}_s^l = \bar{h}_b^l + \bar{h}_f^l \tag{53}$$

$$\bar{q}^l = (\bar{h}_b^l + 0.5\ \tilde{w}) \ : \ \bar{h}_s^l \tag{54}$$

The vector $\bar{h}_b^l$ indicates the employment quantity which was carried out before a certain (unit) quantity was used up by an industy itself; $\bar{h}_f^l$ displais the quantity used in future (including that of the industry itself) and which can be imputed to that industry. The vector $\bar{h}_s^l$ is a measure for thetotal production chain (weighted with employment) while $\bar{q}^l$ represents therelative position of that industry in the production chain.

10. The adjusted Dutch IO-table

The theory we have developed here has been applied to a Dutch IO-table for the year 1972 which has especially been constructed for studies. The classification used for this table rather differs from the standard classification. To meet the need for homogeneity a table with very large dimensions (317 x 317) was compiled, which included rows and columns for the non-competitive imports (22) and the pseudo-industries (28). The imports concerned were mainly tropical agricultural products, forestry products and minerals. In the columns the input structures were recorded, derived from IO-tables of the countries of origin; the rows contain the c.i.f.-value of the imports. To eliminate the discrepancy between these values and the values in producers' prices in the columns, - estimates were made of the transport costs up to the Dutch border; these were added to the input structures.

For the wholesale trade industry transport costs can take up a large part of the inputs. For the sake of homogeneity four new industries were created. From the input structure of the wholesale trade the transport costs were made explicit and - depending on the type of transport - brought over to one of the four columns. A simular operation was carried out for the rows.

11. The results: the transformations matrix

Even though all calculations were carried out with the help of the 317 x 317 table we the results on an aggregated level of 179 industries. Calculating on

such a disaggregated level eliminates a lot of diagonal elements and, consequently, considerably reduces the problem of circularity. This vastly improves the results.

In table 1. we present a selection from the transformations matrix based on equation (16). Here the distances between the various industries are shown. The selection has been made in such way that, besides a few exemplary production chains, only very long and very short distances are shown.

Whenever we come across long distances this means that the industries involved have nothing or next to nothing to do with each other. Examples are the "other wearing apparel" industry or the non-ferrous metal ore pits with the "other slaughtering" industry. Here more than 8 steps are needed, more than the steps needed for any of these industries to reach the consumer.

The shortest distance is the one between the non-competitive imports of tobacco leaves and the tobacco-processing industry. Here the cumulated output of the imports takes slightly more than one step to reach the processing industry. That it is "slightly more" than one step can be attributed to the cumulated input of both industries from the processing industry.

In general short distances indicate small indirect deliveries. Usually industries are involved which are highly interdependent, like poultry farming and poultry slaughtering, sand pits and ready-mixed concrete industry, etc. But they do not always need to be interdependent: the distance from poultry slaughtering to health and medical services is also - understandably - short. In the case of large diagonal elements the distance of an industry to itself can be very short; this often indicates a high degree of heterogeneity, e.g. perfume and cosmetics industries. Table 2 provides an example of a set of industries where short distances between consecutive industries in a production chain lead to long distances between industries at the beginning and the end of the chain. This shows that long distances between two industries do not always indicate independence.

In general most industries are quite independent of each other. Since in the transformations matrix the extremes dominate one might consider to use this as a measure for the degree of independency between industries. However this won't always do. There are exceptions; one condition is that the production path will pass through a number of industries. An example is given in table 2.

Table 1. A selection from the transformations matrix.
The unweighted distances between some industries and those with consumption are given.

		1	2	3	4	5	6	7	8	9	10
01.10D Poultry farming	1	1.113	4.589	1.068	1.322	2.737	4.434	4.998	4.744	5.510	3.874
19.00 Other mining and quarrying	2	2.864	3.339	3.892	4.822	3.986	3.408	4.696	1.434	2.625	3.328
20.15 Poultry slaughtering	3	5.481	2.796	1.017	5.740	4.593	2.941	2.945	4.108	4.726	2.888
20.11-13 Other slaughtering	4	3.780	4.004	3.073	2.848	2.722	3.957	3.652	4.741	4.008	3.302
21.20 Compounded animal stock feeds	5	1.223	5.710	2.246	2.227	2.026	4.472	2.859	4.549	5.154	4.337
21.70 Tobacco products	6	5.705	3.918	4.980	5.277	4.903	1.139	4.631	3.612	4.404	2.886
23.3-.5 Other wearing apparel	7	7.887	6.438	7.838	8.527	7.505	6.100	1.683	4.030	5.006	6.028
26.10A Paper mills	8	4.605	3.395	3.593	5.323	3.640	2.307	3.668	1.291	1.127	2.278
26.21-.22 Paper bags, rolls and envelopes	9	3.196	1.701	2.484	3.827	2.118	1.209	3.957	3.670	1.534	3.109
29.72 Perfumes and cosmetics	10	5.150	4.330	4.506	5.350	4.251	2.887	4.279	3.898	4.415	1.041
32.53 Ready-mixed concrete	11	5.180	3.892	5.762	5.526	4.994	4.328	4.440	4.668	4.299	4.334
51.1,.3-.5 Construction of buildings	12	4.155	2.858	4.702	4.569	3.991	3.309	3.373	3.620	3.235	3.258
67.00 Hotels, restaurants, cafes	13	4.613	1.693	3.750	4.763	3.805	1.851	1.828	3.017	3.657	1.771
93.5-.9 Health and medical practices	14	1.824	3.950	2.860	2.299	3.588	3.901	3.080	4.937	4.054	3.241
93.1-.4 Health and medical services	15	3.431	2.289	4.079	3.506	4.439	4.884	3.995	4.650	5.165	4.607
NCI.B Cassava	16	2.223	6.710	3.246	3.227	1.173	5.472	3.859	5.549	6.154	5.337
NCI.I Tobacco leafs	17	6.705	4.918	5.980	6.277	5.903	1.001	5.631	4.612	5.404	3.886
NCI.K Wood	18	5.773	5.087	5.664	6.710	5.594	4.192	5.527	1.909	2.978	4.316
NCI.O Non-ferrous metal ores	19	7.723	5.841	7.664	8.209	7.141	5.438	5.890	5.644	6.410	4.880
NCI.S Cellulose	20	5.484	4.250	4.554	6.181	4.513	3.151	4.557	1.027	1.912	3.168

		11	12	13	14	15	16	17	18	19	20	consump.
01.10D Poultry farming	1	5.656	4.588	2.211	4.092	2.297	1.131	4.282	5.648	4.681	5.970	1.696
19.00 Other mining and quarrying	2	1.056	1.748	3.800	3.779	3.538	5.201	2.495	2.140	3.926	1.524	3.916
20.15 Poultry slaughtering	3	4.637	3.619	1.035	2.533	1.059	4.821	2.497	3.728	4.849	4.849	1.068
20.11-13 Other slaughtering	4	5.441	4.102	1.292	3.205	1.517	4.348	3.733	4.501	5.329	4.304	1.485
21.20 Compounded animal stock feeds	5	6.605	4.559	3.447	4.991	3.636	2.548	2.991	6.248	6.327	6.332	3.334
21.70 Tobacco products	6	4.293	3.320	3.200	3.293	2.503	2.811	3.922	4.555	4.391	4.769	1.069
23.3-.5 Other wearing apparel	7	7.787	5.190	6.815	6.536	6.155	7.393	5.966	2.445	2.594	3.003	1.436
26.10A Paper mills	8	4.543	3.580	3.209	3.310	3.361	4.769	4.246	3.201	3.859	4.303	3.627
26.21-.22 Paper bags, rolls and envelopes	9	2.829	3.143	2.586	3.534	2.099	4.011	3.586	2.636	1.632	2.491	2.807
29.72 Perfumes and cosmetics	10	5.223	3.314	2.545	2.142	2.137	4.435	4.015	4.815	4.316	4.975	1.255
32.53 Ready-mixed concrete	11	3.748	1.076	3.778	3.115	3.221	5.544	3.395	3.899	4.438	4.198	4.151
51.1,.3-.5 Construction of buildings	12	2.720	3.105	2.742	2.089	2.192	4.586	2.424	2.950	3.540	3.157	3.165
67.00 Hotels, restaurants, cafes	13	3.526	2.506	3.439	2.235	2.240	3.697	1.420	2.564	3.751	3.753	1.218
93.5-.9 Health and medical practices	14	4.644	4.758	3.558	3.552	3.706	2.736	2.792	3.713	4.053	4.815	1.081
93.1-.4 Health and medical services	15	3.870	4.093	4.105	1.002	2.300	3.351	4.163	4.669	3.457	5.094	1.058
NCI.B Cassava	16	7.605	5.559	4.447	5.991	4.636	3.548	3.991	7.248	7.327	7.332	4.334
NCI.I Tobacco leafs	17	5.293	4.320	4.200	4.293	3.503	3.811	4.922	5.555	5.391	5.769	2.069
NCI.K Wood	18	5.674	2.510	4.958	4.604	4.656	5.419	4.469	4.583	5.097	1.031	4.923
NCI.O Non-ferrous metal ores	19	6.833	4.572	6.524	5.868	5.350	6.520	6.285	5.872	6.524	5.097	6.082
NCI.S Cellulose	20	5.463	4.186	4.012	4.267	4.206	5.672	5.133	4.136	4.836	5.091	4.490

Table 2. A subset of industries in an exemplary production path.

	exact number of steps					rounded number of steps			
	2	3	4	5	cons.	2	3	4	5
1 cassave	1.173	2.223	3.246	4.447	4.334	1	2	3	4
2 animal stock feeds		1.223	2.246	3.447	3.334		1	2	3
3 poultry farming			1.068	2.211	1.696			1	2
4 poultry slaughtering				1.035	1.068				1
5 hotels, restaurants					1.218				

The rounded figures are a fine example of how a "filière" (a sequence of industries, where one industry delivers the main part of its products to the next one which in its turn delivers the main part to ... etc.) should look like. In a real economy we will always meet complicated production loops, which is why the distances are never integers. Products of poultry slaughtering are an example: they can be sold directly to the consumer or reach him via poultry slaughtering and restaurants.

In table 3. another example of a filière is given. Here we notice steps

Table 3. A subset of industries in an exemplary production path.

	exact number of steps				rounded number of steps		
	2	3	4	cons.	2	3	4
1 wood	1.031	1.909	2.976	4.923	1	2	3
2 cellulose		1.027	1.912	4.490		1	2
3 paper mills			1.127	3.627			1
4 paper bags				2.807			

Table 4. Numbers of transformations and ranking numbers.
Numbers of backward and forward transformations, total chain lengths and the relative positions in the production chain are shown.
The resulting ranking numbers are compared with those of a pseudo-triangulation.

		Numbers of transformations				Ranking numbers based on numbers of transform.				triangulation	
		backw.	forw.	chain	relat.	b	f	c	r	inp.	outp.
94.00	Welfare services	.039	.000	1.039	.519	2	1	1	111	6	179
83.00	Real estate etc.	1.333	.000	2.333	.786	93	2	20	176	178	178
91.00	Religious organizations	.061	.000	1.061	.529	3	3	2	117	9	177
68.1,.3-.9	Other repair of consumer goods	.940	.000	1.940	.742	39	4	15	166	141	176
92. nec	Primary and secondary education	.379	.002	1.381	.637	6	5	5	143	174	166
90.60	Army, navy and air force	.681	.004	1.685	.701	25	6	8	156	179	172
92.70	Scientific and equivalent education	.689	.015	1.703	.698	26	7	9	154	176	171
65.,66	Retail trade	.707	.031	1.738	.694	27	8	10	152	103	170
92.90	Other education	.286	.036	1.321	.595	4	9	4	137	85	169
93.1-.4	Health and medical services	.589	.058	1.648	.661	18	10	7	148	172	163
20.15	Poultry slaughtering	3.115	.068	4.183	.864	179	11	87	179	164	131
23.1-.2	Ready-made clothing	1.521	.068	2.589	.781	117	12	26	175	169	160
21.70	Tobacco products	.979	.069	2.048	.722	44	11	16	163	168	165
93.5-.9	Health and medical practices	.427	.081	1.507	.615	12	14	6	140	173	164
90.00A	Local government	.659	.092	1.752	.662	24	15	11	149	46	168
22.5,6	Carpets, rugs, mats, linoleum	1.737	.099	2.836	.788	151	16	19	177	154	156
20.50	Bread, rusk, pastry, cake baking	1.578	.101	2.679	.776	126	17	31	174	163	150
90.00B	Central government	.761	.128	1.890	.669	31	18	12	151	23	173
22.30	Knitting and hosiery mills	1.461	.154	2.615	.758	107	19	30	171	139	159
24.30	Footwear	1.610	.157	2.767	.770	130	20	33	173	140	138
24.20	Leather products	1.607	.179	2.786	.756	129	21	35	170	142	141
NCI.O	Subtropical fruits	.718	.206	1.924	.633	29	22	14	141	112	137
NCI.R	Wines	1.233	.215	2.447	.708	76	23	22	158	147	139
99.00	Wage earning staff of households	.000	.218	1.218	.411	1	24	3	76	12	90
67.00	Hotels, restaurants, cafes	1.262	.218	2.480	.710	82	25	24	160	129	151
25.70	Wooden furniture	1.299	.231	2.530	.711	86	26	25	161	145	154
01.21B	Greenhouse horticulture	.869	.236	2.105	.650	35	27	17	145	124	132
29.72	Perfumes and cosmetics	1.344	.255	2.600	.710	95	28	27	159	134	145
20.70	Processing fruits and vegetables	1.539	.275	2.814	.725	122	29	37	164	128	144
20.90	Cacao, chocolate and sugar confect.	1.635	.297	2.931	.728	134	30	43	166	162	149
21.60	Soft drinks	1.678	.300	2.978	.731	142	31	46	167	114	147
21.30	Other food products	1.686	.326	3.012	.726	143	32	47	165	160	148
95.,96.	Culture, sport and recreation	.528	.364	1.892	.543	16	33	13	122	101	97
20.14,16,17	Meat products, preservation	2.816	.382	4.198	.800	177	34	90	178	125	134
29.71	Soap and cleaning preparations	1.555	.398	2.952	.696	123	35	45	153	119	103
97.1,.4,.9	Business and labour organization	.790	.403	2.193	.588	32	36	19	136	130	99
20.30	Preserving and processing of fish	1.877	.436	3.314	.717	159	37	60	162	115	142
23.3-.5	Other wearing apparel	1.661	.436	3.098	.699	138	38	51	155	166	158
20.11-13	Other slaughtering	2.700	.485	4.184	.765	176	39	86	172	123	111
21.50	Brewing and malting	.929	.546	2.475	.577	38	40	23	132	120	140
20.20	Dairy products	2.084	.585	3.669	.706	167	41	67	157	108	127
37.60	Bicycles and motorcycles	1.697	.587	3.283	.669	145	42	59	150	133	152
76.10	Travel agents	.802	.605	2.407	.541	33	43	21	121	152	92
22.70	Made-up textile goods	1.617	.628	3.265	.655	135	44	57	146	143	89
98.00	Other services	.482	.639	2.122	.463	14	45	18	96	31	146
01.100	Poultry farming	2.982	.696	4.678	.744	178	46	115	169	127	135
72.20	Taxies and motor coach services	1.227	.715	2.942	.647	75	47	44	135	45	91
29.60	Drugs, medicines, antiseptics	1.072	.757	2.828	.555	51	48	38	126	149	133
72.10	Tramways and regular bus services	1.927	.772	3.699	.657	161	49	69	147	39	64
27.2-.3	Publishing and binding	1.447	.780	3.227	.609	105	50	55	136	42	98
40.30	Water works and supply	1.018	.826	2.844	.555	49	51	40	125	80	68
21.40	Distilling, alcoholic liquors	1.785	.831	3.616	.639	153	52	85	144	161	143
29.94-.99	Other chemical products	1.164	.900	3.064	.545	65	53	48	121	116	69
75.10	Air transport business	1.321	.959	3.250	.555	90	54	58	127	50	77
01.21A	Open air horticulture	.628	.976	2.604	.431	21	55	29	86	98	123
25.5-.6	Other wood products, cork, brushes	1.070	.998	3.068	.521	52	56	49	114	35	86
68.20	Repair of motorcars	1.037	1.034	3.071	.500	51	57	50	110	5	62
NCI.I	Tobacco leafs	.727	1.069	2.796	.439	30	58	36	89	167	153
26.23-.29	Other paper products	1.692	1.069	3.762	.584	144	59	72	133	76	76
34.50	Metal furniture	1.332	1.168	3.501	.523	91	60	62	116	144	136
32.20	Pottery, china and earthenware	.715	1.181	2.898	.419	28	61	41	82	157	73
82.00	Insurance	1.333	1.186	3.519	.521	92	62	63	115	10	102
24.10	Tanneries and leather finishing	2.475	1.199	4.674	.636	174	63	114	142	132	112
22.40	Finishing textiles	1.663	1.210	3.874	.567	139	64	74	131	131	79
NCI.G	Coffee-berries	.347	1.254	2.602	.328	7	65	28	36	151	116
NCI.H	Thea-leafs	.869	1.256	3.125	.438	36	66	53	88	158	110
77.00	Communication	.646	1.266	2.912	.394	22	67	42	69	1	93
97.50	Research institutions	.512	1.269	2.782	.364	15	68	34	55	43	100
NCI.F	Cacao-beans	.391	1.297	2.688	.312	10	69	32	40	153	109
01.10C	Pig breeding	2.437	1.349	4.787	.614	173	70	117	139	122	106
29.91-.93	Glues, office requisites	1.716	1.413	4.129	.568	148	71	85	124	126	54
20.50	Sugar factories and refineries	1.957	1.426	4.383	.581	164	72	98	129	99	125
03.00	Fishing	1.220	1.446	3.666	.469	72	73	66	100	111	120
22.10	Wool products	1.953	1.452	4.406	.566	163	74	100	130	137	88
20.40	Flour mills, husking	1.301	1.453	3.753	.480	87	75	71	104	113	126
40.20	Gas distribution	1.276	1.461	3.737	.489	84	76	70	107	19	50
22.90	Other textiles	1.726	1.464	4.190	.537	149	77	89	120	136	83
40.10	Electricity generation / distribut.	1.506	1.480	3.986	.510	113	78	78	112	20	56
22.20	Cotton products	1.526	1.499	4.025	.504	119	79	79	111	32	87
81.00	Banking	.603	1.520	3.122	.353	19	80	52	48	7	101
37.1,.7,.9	Motor vehicles, aircrafts	1.799	1.547	4.346	.531	154	81	96	119	144	161
38.00	Instrument engineering	1.249	1.555	3.804	.486	79	82	73	105	81	122
32.81	Glass	.977	1.574	3.551	.416	41	83	64	79	58	94
28.00	Petroleum refineries, cokes, tar	2.422	1.591	5.013	.587	172	84	131	134	14	49
34.80	Tools, cutlery, locks, keys etc.	1.249	1.643	3.892	.449	78	85	75	94	79	42
39.00	Other manufactoring industries	1.978	1.653	4.631	.560	166	86	110	128	83	128
01.10B	Dairy cattle, cattle raising	1.399	1.669	4.068	.467	101	87	81	98	100	107
31.30	Plastic products	1.627	1.714	4.241	.478	120	88	91	102	30	59
31.1-.2	Rubber products, tyre retreading	1.883	1.749	5.971	.434	73	89	77	87	34	61
34.78	Heating and cooking appliances	1.819	1.788	4.884	.471	116	90	93	101	117	119

Table 4. Numbers of transformations and ranking numbers.
Numbers of backward and forward transformations, total chain lengths and the relative positions in the production chain are shown.
The resulting ranking numbers are compared with those of a pseudo-triangulation.

		Numbers of transformations				Ranking numbers based on numbers of transforms.				Ranking numbers based on triangulation	
		backw.	forw.	chain	relat.	b	f	c	r	inp.	outp.
37.20	Motor vehicle bodies, trailers	1.615	1.799	4.414	.479	132	91	101	103	148	124
26.31	Corrugated board mills	1.808	1.805	4.614	.500	156	92	109	109	78	58
26.21-.22	Paper bags, rolls and envelopes	1.707	1.807	4.514	.489	146	93	103	106	53	65
26.32	Folding cartons	1.507	1.818	4.325	.464	114	94	95	97	77	57
61.-64.	Excl. 62.9 wholesale trade	1.196	1.834	4.031	.418	70	95	80	80	3	104
52.30	Electr. engineering on constructions	1.083	1.858	3.941	.402	54	96	76	73	15	43
27.10	Printing	1.403	1.866	4.268	.440	102	97	92	90	38	66
84.00	Business services	.313	1.893	3.206	.254	6	98	54	7	2	84
29.43	Synthetic perfumeus and flavours	1.640	1.926	4.566	.469	136	99	107	99	110	51
85.00	Renting of movables	.482	1.951	3.433	.286	13	100	61	14	6	19
32.3,32.6,32.82-.83	Oth. glass, stone art.	1.139	1.959	4.098	.413	80	101	83	78	171	34
NCI.C	Tropical food products	.291	1.972	3.262	.242	5	102	56	4	106	108
36.00	Electrical engineering	1.109	1.989	4.098	.399	56	103	84	70	4	155
71.00	Railways	1.615	2.039	4.653	.455	131	104	113	95	21	76
20.60	Margarine, oils and fats	2.377	2.046	5.423	.530	171	105	141	118	109	135
34.60	Metal packaging	1.536	2.058	4.594	.443	121	106	108	92	68	37
51.20	Civil engineering	1.019	2.066	4.086	.372	50	107	82	58	177	75
51.1,.3-.5	Construction of buildings	1.361	2.165	4.526	.412	98	108	105	77	18	157
01.10A	Arable farming	1.115	2.173	4.280	.377	57	109	94	61	95	85
52.1,.2	Plumbing, central heating install.	1.190	2.207	4.397	.384	68	110	99	63	118	110
29.498,30.00	Other organic chem., fibres	1.709	2.231	4.939	.448	147	111	125	93	28	46
29.50	Paints, lacquers, varnishes, ink	1.566	2.248	4.814	.430	125	112	120	84	74	55
12.00	Crude oil and natural gas	.423	2.262	3.685	.250	11	113	68	6	11	46
25.40	Wooden containers	1.167	2.292	4.459	.374	66	114	102	59	66	16
21.20	Compounded animal stock feeds	2.305	2.334	5.639	.497	170	115	151	106	121	174
34.10	Forge, stamping and pressing	1.348	2.443	4.791	.386	97	116	118	64	65	5
NCI.M	Crude oil	1.465	2.449	4.914	.400	108	117	123	71	13	47
37.30	Motor vehicle parts and accessories	1.502	2.482	4.954	.404	112	118	127	74	91	60
29.42A	Basic inorganic chemicals n.e.s.	1.667	2.478	5.145	.420	141	119	134	81	33	32
34.90	Blacksmiths' workshops	1.160	2.485	4.646	.357	64	120	112	51	75	18
72.4,74.2,76.2,.3	Transport supporting serv	.588	2.566	4.154	.283	17	121	86	8	47	95
72.30	Freight transport by road	.944	2.589	4.533	.319	40	122	106	31	40	96
29.80	Chemical pesticides	1.964	2.607	5.572	.442	165	123	151	91	51	81
29.30	Pigments and dyes	1.734	2.612	5.346	.418	150	124	141	81	71	33
11.00	Coal mining	1.196	2.616	4.811	.356	69	125	119	50	155	22
26.10C	Regeneration of old paper	1.524	2.622	5.146	.393	118	126	135	68	55	52
26.10A	Paper mills	1.873	2.627	5.500	.432	158	127	146	85	37	51
29.20	Synthetic resins	1.494	2.634	5.129	.384	111	128	133	65	29	41
25.1-.2	Wood sawing, plywood, veneer	.994	2.644	4.637	.323	45	129	111	33	17	71
62.90	Scrap and waste materials trade	.856	2.668	4.524	.300	34	130	104	19	49	3
25.30	Builders' carpentry, parquet	1.157	2.755	4.913	.337	63	131	122	44	88	114
75.20	Business allied to air transport	1.151	2.787	4.938	.334	62	132	124	42	41	8
21.10	Starch and starch derivatives	1.625	2.799	5.424	.393	133	133	144	87	107	44
37.40	Shipbuilding and repairing	1.493	2.803	5.296	.376	110	134	139	80	97	162
32.10	Bricks and roofing tiles	.971	2.815	4.786	.307	42	135	116	23	159	74
26.10B	Board mills	1.818	2.835	5.653	.410	157	136	154	75	52	48
29.10	Synthetic fertilizers	1.667	2.854	5.520	.390	140	137	147	66	71	60
32.70	Non-metalic mineral products	1.293	2.856	5.149	.348	85	138	136	47	102	23
32.51	Concrete articles	1.117	2.878	4.994	.324	58	139	129	14	170	72
19.00	Other mining and quarrying	.965	2.916	4.881	.303	41	140	121	21	25	24
32.52,.54	Other concrete and cement artici.	1.307	2.940	5.248	.344	89	141	138	45	135	70
29.41	Industrial gases	1.017	2.941	4.959	.306	48	142	128	22	54	2
NCI.J	Cotton and wool	.389	2.957	4.346	.202	9	143	97	1	24	82
35.70	Steam-boilers, engines and turbines	1.254	3.043	5.297	.331	80	144	140	39	93	31
35.20	Metal working machinery	1.103	3.076	5.179	.309	55	145	137	25	87	20
02.00	Forestry and logging	.918	3.079	4.996	.284	37	146	130	11	150	14
NCI.E	Palm oil, palm-kernels	.994	3.087	5.082	.294	46	147	132	16	72	17
NCI.A	Maize and soy beans	1.393	3.095	5.488	.345	100	148	145	46	104	115
32.53	Ready-mixed concrete	1.649	3.151	5.801	.371	137	149	158	57	44	63
29.49A	Petrochemicals	1.929	3.155	6.084	.400	162	150	166	72	22	36
35.90	Other machinery	1.217	3.159	5.376	.319	71	151	142	32	64	121
29.42B	Basic inorganic electro-chemicals	1.555	3.208	5.763	.358	124	152	157	52	27	29
34.40	Other structural engineering	1.267	3.290	5.557	.318	83	153	150	30	84	118
34.02	Non-ferrous metal foundries	1.239	3.297	5.535	.314	77	154	148	28	67	11
NCI.B	Cassava	.615	3.334	4.950	.225	20	155	126	3	105	167
NCI.L	Coal	1.460	3.448	5.908	.332	106	156	160	41	156	28
NCI.S	Cellulose	1.508	3.490	5.998	.335	115	157	164	43	36	36
35.60	Other industrial machinery	1.415	3.501	5.916	.324	103	158	161	35	138	21
35.60	Office machinery	1.226	3.518	5.743	.300	74	159	155	20	90	30
34.20	Screws, bolts, nuts, springs	1.473	3.539	6.013	.328	109	160	165	38	82	12
34.01	Iron and steel foundries	.997	3.542	5.539	.270	47	161	149	9	69	8
NCI.P	Minerals	1.804	3.551	6.355	.363	155	162	171	51	61	27
35.40	Lifting and transporting machinery	1.342	3.564	5.906	.312	94	163	159	27	94	39
37.50	Railway equipment	1.345	3.588	5.933	.311	96	164	162	26	175	175
33.30	Wire drawing, steel cold rolling	1.746	3.593	6.339	.354	152	165	170	49	62	35
35.50	Gears, bearings etc.	1.128	3.624	5.751	.283	59	166	156	12	89	13
32.40	Cement, lime and plaster	1.372	3.714	6.086	.307	99	167	169	24	26	26
33.20	Steel pipes and tubes	1.922	3.731	6.652	.364	160	168	175	56	70	4
35.10	Agricultural machinery and equipment	1.304	3.751	6.055	.298	88	169	167	17	96	119
NCI.Q	Stones	1.260	3.773	6.033	.292	81	170	166	15	165	25
35.30	Machinery for food and chem. industr	1.184	3.791	5.976	.282	67	171	163	11	88	40
73.00	Sea transport	1.606	3.831	6.436	.327	128	172	173	37	56	7
NCI.K	Wood	.649	3.923	5.672	.207	23	173	152	2	16	15
34.30	Tanks, reservoirs, industr. piping	1.517	3.992	6.409	.299	104	174	172	18	92	67
33.1,.4	Basic iron and non-ferrous metal	2.209	4.111	7.320	.383	169	175	176	54	60	117
NCI.T	Copper	2.535	4.388	7.923	.383	175	176	178	62	63	10
74.10	Inland water transport business	1.141	4.496	6.637	.247	61	177	174	5	48	1
NCI.N	Iron-ore	1.600	4.858	7.458	.282	127	178	177	10	67	113
NCI.O	Non-ferrous metal ores	2.098	5.068	8.178	.317	168	179	179	29	89	9

that are smaller than the rounded figures in the table. This is due to the phenomenon of the 'by-pass' where part of an industries' output will "jump" over another industry, while the rest of the output still will flow through that industry. Clearly, for the average distance a by-pass can overcompensate present production loops.

Returning to table 1. we notice that the transformations matrix is not symmetric. Just look at both tobacco leaves to tobacco-processing industry (1.001) and wearing apparel to other slaughtering (8.527): for the other way around the distances are 3.922 and 3.652 respectively.

Finally we draw attention to the fact that the distance from an industry that produces nothing but capital goods to any other industry should be longer than 2 by definition.

12. Results: production chains and ordering

Table 4. gives the unweighted numbers of transformations by industry. The first column, derived from eq. (23), gives the length of the backward chain; the second one based on eq. (25) the forward chain; the third one (based on eq. (26)) the total chain length; and the fourth column column (based on eq. (27)). the relative positions of the industries in the chains. The next four columns indicate which rank each industry has with respect to the variables of the first four columns, respectively. Finally, in the last column of the table we find the rankings that resulted from a pseudo-triangularization. Here "pseudo" indicates that not all possibles permutations were taken into account: we have restricted ourselves to all possible binary permutations and removals cum insertions into another position of sequences of industries.

Discussing the results we start with the backward transformations. The industries with less than half a backward transformation may be considered as a kind of "basic" industries: they create almost all value added incorporated in their own products by themselves. In this group we encounter education, crude oil and natural gas exploration, several non-competitive agricultural tropical products, various services, all of them with small inputs. Note that this group contains a number of industries that do not belong to the primary sector as usually defined. Moreover the primary subgroups of Dutch agriculture do not belong to the group of "basic" industries but to the next group of 0.5 - 1.5

transformations. Here we also find services that use a lot of devices, like research instruments. The range of the numbers of backward transformations is not very wide: at its furthest (2.5 - 3.5) we find industries like slaughtering and poultry farming and the imports of copper.

The numbers of forward transformations have made a much wider range. Industries with less than half a transformation can be considered as being typically consumption-oriented. So we find greenhouse horticulture, various food-processing, textile and leather industries, soap and cleaning preparations, perfumes and cosmetics, retail trade etc. The imports of ores are the furthest away from the consumer (about 5 transformations). For all industries the distance to the consumer as displayed in table 4. is intuitively appealing.

Table 5. Numbers of industries in various ranges of the backward and forward transformations.

backward / forward	0 - 0.5	0.5 - 1.5	1.5 - 2.5	2.5 - 3.5	total
0 - 0.5	6	18	12	3	39
0.5 - 1.5	3	21	15	1	40
1.5 - 2.5	4	19	18		41
2.5 - 3.5	1	25	11		37
3.5 - 4.5		14	5	1	20
4.5 - 5.5			2		2
total	14	97	63	5	179

Table 6. Normalized numbers of transformations.
The numbers of backward and forward transformations and the resulting relative positions in the production chain are shown according to three different weighting methods.

	Numbers of transformations								
	Unweighted transform.			Value added			Labour		
	backw.	forw.	relat.	backw.	forw.	relat.	backw.	forw.	relat.
94.00 Welfare services	.037	.000	.519	.010	.000	.505	.007	.000	.503
68.1,.3-.9 Other repair of consumer goods	.465	.000	.742	.385	.000	.692	.239	.000	.620
83.00 Real estate etc.	.571	.000	.786	.444	.000	.722	1.000	.000	1.000
91.00 Religious organizations	.058	.000	.529	.016	.000	.508	.008	.000	.504
92. nec Primary and secondary education	.275	.001	.637	.159	.001	.579	.217	.001	.608
90.60 Army, navy and air force	.405	.002	.701	.303	.002	.650	.271	.002	.634
92.70 Scientific and equivalent education	.408	.009	.696	.323	.007	.657	.437	.007	.715
65.,66 Retail trade	.414	.018	.696	.273	.010	.630	.209	.009	.599
92.90 Other education	.222	.028	.595	.112	.013	.549	.087	.013	.537
93.5-.9 Health and medical practices	.299	.056	.615	.188	.030	.577	.424	.027	.694
20.15 Poultry slaughtering	.757	.016	.864	.852	.028	.901	.883	.030	.914
21.70 Tobacco products	.495	.035	.722	.541	.031	.747	.892	.031	.918
23.1-.2 Ready-made clothing	.603	.027	.781	.655	.024	.808	.533	.031	.743
93.1-.4 Health and medical services	.371	.037	.661	.225	.040	.589	.202	.033	.581
22.5.6 Carpets, rugs, mats, linoleum	.635	.036	.788	.715	.039	.827	.747	.033	.847
NCI.R Wines	.552	.096	.708	.510	.061	.712	.247	.042	.599
90.00A Local government	.397	.056	.662	.251	.047	.597	.268	.044	.607
20.80 Bread, rusk, pastry, cake baking	.612	.039	.776	.597	.048	.762	.504	.053	.714
22.30 Knitting and hosiery mills	.594	.063	.758	.622	.055	.771	.581	.057	.751
24.30 Footwear	.617	.060	.770	.572	.069	.751	.537	.057	.739
90.00B Central government	.432	.073	.669	.354	.066	.636	.445	.060	.682
24.20 Leather products	.616	.068	.756	.585	.077	.736	.527	.077	.709
25.70 Wooden furniture	.565	.101	.711	.544	.091	.708	.494	.068	.687
20.30 Preserving and processing of fish	.652	.152	.717	.819	.109	.820	.857	.093	.850
67.00 Hotels, restaurants, cafes	.558	.097	.710	.494	.101	.679	.383	.094	.632
20.90 Cacao, chocolate and sugar confect.	.620	.113	.728	.718	.107	.776	.872	.096	.854
20.70 Processing fruits and vegetables	.606	.108	.725	.675	.101	.754	.774	.100	.807
NCI.O Subtropical fruits	.418	.120	.633	.312	.089	.602	.199	.105	.542
20.14,16,17 Meat products, preservation	.738	.100	.800	.841	.112	.832	.875	.106	.851
01.100 Poultry farming	.749	.175	.744	.920	.132	.848	.916	.108	.865
01.21B Greenhouse horticulture	.465	.126	.650	.323	.112	.595	.317	.112	.592
20.11-13 Other slaughtering	.730	.111	.765	.965	.132	.869	.984	.127	.880
21.30 Other food products	.628	.122	.726	.762	.126	.782	.910	.134	.842
NCI.I Tobacco leafs	.421	.619	.439	.283	.490	.431	.026	.138	.451
21.60 Soft drinks	.627	.112	.731	.624	.128	.720	.658	.142	.726
29.71 Soap and cleaning preparations	.609	.156	.696	.614	.156	.698	.722	.143	.753
20.20 Dairy products	.676	.190	.706	.837	.164	.790	.902	.144	.832
23.3-.5 Other wearing apparel	.624	.164	.699	.623	.125	.721	.539	.152	.690
99.00 Wage earning staff of households	.000	.218	.411	.000	.138	.439	.000	.154	.433
97.1,.4,.9 Business and labour organization	.441	.225	.588	.365	.177	.580	.445	.171	.617
01.10C Pig breeding	.709	.392	.614	.764	.200	.735	.860	.171	.794
29.72 Perfumes and cosmetics	.573	.109	.710	.631	.175	.694	.600	.184	.675
95.,96. Culture, sport and recreation	.345	.238	.543	.243	.198	.519	.273	.185	.517
NCI.G Coffee-berries	.258	.931	.326	.140	.332	.428	.045	.207	.433
NCI.H Thea-leafs	.465	.672	.438	.328	.333	.498	.020	.208	.422
NCI.F Cacao-beans	.281	.932	.332	.146	.389	.412	.031	.223	.422
03.00 Fishing	.550	.651	.469	.419	.295	.556	.464	.240	.591
37.60 Bicycles and motorcycles	.629	.218	.669	.645	.230	.669	.594	.258	.634
22.70 Made-up textile goods	.621	.238	.655	.607	.265	.635	.614	.263	.639
01.108 Dairy cattle, cattle raising	.583	.696	.467	.489	.326	.561	.505	.270	.592
21.50 Brewing and malting	.482	.283	.577	.408	.254	.561	.579	.278	.618
01.21A Open air horticulture	.386	.600	.433	.255	.375	.456	.283	.303	.492
76.10 Travel agents	.445	.336	.541	.370	.307	.524	.331	.312	.507
20.60 Margarine, oils and fats	.704	.606	.610	.870	.441	.649	.966	.326	.741
72.10 Tramways and regular bus services	.658	.264	.657	.660	.349	.616	.374	.333	.516
72.20 Taxies and motor coach services	.551	.321	.587	.430	.349	.530	.261	.335	.472
NCI.C Tropical food products	.225	1.528	.242	.123	.469	.382	.012	.342	.377
98.00 Other services	.325	.431	.463	.197	.372	.436	.098	.353	.406
20.50 Sugar factories and refineries	.662	.462	.561	.821	.412	.645	.874	.358	.690
40.30 Water works and supply	.504	.409	.555	.390	.362	.517	.475	.359	.551
34.50 Metal furniture	.571	.501	.523	.538	.397	.551	.522	.385	.549
27.2-.3 Publishing and binding	.591	.319	.609	.647	.398	.598	.684	.396	.615
75.10 Air transport business	.569	.413	.555	.691	.419	.596	.690	.400	.604
32.20 Pottery, china and earthenware	.417	.690	.419	.310	.461	.448	.271	.404	.452
29.60 Drugs, medicines, antiseptics	.517	.385	.555	.486	.438	.517	.594	.407	.566
25.5-.6 Other wood products, cork, brushes	.517	.482	.521	.495	.414	.536	.375	.415	.493
21.40 Distilling, alcoholic liquors	.641	.299	.639	.655	.383	.603	.670	.415	.594
NCI.A Maize and soy beans	.582	1.294	.345	.573	.436	.481	.582	.428	.554
68.20 Repair of motorcars	.509	.808	.500	.410	.440	.490	.285	.429	.458
29.94-.99 Other chemical products	.538	.416	.545	.462	.441	.510	.522	.431	.535
26.23-.29 Other paper products	.629	.397	.584	.637	.469	.559	.680	.441	.585
22.40 Finishing textiles	.625	.454	.587	.384	.422	.495	.536	.444	.545
51.1,.3-.5 Construction of buildings	.577	.916	.412	.598	.729	.442	.541	.465	.530
21.20 Compounded animal stock feeds	.697	.706	.497	.662	.551	.600	.958	.465	.668
28.40 Flour mills, husking	.565	.832	.480	.682	.446	.574	.940	.477	.656
82.00 Insurance	.571	.509	.521	.518	.530	.496	.564	.478	.529
01.10A Arable farming	.527	1.027	.377	.428	.609	.444	.431	.494	.479
22.10 Wool products	.661	.492	.586	.762	.459	.608	.722	.501	.578
39.00 Other manufactoring industries	.664	.555	.560	.666	.530	.562	.663	.506	.568
NCI.B Cassava	.381	2.064	.225	.264	.689	.374	.013	.507	.336
22.90 Other textiles	.633	.537	.537	.704	.509	.572	.735	.520	.575
NCI.E Palm oil, palm-kernels	.499	1.548	.294	.388	.716	.405	.113	.523	.365
24.10 Tanneries and leather finishing	.712	.345	.616	.773	.472	.602	.793	.527	.587
37.1,.7,.9 Motor vehicles, aircrafts	.643	.553	.531	.740	.533	.575	.733	.532	.571
40.20 Gas distribution	.561	.642	.489	.754	.565	.567	.660	.544	.543
32.81 Glass	.494	.796	.416	.393	.625	.429	.415	.572	.460
40.10 Electricity generation / distribut.	.601	.591	.510	.548	.602	.486	.635	.576	.521
72.4,74.2,76.2,.3 Transport supporting serv	.370	1.616	.263	.238	.616	.384	.106	.578	.415
22.20 Cotton products	.604	.593	.504	.689	.542	.550	.823	.579	.579
72.30 Freight transport by road	.486	1.331	.319	.429	.629	.439	.403	.582	.444

Table 6. Normalized numbers of transformations.
The numbers of backward and forward transformations and the resulting relative positions in the production chain are shown according to three different weighting methods.

	Numbers of transformations								
	Unweighted transform.			Value added			Labour		
	backw.	forw.	relat.	backw.	forw.	relat.	backw.	forw.	relat.
77.00 Communication	.393	.769	.394	.253	.623	.386	.286	.587	.405
29.91-.93 Glues, office requisites	.632	.520	.548	.650	.629	.531	.635	.592	.534
38.00 Instrument engineering	.555	.691	.486	.534	.610	.498	.521	.598	.496
28.00 Petroleum refineries, cokes, tar	.708	.465	.587	.953	.637	.605	.910	.616	.601
NCI.M Crude oil	.594	.993	.400	.514	.606	.472	.951	.618	.603
52.30 Electr. engineering on constructions	.520	.892	.402	.474	.762	.418	.323	.625	.407
37.20 Motor vehicle bodies, trailers	.618	.686	.479	.648	.606	.513	.566	.625	.482
34.80 Tools, cutlery, locks, keys etc.	.555	.731	.449	.685	.646	.451	.451	.626	.446
21.10 Starch and starch derivatives	.619	1.066	.393	.680	.784	.475	.867	.630	.576
32.3,32.6,32.82-.83 Oth. glass, stone art.	.532	.916	.413	.495	.772	.434	.533	.651	.474
31.1-.2 Rubber products, tyre retreading	.550	.787	.434	.500	.659	.452	.547	.659	.466
97.50 Research institutions	.339	.840	.364	.202	.744	.345	.226	.677	.366
81.00 Banking	.376	.948	.353	.201	.769	.339	.367	.681	.407
52.1,.2 Plumbing, central heating install.	.543	1.008	.384	.457	.867	.390	.367	.689	.405
29.43 Synthetic perfumees and flavours	.621	.730	.469	.645	.771	.464	.696	.693	.501
61.-64. Excl. 62.9 wholesale trade	.545	.835	.418	.574	.712	.463	.562	.696	.465
84.00 Business services	.238	1.442	.254	.110	.782	.311	.121	.696	.331
31.30 Plastic products	.604	.678	.478	.608	.716	.469	.534	.697	.452
71.00 Railways	.618	.780	.455	.587	.736	.457	.374	.702	.404
34.70 Heating and cooking appliances	.603	.701	.471	.575	.745	.451	.540	.705	.452
34.60 Metal packaging	.606	.811	.443	.623	.758	.462	.617	.707	.474
26.21-.22 Paper bags, rolls and envelopes	.631	.667	.469	.647	.752	.471	.606	.710	.470
51.20 Civil engineering	.505	1.023	.372	.447	.836	.394	.413	.764	.400
26.31 Corrugated board mills	.644	.643	.500	.671	.789	.467	.633	.765	.463
36.00 Electrical engineering	.526	.943	.399	.499	.769	.428	.515	.772	.433
26.32 Folding cartons	.601	.725	.464	.617	.801	.449	.567	.778	.441
NCI.J Cotton and wool	.280	2.129	.202	.151	.990	.290	.024	.783	.287
12.00 Crude oil and natural gas	.297	1.590	.250	.180	776	.332	.814	.792	.506
29.50 Paints, lacquers, varnishes, ink	.618	.876	.430	.609	.897	.428	.617	.803	.465
29.498,30.00 Other organic chem., fibres	.631	.824	.448	.628	.824	.451	.734	.820	.480
27.10 Printing	.584	.776	.440	.512	.853	.407	.486	.825	.408
11.00 Coal mining	.544	1.192	.356	.509	1.019	.378	.394	.825	.361
25.30 Builders' carpentry, parquet	.536	1.277	.337	.551	.992	.389	.519	.862	.413
75.20 Business allied to air transport	.535	1.296	.334	.442	.974	.365	.590	.888	.421
34.10 Forge, stamping and pressing	.574	1.040	.386	.522	.912	.398	.485	.895	.392
85.00 Renting of movables	.325	1.317	.286	.186	.995	.297	.372	.898	.361
62.90 Scrap and waste materials trade	.461	1.438	.300	.335	.954	.342	.349	.904	.354
37.40 Shipbuilding and repairing	.579	1.125	.376	.610	.943	.420	.625	.923	.423
25.40 Wooden containers	.539	1.057	.374	.587	.924	.413	.583	.924	.411
29.30 Pigments and dyes	.634	.955	.418	.642	.998	.411	.696	.936	.438
29.10 Synthetic fertilizers	.625	1.070	.390	.649	1.028	.407	.685	.937	.435
32.52,.54 Other concrete and cement articl.	.567	1.274	.344	.534	1.131	.360	.648	.957	.421
25.1-.2 Wood sawing, plywood, veneer	.498	1.326	.323	.477	1.031	.365	.396	.961	.357
32.10 Bricks and roofing tiles	.493	1.429	.307	.391	1.119	.328	.377	.962	.351
29.80 Chemical pesticides	.663	.880	.442	.724	1.016	.427	.730	.973	.438
32.53 Ready-mixed concrete	.623	1.189	.371	.690	1.168	.390	.759	.974	.446
32.51 Concrete articles	.528	1.360	.324	.484	1.134	.348	.441	.974	.365
29.42A Basic inorganic chemicals n.e.c.	.625	.929	.420	.681	1.057	.409	.695	.974	.430
37.30 Motor vehicle parts and accesoires	.600	.980	.404	.552	.912	.406	.536	.977	.389
32.70 Non-metalic mineral products	.564	1.245	.348	.547	1.107	.367	.415	.980	.357
34.90 Blacksmiths' workshops	.537	1.151	.357	.428	1.024	.353	.343	.996	.336
29.41 Industrial gases	.504	1.458	.306	.420	1.129	.333	.521	1.022	.376
35.70 Steam-boilers, engines and turbines	.556	1.350	.331	.560	1.052	.380	.547	1.042	.379
35.60 Other industrial machinery	.506	1.450	.324	.595	1.109	.379	.563	1.065	.378
29.20 Synthetic resins	.599	1.056	.389	.580	1.077	.380	.749	1.067	.423
29.428 Basic inorganic electro-chemicals	.609	1.255	.358	.596	1.211	.364	.693	1.067	.413
35.10 Agricultural machinery and equipment	.566	1.628	.298	.547	1.147	.360	.588	1.079	.382
19.00 Other mining and quarrying	.491	1.484	.303	.399	1.202	.321	.556	1.080	.377
34.40 Other structural engineering	.559	1.452	.318	.523	1 200	.346	.509	1.080	.363
73.00 Sea transport	.616	1.470	.327	.750	1.329	.378	.694	1.088	.406
35.90 Other machinery	.549	1.425	.319	.505	1.127	.354	.496	1.093	.357
35.40 Lifting and transporting machinery	.573	1.522	.312	.572	1.143	.367	.552	1.102	.369
29.49A Petrochemicals	.659	1.077	.400	.681	1.212	.382	.766	1.106	.419
26.10C Regeneration of old paper	.604	1.039	.391	.641	1.102	.390	.802	1.110	.427
35.20 Metal working machinery	.524	1.443	.309	.443	1.133	.338	.400	1.115	.331
26.10A Paper mills	.652	.914	.432	.742	1.170	.401	.675	1.139	.392
NCI.P Minerals	.643	1.267	.363	.705	1.280	.374	.734	1.155	.402
34.30 Tanks, reservoirs, industr. piping	.586	1.651	.299	.536	1.205	.349	.506	1.165	.346
35.80 Office machinery	.551	1.581	.300	.542	1.211	.349	.648	1.173	.379
26.10B Board mills	.645	1 006	.410	.704	1.182	.398	.597	1.195	.384
37.50 Railway equipment	.573	1.530	.311	.553	.987	.391	.509	1.198	.343
34.01 Iron and steel foundries	.499	1.773	.270	.389	1.244	.309	.332	1.200	.303
35.30 Machinery for food and chem. industr	.542	1.736	.282	.506	1.244	.336	.517	1.201	.345
34.02 Non-ferrous metal foundries	.553	1.473	.314	.387	1.242	.309	.503	1.210	.340
33.20 Steel pipes and tubes	.658	1.277	.364	.778	1.284	.389	.697	1.219	.382
NCI.L Coal	.594	1.402	.332	.571	1.356	.333	.628	1.246	.362
02.00 Forestry and logging	.479	1.605	.284	.373	1.246	.306	.501	1.278	.330
74.10 Inland water transport business	.533	2.100	.247	.512	1.255	.335	.381	1.283	.302
32.40 Cement, lime and plaster	.578	1.566	.307	.536	1.450	.314	.576	1.286	.345
33.30 Wire drawing, steel cold rolling	.636	1.309	.354	.689	1.358	.358	.635	1.308	.354
35.50 Gears, bearings etc.	.530	1.703	.283	.476	1.345	.315	.436	1.331	.308
34.20 Screws, bolts, nuts, springs	.596	1.431	.328	.546	1.344	.330	.466	1.333	.314
NCI.Q Stones	.557	1.670	.292	.519	1.522	.301	.899	1.416	.393
NCI.S Cellulose	.601	1.392	.335	.696	1.396	.354	.730	1.423	.357
33.1,.4 Basic iron and non-ferrous metal	.688	1.281	.363	.686	1.445	.345	.782	1.424	.368
NCI.K Wood	.394	2.378	.207	.216	1.541	.240	.254	1.473	.254
NCI.T Copper	.717	1.241	.383	.819	1.518	.361	.812	1.474	.366
NCI.Q Non-ferrous metal ores	.677	1.643	.317	.926	1 566	.375	.691	1.528	.335
NCI.N Iron-ore	.615	1.869	.282	.686	1.890	.292	.776	1.746	.323

Table 7. Ranking numbers based on three normalized numbers of transformations.
The ranking numbers based on the numbers of backward and forward transformations and the relative positions in the production chain (cf. Table 6.) are compared with those of a pseudo-triangulation.

	Normalized transform.			Ranking numbers Value added			Labour			Triangulation	
	backw.	form.	rel.	backw.	form.	rel.	backw.	form.	rel.	inp.	outp.
94.00 Welfare services	2	3	113	2	1	108	2	1	103	8	179
88.1,.3-.9 Other repair of consumer goods	39	1	168	39	4	155	20	2	145	141	176
83.00 Real estate etc.	93	4	176	57	3	162	179	3	179	178	178
91.00 Religious organizations	3	2	117	3	2	109	3	4	104	9	177
92. nec Primary and secondary education	8	5	143	10	5	132	18	5	141	174	166
90.60 Army, navy and air force	25	6	156	27	6	151	25	6	148	179	172
92.70 Scientific and equivalent education	26	7	154	30	7	152	57	7	159	176	171
65.,66 Retail trade	27	9	152	25	8	146	17	8	136	103	170
92.90 Other education	4	11	137	5	9	119	11	9	111	85	169
93.5-.9 Health and medical practices	12	17	140	13	12	131	54	10	157	173	164
20.15 Poultry slaughtering	179	8	179	173	11	179	167	11	177	164	131
21.70 Tobacco products	44	12	163	89	13	165	168	12	178	168	165
23.1-.2 Ready-made clothing	117	10	175	137	10	173	83	13	164	169	160
93.1-.4 Health and medical services	18	14	148	18	15	134	16	14	128	172	163
22.5,6 Carpets, rugs, mats, linoleum	151	13	177	156	14	175	149	15	171	154	156
NCI.R Wines	76	22	158	76	19	159	21	16	135	147	139
90.00A Local government	24	16	149	21	16	137	24	17	140	96	168
20.60 Bread, rusk, pastry, cake baking	126	15	174	112	17	168	71	18	160	163	150
22.30 Knitting and hosiery mills	107	19	171	119	18	169	103	19	165	139	159
24.30 Footwear	130	18	173	102	21	166	88	20	162	140	138
90.00B Central government	31	21	151	34	20	148	59	21	153	23	173
24.20 Leather products	129	20	170	107	22	164	82	22	158	142	141
25.70 Wooden furniture	86	25	161	91	24	158	67	23	154	145	154
20.30 Preserving and processing of fish	159	34	162	168	28	174	161	24	172	115	142
67.00 Hotels, restaurants, cafes	82	23	160	68	25	154	46	25	146	129	151
20.90 Cacao, chocolate and sugar confect.	134	29	166	157	27	170	164	26	174	162	149
20.70 Processing fruits and vegetables	122	26	164	141	26	167	153	27	168	128	144
NCI.D Subtropical fruits	29	30	141	29	23	140	15	28	115	112	137
20.14,16,17 Meat products, preservation	177	24	178	172	30	176	166	29	173	125	134
01.100 Poultry farming	178	37	169	176	35	177	173	30	175	127	105
01.21B Greenhouse horticulture	35	32	145	31	29	135	32	31	132	124	132
20.11-13 Other slaughtering	176	33	172	179	34	178	178	32	176	123	111
21.30 Other food products	143	31	165	164	32	171	172	33	170	160	148
NCI.I Tobacco leafs	30	74	89	26	74	78	8	34	84	167	153
21.60 Soft drinks	142	28	167	122	33	160	125	35	161	114	147
29.71 Soap and cleaning preparations	123	35	163	117	37	157	142	36	166	119	101
20.20 Dairy products	167	38	157	171	38	172	170	37	169	103	127
23.3-.5 Other wearing apparel	138	36	155	121	31	161	107	38	158	166	156
99.00 Wage earning staff of households	1	40	76	1	36	82	1	39	74	12	90
97.1,.4,.9 Business and labour organization	32	41	136	36	40	133	60	40	143	130	99
01.10C Pig breeding	173	52	139	165	42	163	162	41	167	122	106
29.72 Perfumes and cosmetics	95	27	159	125	39	156	112	42	152	134	145
95.,96. Culture, sport and recreation	16	43	122	20	41	114	27	43	114	101	97
NCI.G Coffee-berries	7	107	36	7	49	75	10	44	73	151	116
NCI.H Thea-leafs	36	80	88	32	50	107	6	45	67	158	110
NCI.F Cacao-beans	10	108	40	8	57	69	9	46	66	153	109
03.00 Fishing	72	78	100	54	46	122	62	47	131	111	120
37.60 Bicycles and motorcycles	145	39	150	130	43	153	110	48	147	133	152
22.70 Made-up textile goods	135	42	144	114	45	147	114	49	149	143	89
01.10B Dairy cattle, cattle raising	101	85	98	67	48	125	72	50	133	100	107
21.50 Brewing and malting	38	45	132	47	44	124	102	51	144	120	140
01.21A Open air horticulture	21	72	86	23	55	90	28	52	99	98	121
76.10 Travel agents	33	49	121	37	47	115	34	53	106	152	92
20.60 Margarine, oils and fats	171	73	116	175	66	150	177	54	163	109	135
72.10 Tramways and regular bus services	161	44	147	138	51	145	42	55	107	39	64
72.20 Taxies and motor coach services	75	46	135	51	52	116	23	56	93	45	91
NCI.C Tropical food products	5	161	4	6	71	50	4	57	37	104	103
98.00 Other services	14	57	96	14	54	80	12	58	55	31	146
20.50 Sugar factories and refineries	164	61	129	170	60	149	165	59	155	99	125
40.30 Water works and supply	49	54	125	43	53	111	64	60	119	80	68
34.50 Metal furniture	91	63	116	87	58	121	80	61	118	144	136
27.2-.3 Publishing and binding	105	47	138	131	59	138	131	62	142	42	98
75.10 Air transport business	90	55	127	151	62	136	133	63	139	58	77
32.20 Pottery, china and earthenware	28	83	82	28	69	84	26	64	87	157	73
29.60 Drugs, medicines, antiseptics	53	51	126	66	64	112	109	65	121	149	133
25.5-.6 Other wood products; cork, brushes	52	60	114	69	61	116	43	66	100	35	86
21.40 Distilling, alcoholic liquors	153	46	144	136	56	142	125	67	134	161	143
NCI.A Maize and soy beans	100	138	46	103	92	101	104	68	120	104	115
88.20 Repair of motorcars	51	64	110	48	65	103	29	69	82	5	82
29.94-.99 Other chemical products	65	56	123	60	67	110	81	70	112	116	69
26.23-.29 Other paper products	144	53	133	126	72	123	130	71	129	76	78
22.40 Finishing textiles	139	58	131	35	63	104	86	72	117	131	79
51.1,.3-.5 Construction of buildings	98	105	77	111	104	92	91	73	110	18	157
21.20 Compounded animal stock feeds	170	67	108	174	80	139	176	74	151	121	174
20.40 Flour mills, husking	87	75	104	145	70	129	174	75	150	113	126
82.00 Insurance	92	65	115	80	76	105	98	76	109	10	102
01.10A Arable farming	57	118	61	51	85	81	55	77	96	95	85
22.10 Wool products	163	62	130	161	68	144	141	78	126	117	88
39.00 Other manufactoring industries	166	69	128	139	77	126	127	79	122	83	128
NCI.S Cassava	20	177	3	24	96	42	5	80	12	105	167
22.90 Other textiles	149	67	120	151	75	128	148	81	124	136	83
NCI.E Palm oil, palm-kernels	46	163	16	41	90	63	13	82	31	72	17
24.10 Tanneries and leather finishing	174	50	142	166	73	141	156	83	130	132	112
37.1,.7,.9 Motor vehicles, aircrafts	154	68	119	159	78	130	145	84	123	146	161
40.20 Gas distribution	84	76	107	162	81	127	126	85	116	19	50
32.81 Glass	43	95	79	45	89	77	53	86	83	58	94
40.10 Electricity generation / distribut.	113	70	112	95	82	102	121	87	108	20	56
72.4,74.2,76.2,.3 Transport supporting serv	17	148	8	19	87	61	31	88	62	47	95
88.80 Cotton products	119	71	111	144	79	120	160	89	127	12	87
78.30 Freight transport by road	40	143	31	82	98	81	80	90	79	40	96

Table 7. Ranking numbers based on three normalized numbers of transformations.
The ranking numbers based on the numbers of backward and forward transformations and the relative positions in the production chain (cf. Table 6.) are compared with those of a pseudo-triangulation.

		Ranking numbers										
		Normalized transform.			Value added			Labour			Triangulation	
		backw.	forw.	rel.	backw.	forw.	rel.	backw.	forw.	rel.	inp.	outp.
77.00	Communication	22	91	69	22	66	52	30	91	53	1	93
29.91-.93	Glues, office requisites	148	66	124	135	91	117	120	92	111	125	54
38.00	Instrument engineering	79	84	105	84	86	106	79	93	101	81	122
28.00	Petroleum refineries, cokes, tar	172	59	134	178	93	143	171	94	137	14	49
NCI.M	Crude oil	108	113	71	79	83	99	175	95	138	13	47
52.30	Electr. engineering on constructions	54	102	73	61	106	71	33	96	57	15	43
37.20	Motor vehicle bodies, trailers	132	62	103	133	84	111	99	97	98	148	124
34.60	Tools, cutlery, locks, keys etc.	78	90	94	65	94	87	61	98	81	79	42
21.10	Starch and starch derivatives	133	123	67	142	113	100	163	99	125	107	44
32.3,32.6,32.82-.83	Oth. glass, stone art.	60	104	78	70	110	79	64	100	95	171	34
31.1-.2	Rubber products, tyre retreading	73	94	87	72	95	89	93	101	91	34	61
97.50	Research institutions	15	99	55	16	102	23	19	102	32	43	100
81.00	Banking	19	110	48	15	107	21	39	103	56	7	101
52.1..2	Plumbing, central heating install.	68	116	63	59	119	57	38	104	52	118	130
29.43	Synthetic perfumees and flavours	136	89	99	129	109	95	138	105	102	110	53
61.-64.	Excl. 62.9 wholesale trade	70	98	80	104	97	94	96	106	90	3	104
84.00	Business services	6	152	7	4	112	9	14	107	9	2	84
31.30	Plastic products	120	81	102	115	99	97	85	108	86	30	59
71.00	Railways	111	93	95	108	101	91	41	109	51	21	76
34.70	Heating and cooking appliances	116	86	101	105	103	88	90	110	85	117	129
34.60	Metal packaging	121	96	92	120	105	93	116	111	94	68	37
26.21-.22	Paper bags, rolls and envelopes	146	79	106	132	104	98	113	112	92	53	65
51.20	Civil engineering	50	117	58	58	117	60	51	113	69	177	75
26.31	Corrugated board mills	156	77	109	140	114	96	119	114	89	78	56
36.00	Electrical engineering	56	109	70	71	108	76	76	115	72	4	155
26.32	Folding cartons	114	88	97	118	115	85	100	116	78	77	57
NCI.J	Cotton and wool	9	179	1	9	128	2	7	117	2	24	62
12.00	Crude oil and natural gas	11	166	6	11	111	15	159	118	105	11	46
29.50	Paints, lacquers, varnishes, ink	125	100	64	116	120	74	115	119	80	74	55
29.498,30.00	Other organic chem., fibres	147	97	93	123	116	88	146	120	97	28	45
27.10	Printing	102	92	90	77	118	66	66	121	56	38	66
11.00	Coal mining	69	129	50	75	133	45	47	122	42	155	22
25.30	Builders' carpentry, parquet	63	116	44	96	129	54	89	123	61	86	114
75.20	Business allied to air transport	62	139	42	55	126	37	108	124	65	41	6
34.10	Forge, stamping and pressing	97	120	64	82	121	61	65	125	46	65	5
85.00	Renting of movables	13	141	14	12	130	4	40	126	26	6	19
62.90	Scrap and waste materials trade	34	151	19	33	125	22	37	127	20	49	3
37.40	Shipbuilding and repairing	110	126	60	124	124	72	117	128	68	97	162
25.40	Wooden containers	66	122	59	109	123	70	105	129	59	66	16
29.10	Pigments and dyes	150	111	81	128	131	68	139	130	76	73	33
29.10	Synthetic fertilizers	140	124	66	134	135	65	132	131	75	71	60
32.52,.54	Other concrete and cement articl.	89	134	45	85	146	33	123	132	44	135	70
25.1-.2	Wood sawing, plywood, veneer	45	142	33	63	136	38	48	133	24	17	71
32.10	Bricks and roofing tiles	42	149	23	44	143	13	44	134	19	159	74
29.80	Chemical pesticides	165	101	91	158	132	73	144	135	77	51	81
32.53	Ready-mixed concrete	137	128	57	150	151	55	151	136	80	44	63
32.51	Concrete articles	58	145	34	84	148	26	58	137	30	170	72
29.42A	Basic inorganic chemicals n.e.c.	141	106	83	143	138	67	137	138	71	33	32
37.30	Motor vehicle parts and accessories	112	112	74	97	122	64	87	139	45	91	60
32.70	Non-metalic mineral products	85	131	47	93	141	40	52	140	23	102	21
34.90	Blacksmiths' workshops	64	127	51	50	134	29	36	141	13	75	18
29.41	Industrial gases	48	155	22	49	145	17	78	142	36	54	2
35.70	Steam-boilers, engines and turbines	80	144	39	99	137	47	92	143	48	93	31
35.60	Other industrial machinery	103	153	35	113	142	46	97	144	39	138	21
29.20	Synthetic resins	111	121	65	106	139	48	150	145	69	29	41
29.42B	Basic inorganic electro-chemicals	124	132	62	118	156	36	135	146	60	27	29
35.10	Agricultural machinery and equipment	88	149	17	94	150	34	106	147	43	96	119
19.00	Other mining and quarrying	41	159	21	46	155	12	95	148	38	25	24
34.40	Other structural engineering	83	154	30	83	154	25	75	149	28	64	118
73.00	Sea transport	128	157	37	161	167	44	134	150	84	66	7
35.90	Other machinery	71	140	32	73	144	30	68	151	25	64	121
35.40	Lifting and transporting machinery	94	160	27	101	149	39	94	152	35	94	19
29.49A	Petrochemicals	162	125	72	144	159	49	152	153	63	22	38
26.10C	Regeneration of old paper	118	119	68	127	140	56	157	154	70	55	52
35.20	Metal working machinery	55	156	25	56	147	20	49	155	10	87	20
26.10A	Paper mills	158	103	85	160	152	62	129	156	47	17	51
NCI.P	Minerals	155	133	53	155	165	41	147	157	50	61	27
34.30	Tanks, reservoirs, industr. piping	104	171	18	88	156	28	73	158	18	92	67
35.80	Office machinery	74	165	20	90	157	27	124	159	41	90	30
26.10B	Board mills	157	115	75	154	153	58	111	160	29	52	48
37.50	Railway equipment	96	142	26	98	127	59	74	161	15	175	175
34.01	Iron and steel foundries	47	175	9	42	161	8	35	162	4	69	8
35.30	Machinery for food and chem. industr	67	174	11	74	162	19	77	163	16	88	40
34.02	Non-ferrous metal foundries	77	158	28	40	160	7	70	164	14	67	11
33.20	Steel pipes and tubes	160	135	84	147	166	53	140	165	44	70	4
NCI.L	Coal	106	147	41	100	170	16	118	166	27	156	28
02.00	Forestry and logging	37	167	13	38	163	6	69	167	8	150	14
74.10	Inland water transport business	61	178	5	78	144	18	45	168	3	46	1
32.40	Cement, lime and plaster	99	164	24	86	174	10	101	169	17	26	26
33.30	Wire drawing, steel cold rolling	152	140	49	149	171	32	122	170	21	62	35
35.50	Gears, bearings etc.	59	173	12	62	169	11	56	171	6	89	13
34.20	Screws, bolts, nuts, springs	109	150	38	92	168	14	63	172	6	82	12
NCI.Q	Stones	81	172	15	81	176	5	169	173	44	165	25
NCI.S	Cellulose	115	146	43	152	172	31	143	174	22	36	36
33.1..4	Basic iron and non-ferrous metal	149	137	54	147	173	24	155	175	34	60	117
NCI.K	Wood	23	180	2	17	177	1	22	176	1	16	15
NCI.T	Copper	175	130	62	169	175	35	158	177	33	63	10
NCI.O	Non-ferrous metal ores	168	170	29	177	178	43	134	178	11	59	9
NCI.N	Iron-ore	127	176	16	146	179	3	154	179	7	57	113

Table 5. is a frequency table for the numbers of forward and backward transformations. The results in this table might lead to the conclusion that the classical division in primary, secondary and tertiary sectors leaves much to be desired. A classification based on the positions in the production chains would look quite different. In such a classification the extent to which an industry is 'basic' or 'consumption-oriented' or both plays a crucial role. Industries which are both basic and consumption-oriented are various services: welfare services, education, health services etc., while on the other end of the scale we find industries like slaughtering that are both far from consumption and from the initial creation of value added. From table 4. again it becomes clear that the total lengths of production chains can vary widely, viz. between 1.039 (welfare services) and 8.175 (non ferrous metal ores). Depending on the purpose one has in mind it is possible to employ four different ordenings, none of them corresponding with the one of the pseudo-triangularization.

In table 6. the weighted numbers of backward and forward transformations are compared. The 9 columns are based on the expressions (42), (44), (46), (37), (36), (39), (52), (51) and (54) respectively. For reasons of comparison the normed unweighted transformations are included in the table. The ordering is based on the forward transformation weighted for employment. The general picture emerging from the table is similar to that of table 5.

In table 7. the industries are ordered according to their employment weighted number of forward transformationss and are compared with an ordering based on pseudo-triangularization. In table 8. we have applied Spearman's coefficients of rank correlation to the various orderings.

We are now able to draw several conclusions about the various orderings:

a. based on backward transformations they look similar, independent of the weighting applied;
b. the same applies for forward transformations;
c. based on the weighted relative positions they look similar but for the unweighted ordering we find a rather negative correlation;
d. we find hardly any correlation between orderings based on backward transformations and those based on either forward transformations or relative positions;
e. between orderings based on forward transformations and those based on relative positions there exists a negative correlation;

Table 8. Spearman's rank correlation coefficients.

		Unweighted transform.			Normalized transform.			Value added			Labour			Triangulation		S.I.C.
		backw.	forw.	rel.	backw.	forw.	rel.	backw.	forw.	rel.	backw.	forw.	rel.	inp.	outp.	
Unweighted transform.	backw.	1.000	.141	.452	1.000	-.104	.304	.939	.134	.290	.805	.157	.268	.076	-.101	-.318
	forw.	.141	1.000	.930	.141	.951	-.876	.154	.961	-.849	.150	.944	-.822	-.344	-.705	-.101
	relat.	.452	.930	1.000	.452	.797	-.665	.446	.886	-.645	.403	.878	-.630	-.260	-.648	-.181
Normalized transform.	backw.	1.000	.141	.452	1.000	-.104	.304	.939	.134	.290	.805	.157	.268	.076	-.101	-.318
	forw.	-.104	.951	.797	-.104	1.000	-.985	-.082	.910	-.936	-.047	.886	-.899	-.370	-.704	-.096
	relat.	.304	-.876	-.665	.304	-.985	1.000	.276	-.844	.954	.219	-.816	.914	.390	.628	-.016
Value added	backw.	.939	.154	.446	.939	-.082	.276	1.000	.147	.295	.848	.165	.271	.060	-.087	-.310
	forw.	.134	.961	.886	.134	.910	-.844	.147	1.000	-.886	.146	.989	-.854	-.396	-.768	-.020
	relat.	.290	-.849	-.645	.290	-.936	.954	.295	-.886	1.000	.228	-.865	.954	.424	.673	-.111
Labour	backw.	.805	.150	.403	.805	-.047	.219	.848	.146	.228	1.000	.166	.339	.056	-.099	-.342
	forw.	.157	.944	.878	.157	.886	-.816	.165	.989	-.865	.166	1.000	-.844	-.407	-.768	.012
	relat.	.268	-.822	-.630	.268	-.899	.914	.271	-.854	.954	.339	-.844	1.000	.403	.647	-.139
Triangulation	input	.076	-.344	-.260	.076	-.370	.390	.060	-.396	.424	.056	-.407	.403	1.000	.415	-.259
	output	-.101	-.705	-.648	-.101	-.704	.628	-.087	-.768	.673	-.099	-.768	.647	.415	1.000	.039
Standard Industrial Classif.		-.318	-.101	-.181	-.318	-.096	-.016	-.310	-.020	-.111	-.342	.012	-.139	-.259	.039	1.000

f. there exists a weak correlation only between any of these orderings and a pseudo-triangularization, based on the input-coefficients;
g. there exists a positive correlation between an ordering based on forward transformations and a pseudo-triangularization based on the output-coefficients;
h. there exists no correlation between any of these orderings and the Dutch adaptation of the Standard Industrial Classification of all Economic Activities.

Conclusions a and b are not surprising. Here our starting-point was the number of transformations. Attaching different weights to different transformations does not make much difference when those weights don't diverge too much. Thus, for value added weighted transformations, the correlation with employment weighted transformations is natural, since labour costs are a large part of the Dutch value added.

The negative correlation mentioned in c is as yet unexplainable. Maybe the production chains have been deformed badly by the norming.

Conclusion d is not surprising. In principle there is no relation between backward and forward transformations. But it is contrary to the foundations of the idea of triangularization, viz. one can always tell whether an industry belongs to the begin or the end of a production chain and that it would be impossible for an industry to belong to both ends simultaneously. Would the idea of triangularization be true, a strong negative correlation was to be expected.

The strong negative correlation mentioned in e indicates a dominant influence of the forward transformations over the backward ones. This is understandable when we look at table 6. Here the numbers of forward transformations can be larger than one, while those of the backward transformations are at most one, by definition. We see the same for the unnormed unweighted numbers of transformations of table 4. The correlation should be negative: the larger the numbers of forward transformations, the lower the ratio of the backward plus (half of) the own transformation to the total length. The negative character of the correlation indicates a reversion in the ordering.

The weak correlation of f indicates that comparing triangularization based on input-coefficients and the ordering here developed is not fruitful. The

foundations of both techniques are incompatible.

The correlation we mentioned in g is caused by the maximalization in the upper triangle of the table. The pseudo-triangularization automatically causes the industries which hardly deliver to consumption to appear at the beginning; small deliveries to consumption are necessarily associated with a large number of forward transformations. (For the backward transformations it is the other way around, hence the negative correlation.)

A priori, one might have expected a slight correlation between the industrial classification and some orderings since the former reflects the distinction between primary, secondary and tertiary industries. However, the fact that there is no correlation confirms that this distinction is of doubtful value in characterizing the position of industries in production chains.

We now return to tables 6. and 7. In table 6. we compared the weighted numbers of backward and forward transformations, in table 7. the from these numbers derived rankings are given. In both tables the industries are ordered according to their rankings based on the numbers of employment weighted forward transformations. We would like to know which industries behave inconsistantly with respect to the various ways in which we order the industries. For the unweighted and for value added weighted numbers of backward transformations we look at several industries which differ 50 positions or more: gas distribution (84 - 162), flour mills (87 - 145), air transport business (90 - 151) and finishing of textiles (139 - 35). To explain the difference for the gas distribution we only need to take one step backward, since a relative large part of the value added was formed exploiting the natural gas fields. Something similar applies for the air transport business. Much of its value added was generated in the production of jet fuels and capital goods. Flour mills also add only a little to the value added incorporated in the products they buy from agriculture. For the finishing of textiles the reverse is true: the imported raw materials from lesser developed countries do not contain much value added, while the domestic costs of labour are very high.

When we compare the orderings according to the value added weighted and the employment weighted numbers of backward transformations, we find even higher differences: crude oil and natural gas (11 - 159), non-competing imports of crude oil (79 - 175), business allied to air transport (55 - 108), brewing and malting (47 - 102), non-competing imports of stones (81 - 169) and tramways and regular bus services (138 - 42).

For the orderings based on the weighted numbers of forward transformation we can conclude that there are no great differences. However, when we look at the unweighted number of transformations we right away notice a few differences, notably in case of non-competing tropical agricultural products: coffee berries (107 - 49 - 44), cacao beans (108 - 57 - 46), cassave (177 - 96 - 80), maize and soy beans (138 - 92 - 68), palm oil and kernels (163 - 98 - 82), cotton and wool (179 - 128 - 117), crude oil and natural gas (166 - 111 - 118), tropical food products (161 - 71 - 57) and tranport supporting services (168 - 87 - 80). Most probably, the largest part of the value added has already been generated before these products arrived at the Dutch border; only little value is added to them by the highly mechanised Dutch food-processing industries. The same applies for labour-intensive production processes.

The orderings based on pseudo-triangularization are quite uninformative. That the method does not work too well is illustrated by the industries that take up the top rows: communications, business services and wholesale trade. These industries supply to nearly all industries. Clearly this is not a good criterion to determine an ordering of industries.

Summarizing the discussion of the differences between the orderings it is clear that each of the orderings based on transformations has its own merits. Which ordering one will use depends on the purpose at hand.

13. Results: characterization of imports, exports and consumption.

The method developed in section 6 has been applied to a number of Dutch baskets of goods and services: imports, exports and consumption. The results are summarized in Table 9. For the numbers of unweighted transformations, value added weighted transformations and employment weighted transformations the results for the backward and forward cases, the total production chains and the relative positions were calculated applying the expressions developed in section 6. Note that we calculate each commodity's production chain for the 'closed economy' total input-output table. Next we use these chains to the average production chain associated with a basket of goods and services composed exactly like Dutch imports and exports. In case of consumption, the interpretation is similar though maybe a bit subtle at first glance. By definition the basket for consumption is a basket of goods and services on which no more transformations can be applied. However, a large part of the

Table 9. Characterization of import, export and consumption.

The figures represent expectation values of the numbers of activities.

	backward	own	forward	total length	relative position	
unweighted						
import	1.348	1.000	1.994	4.370	.450	(.423)
export	1.450	1.000	1.970	4.419	.458	(.441)
consumption	1.074	1.000	.450	2.524	.641	(.624)
value added weighted						
import	.610	.390	.689	1.689	.511	(.477)
export	.625	.375	.704	1.704	.508	(.477)
consumption	.433	.567	.180	1.180	.622	(.607)
labour weighted						
import	.652	.348	.657	1.657	.531	(.498)
export	.666	.344	.667	1.667	.530	(.503)
consumption	.473	.527	.170	1.170	.646	(.629)

goods and services could also be used for intermediate consumption instead of final consumption. These undergo at least one more transformation; as a consequence the average good in the basket goes through 0.45 additional transformations.

For imports we find 1.970 and for exports 1.994 additional transformations,

which exceeds the average number for the consumption by 1.5. So we may conclude that imports and exports differ completely in character from consumption. It is rather surprising that the number of forward transformations hardly differs for imports and exports. One would have expected that a highly industrialized country like the Netherlands, which is rather poor in raw materials, would import many raw materials and would export finished products; the latter would have only a limited number of forward transformations. An explanation is the exports of chemical bulks and products of the oil refineries, since the contribution of finished chemical products is relatively small.

For the weighted transformations we find the same phenomenon. The 'forward value added contribution' is larger than the 'forward employment contribution'; for imports this can be explained by the fact that to a large extent we import raw materials from low-wage countries. For the exports we might conclude that the Dutch economy exports many intermediate goods, which still need a lot of highly qualified labour; this would mean that Dutch industries leave a large part of the creation of the value added concerned to industries abroad. The number of backward transformations is a lot lower for consumption than for imports or exports.

For the total length of production chains we again find a remarkable difference between consumption on the one hand and imports and exports on the other. Of course a number of consumer-oriented services will not be represented in the baskets of foreign trade. They all have a very short production chain, which makes it less likely that they will become involved in foreign trade.

For the relative positions we have displayed - after the arithmetic averages - the positions we would expect to find if the basket were one "pseudo-product" (that is, the weighted averages, the weights being the shares of each industry in consumption). It can be proved that, in general, both positions are not identical. For the unweighted numbers we find the foreign trade pseudo-product in the 90th position and the consumption pseudo-product in the 140th; for the weighted ones the positions are 110th and 150th respectively. We should remark that here the average relative position of the suppliers is shown and not the relative position at the moment of delivery, c.q. at the Dutch border. To find the latter figure we have to take the sum of the numbers of backward and own transformations and divide the result by the total length. For foreign trade this ratio shows the distribution over domestic and foreign transformations.

14. Results: the domestic contribution.

In the preceding sections we have introduced the total IO-table, which has been used for a number of studies. The studies resulted in a characterization of industries that enabled us to compare them mutually. Would we do the same to the standard Dutch IO-table we would obtain results in which the production processes in the rest of the world would be left out. Generally spoken this would lead to shorter production chains.

We define the domestic contribution as the ratio of two production chains.

$$p_r^z = \bar{h}_r^{z,d} \oslash \bar{h}_r^{z,t} \tag{55}$$

The superscript z represents the relevant weighting method (transformations, value added, employment), d represents the domestic IO-table and t the total IO-table. The subscript r represents part of the production chain (backward, forward, total length). So p_r^z indicates which part of the production process could be called domestic. In table 10. the unweighted and the domestic production weighted for value added is given. The industries have been ordered according to the lengths p_s^v. The domestic production based on the numbers of transformations and on the generated value added has been compared. It is not necesarry that the ratio of the domestic contribution with respect to the total chain length has a value between those with respect to the backward and forward parts respectively. The reason is that the total chain length contains, besides these parts, also the own contribution. In general domestic contributions on the basis of value added are slightly higher.

The first part of the table is dominated by industries with a small domestic contribution, e.g. the chemical basic products industry. One may conclude that research into the economic feasibility of encouraging industries that use basic chemical product might prove fruitful. The last part of the table is dominated by the tertiary sector, food-processing industries and construction.

In table 11. the domestic contributions to baskets of imports, exports and consumption are shown. In case of imports, table 11. may be interpreted as follows. Consider a basket of goods composed exactly like imports. The use of each of these goods is supplied to a varying degree both by imports and by domestic producers. Thus an incremental use of the whole basket will not lead to additional imports only but to additional domestic production as well.

Table 10. Domestic contributions.
Ratios of the lengths of the chains of production based on the domestic and the total input-output table.

			Unweighted			Value added weighted		
			backward	forward	total	backward	forward	total
1	28.00	Petroleum refineries, cokes, tar	.065	.323	.332	.088	.332	.202
2	73.00	Sea transport	.274	.002	.225	.317	.004	.206
3	NCI.O	Non-ferrous metal ores	.000	.374	.355	.000	.305	.215
4	35.80	Office machinery	.147	.046	.233	.184	.051	.250
5	29.49A	Petrochemicals	.197	.117	.286	.273	.110	.258
6	20.60	Margarine, oils and fats	.122	.467	.414	.163	.432	.323
7	29.20	Synthetic resins	.209	.077	.296	.306	.071	.323
8	31.1,.4	Basic iron and non-ferrous metal	.173	.231	.316	.260	.238	.341
9	29.30	Pigments and dyes	.184	.174	.332	.250	.169	.345
10	29.80	Chemical pesticides	.178	.247	.358	.284	.213	.345
11	NCI.N	Iron-ore	.000	.333	.351	.000	.371	.351
12	NCI.T	Copper	.000	.506	.406	.000	.473	.357
13	75.10	Air transport business	.141	.187	.417	.177	.230	.360
14	NCI.P	Minerals	.000	.381	.370	.000	.421	.366
15	24.10	Tanneries and leather finishing	.138	.292	.362	.235	.292	.376
16	35.60	Other industrial machinery	.241	.209	.350	.354	.186	.384
17	29.43	Synthetic perfumees and flavours	.232	.200	.387	.350	.179	.387
18	29.49B,30.00	Other organic chem., fibres	.272	.099	.346	.377	.104	.392
19	35.50	Gears, bearings etc.	.283	.168	.335	.386	.158	.393
20	NCI.M	Crude oil	.000	.456	.431	.000	.271	.405
21	29.42B	Basic inorganic electro-chemicals	.345	.187	.380	.463	.180	.406
22	35.10	Agricultural machinery and equipment	.228	.250	.369	.328	.222	.412
23	74.10	Inland water transport business	.393	.169	.347	.505	.160	.417
24	37.40	Shipbuilding and repairing	.298	.216	.398	.431	.210	.410
25	33.20	Steel pipes and tubes	.217	.394	.434	.323	.394	.430
26	22.10	Wool products	.178	.458	.458	.243	.445	.438
27	37.30	Motor vehicle parts and accesoires	.225	.204	.371	.331	.217	.440
28	NCI.S	Cellulose	.000	.600	.516	.000	.575	.462
29	35.20	Metal working machinery	.239	.215	.383	.345	.248	.463
30	26.10A	Paper mills	.201	.478	.479	.243	.479	.464
31	35.70	Steam-boilers, engines and turbines	.221	.356	.447	.326	.337	.470
32	37.1,.7,.9	Motor vehicles, aircrafts	.212	.452	.472	.311	.462	.470
33	29.10	Synthetic fertilizers	.414	.258	.434	.535	.283	.474
34	NCI.L	Coal	.000	.477	.447	.000	.514	.478
35	39.00	Other manufactoring industries	.175	.540	.440	.267	.583	.484
36	22.5,6	Carpets, rugs, mats, linoleum	.199	.377	.504	.259	.339	.485
37	29.42A	Basic inorganic chemicals n.e.c.	.437	.287	.475	.605	.265	.485
38	01.100	Poultry farming	.263	1.007	.511	.385	.821	.485
39	35.30	Machinery for food and chem. industr	.293	.306	.420	.428	.313	.486
40	36.00	Electrical engineering	.190	.302	.454	.245	.286	.486
41	62.90	Scrap and waste materials trade	.428	.090	.355	.534	.100	.489
42	33.30	Wire drawing, steel cold rolling	.246	.436	.473	.352	.436	.491
43	22.20	Cotton products	.211	.470	.501	.261	.497	.496
44	21.20	Compounded animal stock feeds	.172	.841	.596	.231	.785	.499
45	35.40	Lifting and transporting machinery	.230	.386	.454	.333	.407	.502
46	NCI.A	Maize and soy beans	.000	.668	.559	.000	.624	.503
47	34.20	Screws, bolts, nuts, springs	.215	.386	.446	.328	.411	.504
48	20.90	Cacao, chocolate and sugar confect.	.298	.340	.542	.330	.351	.504
49	21.30	Other food products	.259	.852	.571	.301	.786	.505
50	NCI.R	Wines	.000	.997	.496	.000	.946	.516
51	22.90	Other textiles	.247	.452	.505	.341	.461	.516
52	21.10	Starch and starch derivatives	.404	.245	.429	.531	.299	.518
53	26.10B	Board mills	.289	.490	.516	.383	.483	.522
54	23.1-.2	Ready-made clothing	.200	.935	.528	.251	.927	.527
55	29.91-.93	Glues, office requisites	.263	.444	.514	.370	.426	.534
56	11.00	Coal mining	.479	.242	.471	.645	.262	.543
57	20.40	Flour mills, husking	.186	.729	.613	.200	.743	.545
58	NCI.Q	Stones	.000	.594	.538	.000	.590	.547
59	23.3-.5	Other wearing apparel	.235	.348	.497	.355	.348	.550
60	37.60	Bicycles and motorcycles	.228	.491	.510	.341	.450	.552
61	75.20	Business allied to air transport	.493	.115	.382	.637	.278	.554
62	31.1-.2	Rubber products, tyre retreading	.232	.378	.489	.342	.402	.559
63	34.02	Non-ferrous metal foundries	.140	.431	.469	.260	.448	.563
64	01.10C	Pig breeding	.265	.804	.571	.390	.676	.563
65	35.90	Other machinery	.260	.477	.525	.384	.464	.564
66	20.15	Poultry slaughtering	.339	.353	.497	.489	.292	.565
67	NCI.E	Palm oil, palm-kernels	.000	.576	.547	.000	.499	.565
68	34.30	Tanks, reservoirs, industr. piping	.211	.545	.542	.315	.517	.570
69	29.60	Drugs, medicines, antiseptics	.308	.288	.546	.378	.277	.575
70	22.30	Knitting and hosiery mills	.257	.834	.551	.336	.834	.583
71	32.70	Non-metallic mineral products	.280	.426	.501	.435	.514	.588
72	31.30	Plastic products	.193	.642	.565	.277	.645	.592
73	26.23-.29	Other paper products	.251	.685	.552	.375	.671	.594
74	21.70	Tobacco products	.227	.855	.626	.237	.789	.596
75	NCI.H	Thea-leafs	.000	.408	.464	.000	.391	.602
76	29.94-.99	Other chemical products	.298	.334	.527	.455	.341	.602
77	26.10C	Regeneration of old paper	.442	.475	.567	.611	.466	.603
78	34.01	Iron and steel foundries	.240	.488	.536	.337	.496	.607
79	29.50	Paints, lacquers, varnishes, ink	.284	.646	.583	.333	.623	.609
80	29.71	Soap and cleaning preparations	.268	.467	.543	.391	.478	.609
81	34.60	Metal packaging	.304	.603	.589	.456	.569	.623
82	20.14,16,17	Meat products, preservation	.393	.612	.551	.561	.540	.625
83	26.21-.22	Paper bags, rolls and envelopes	.245	.652	.575	.377	.692	.633
84	37.50	Railway equipment	.000	.834	.673	.000	.844	.644
85	38.00	Instrument engineering	.272	.809	.601	.378	.810	.645
86	20.11-13	Other slaughtering	.431	.609	.589	.644	.488	.647
87	24.30	Footwear	.227	1.152	.534	.362	1.050	.649
88	02.00	Forestry and logging	.324	.568	.610	.482	.536	.657
89	26.32	Folding cartons	.349	.631	.618	.511	.645	.659
90	26.31	Corrugated board mills	.318	.699	.615	.446	.694	.660

Table 10. Domestic contributions.
Ratios of the lengths of the chains of production based on the domestic and the total input-output table.

			Unweighted			Value added weighted		
			backward	forward	total	backward	forward	total
91	20.50	Sugar factories and refineries	.416	.615	.614	.596	.636	.662
92	32.61	Glass	.343	.450	.576	.446	.465	.663
93	34.40	Other structural engineering	.263	.670	.636	.392	.652	.664
94	25.40	Wooden containers	.269	.809	.710	.333	.741	.669
95	NCI.O	Subtropical fruits	.000	.568	.561	.000	.523	.675
96	22.70	Made-up textile goods	.223	1.014	.613	.314	1.046	.688
97	20.80	Bread, rusk, pastry, cake baking	.343	.866	.608	.468	.853	.695
98	21.60	Soft drinks	.349	.941	.627	.475	.879	.700
99	01.21A	Open air horticulture	.335	.250	.556	.417	.272	.701
100	24.20	Leather products	.275	1.273	.599	.426	1.168	.702
101	72.10	Tramways and regular bus services	.248	1.065	.621	.336	1.086	.703
102	34.10	Forge, stamping and pressing	.241	.756	.662	.336	.749	.703
103	71.00	Railways	.413	.576	.618	.531	.665	.705
104	20.30	Preserving and processing of fish	.511	.050	.598	.721	.092	.712
105	01.10A	Arable farming	.398	.582	.632	.539	.560	.716
106	72.30	Freight transport by road	.335	.699	.689	.419	.667	.717
107	29.41	Industrial gases	.368	.597	.631	.514	.669	.719
108	20.70	Processing fruits and vegetables	.446	.673	.665	.595	.623	.721
109	20.20	Dairy products	.510	.502	.636	.718	.466	.726
110	NCI.K	Wood	.000	.696	.671	.000	.668	.727
111	34.80	Tools, cutlery, locks, keys etc.	.274	.773	.671	.407	.765	.733
112	NCI.J	Cotton and wool	.000	.663	.685	.000	.621	.736
113	NCI.I	Tobacco leafs	.000	.779	.655	.000	.776	.736
114	12.00	Crude oil and natural gas	.353	.557	.654	.415	.534	.736
115	25.1-.2	Wood sawing, plywood, veneer	.332	.760	.728	.380	.756	.737
116	34.90	Blacksmiths' workshops	.248	.719	.662	.393	.754	.745
117	34.70	Heating and cooking appliances	.229	.954	.768	.342	.912	.748
118	61.-64.	Excl. 62.9 wholesale trade	.522	.646	.690	.660	.648	.751
119	34.50	Metal furniture	.279	.984	.720	.403	.926	.752
120	NCI.B	Cassava	.000	.832	.762	.000	.776	.752
121	01.10B	Dairy cattle, cattle raising	.357	.797	.696	.513	.706	.755
122	29.72	Perfumes and cosmetics	.348	1.305	.693	.539	1.321	.757
123	37.20	Motor vehicle bodies, trailers	.262	1.036	.745	.380	1.012	.758
124	72.4,74.2,76.2,.3	Transport supporting serv	.513	.493	.611	.665	.491	.759
125	25.5-.6	Other wood products, cork, brushes	.336	.910	.733	.422	.892	.762
126	21.50	Brewing and malting	.372	.635	.684	.483	.647	.764
127	32.40	Cement, lime and plaster	.315	.814	.732	.403	.819	.767
128	27.10	Printing	.272	.835	.694	.406	.852	.769
129	25.70	Wooden furniture	.294	1.871	.720	.400	1.746	.772
130	68.1,.3-.9	Other repair of consumer goods	.273	1.000	.648	.403	1.000	.776
131	21.40	Distilling, alcoholic liquors	.449	.798	.682	.595	.886	.779
132	97.50	Research institutions	.368	.591	.637	.502	.614	.781
133	25.30	Builders' carpentry, parquet	.320	.924	.797	.412	.890	.784
134	19.00	Other mining and quarrying	.406	.762	.753	.577	.746	.786
135	03.00	Fishing	.406	.707	.687	.582	.654	.787
136	22.40	Finishing textiles	.212	.690	.584	.525	.651	.788
137	51.1,.3-.5	Construction of buildings	.382	.947	.789	.510	.897	.791
138	01.21B	Greenhouse horticulture	.420	.289	.661	.507	.283	.792
139	51.20	Civil engineering	.400	.869	.784	.499	.812	.795
140	40.10	Electricity generation / distribut.	.447	.782	.721	.630	.805	.801
141	32.3,32.6,32.82-.83	Oth. glass, stone art.	.288	1.067	.795	.386	1.027	.801
142	52.30	Electr. engineering on constructions	.215	1.057	.811	.289	.991	.803
143	68.20	Repair of motorcars	.205	1.026	.740	.301	1.025	.810
144	72.20	Taxies and motor coach services	.277	1.001	.699	.424	1.019	.812
145	32.52,.54	Other concrete and cement articl.	.366	.917	.795	.497	.907	.815
146	NCI.C	Tropical food products	.000	.766	.770	.000	.707	.823
147	32.51	Concrete articles	.386	.930	.822	.513	.905	.829
148	32.10	Bricks and roofing tiles	.502	.841	.806	.637	.813	.838
149	90.60	Army, navy and air force	.334	.236	.729	.473	1.000	.841
150	NCI.F	Cacao-beans	.000	.849	.782	.000	.821	.845
151	82.00	Insurance	.548	.705	.729	.642	.715	.846
152	27.2-.3	Publishing and binding	.483	.917	.749	.707	.937	.850
153	40.30	Water works and supply	.481	.847	.774	.655	.866	.858
154	52.1,.2	Plumbing, central heating install.	.307	1.046	.835	.452	.984	.862
155	NCI.G	Coffee-berries	.000	.928	.832	.000	.891	.867
156	32.53	Ready-mixed concrete	.533	.944	.836	.668	.948	.872
157	40.20	Gas distribution	.635	.837	.813	.831	.878	.874
158	77.00	Communication	.349	.873	.801	.477	.921	.883
159	67.00	Hotels, restaurants, cafes	.505	1.401	.784	.653	1.441	.893
160	65.,66	Retail trade	.453	.783	.774	.601	.771	.904
161	76.10	Travel agents	.587	.813	.816	.776	.825	.907
162	83.00	Real estate etc.	.683	1.000	.819	.722	1.000	.911
163	85.00	Renting of movables	.452	.848	.837	.556	.906	.915
164	32.20	Pottery, china and earthenware	.399	1.075	.882	.513	1.067	.916
165	97.1,.4,.9	Business and labour organization	.534	1.082	.847	.723	1.074	.923
166	92.70	Scientific and equivalent education	.685	.609	.869	.766	.883	.923
167	93.1-.4	Health and medical services	.509	1.006	.825	.581	1.011	.923
168	84.00	Business services	.519	.899	.893	.575	.859	.928
169	98.00	Other services	.410	.998	.870	.566	.998	.941
170	93.5-.9	Health and medical practices	.542	1.290	.886	.649	1.289	.943
171	95.,96.	Culture, sport and recreation	.526	1.033	.874	.685	1.027	.944
172	90.00B	Central government	.664	.898	.856	.753	1.074	.954
173	90.00A	Local government	.655	.411	.840	.699	.544	.957
174	92. nec	Primary and secondary education	.710	1.000	.919	.749	.632	.958
175	81.00	Banking	.697	.741	.825	.762	.788	.958
176	92.90	Other education	.458	1.424	.894	.633	1.347	.969
177	99.00	Wage earning staff of households	.000	.911	.984	.000	.916	.992
178	91.00	Religious organizations	.398	1.000	.965	.386	1.000	.995
179	94.00	Welfare services	.407	1.000	.978	.360	1.000	.998

Table 11. Domestic contributions to imports, exports and consumption

	Unweighted transformations			Value added weithed transf.		
	backward	forward	total lengths	backward	forward	total lengths
import	.219	.421	.484	.459	.403	.518
export	.271	.308	.440	.366	.306	.479
consumption	.377	.547	.600	.468	.578	.708

The additional imports have 'forward' consequences, the additional domestic production has 'backward' and 'own contribution' type consequences as well. Hence domestic forward and backward transformations are associated with this 'imports basket'. These domestic contributions to the total chains are shown in the first line of table 11.

In case of exports and consumption, a similar reasoning applies. Consider the example of a basket of goods composed exactly like consumption. Most of these goods are not only consumed but are exported and used as imports as well, to varying degrees. Thus forward linkages are associated with these goods, just like backward linkages are associated with the goods in the imports basket. Table 11. shows the domestic contribution to these forward chains.

The ratio's of table 11. are very low and indicate that the Dutch economy is very open. The domestic contribution to the forward production chain is higher for the imports basket than for the exports basket. This is easy to understand when we realise that many of the imports are destined for Dutch production processes while exports are meant for processes abroad. The basket of consumption is clearly different; the hypothetical forward production chains show a much higher contribution. There is practically no difference between unweighted transformations and those weighted for value added weighted transformations.

For the backward chains the unweighted domestic contributions are low but for value added weighted chains the contributions are about average. One possible cause might be the non-competitive imports. In the Netherlands the generation of value added per production step is considerably higher than in the lesser developed countries from where we obtain the main part of non-

competitive imports. The low domestic contribution to the backward production chain can be attributed to the oil refineries which take up a large share of the exports (in 1972 we defined crude oil as non-competitive).

The domestic contribution to the total production chains are higher than those to the backward or forward chains. This is because the domestic contribution to each industry's 'own transformation' is higher than that to forward and backward chains. The domestic contribution to the own contribution is simply the ratio of the domestic production to the sum of domestic production and imports. The domestic contributions to the steps in the forward and backward production chains are on the contrary related to ratios of higher order transformations of the domestic contribution and the sum of foreign and domestic contribution, respectively. In the cases of the forward and backward chains the numerator consists solely of domestic production steps. However, the denominator contains, besides pure foreign production steps, also production steps which could have been domestic if their destination would have been domestic. Therefore the denominator is larger in the cases of forward and backward chains than in the case of the own transformation. Thus, the ratio is higher in the latter case.

In order to illustrate how data like those in table 11. might be employed in policy planning, consider the domestic contribution to the value added weighted forward chain of exports. This contribution, 0.306, is very low. This can be taken to indicate that the major part of the production processes required to transform Dutch exported products into final consumption goods, is located abroad. Thus one might study the possibilities to expand or newly create industries engaged in this further processing of goods that are now exported.

15. Possible applications

Our method has more applications than triangularization. Here we mention just a few of them.

1. The classification of industries.
   With the help of backward, forward and total production chain lengths plus the relative positions we can compare the positions of the various industries within the economy. Here we can take into account the phenomenon of circularity. On the basis of these characteristics a new approach to a classification of industries should be possible.

2. Preparing an industrial policy.

   The data from tables 10. and 11. give policy information. Specifically, information of this type can be a helpful tool when a government wishes to determine which particular industries should be stimulated.

3. Studies of technological changes in time.

   It is plausible that with the increassing technological development production chains will become longer and longer. It is worthwhile to take a closer look at this theory for - if proven true - it would give us a tool that would enable us to analyse a technological development.

4. Determining the level of development of various countries.

   On the basis of the lengths of the domestic production chains and contributions we might compare the development levels of countries. In case of a lesser developed country it might be necessary to relate the domestic contributions to the total IO-table of the production structure of a developed country.

5. Determining the interdependences between countries.

   The degree of dependence of specific industries of a country on foreign trade can be inferred from the domestic contributions.

6. Determining the interdependences between industries.

   Indications as to the interdependecies between industries are given by the normed transformations matrix H_f (eq. (16)). From this matrix we can track down the "distances" between the industries in the production processes.

7. Tracking down the filières.

   In a filière the industries are characterized by way of the distances between succeeding industries; each step should be approximately one. The filières should be selected on the basis of the matrix H_f.

Literature

1. Wessels, H., Triangulation und Blocktriangulation von Input-Output-Tabellen und ihre Bedeutung, Deutsches Institut für Wirtschaftsforschung, Beiträge zur Strukturforschung, Heft 63, 1981.

2. Leontief, W.W., The Structure of Development, Scientific American, Vol 209, No. 3 (1963), pp. 148-167.

3. Chenery, H.B. and Watanabe, T., International Comparisons of the Structure of Production, Econometrica, Vol. 26 (1958), pp. 487-521.

4. Aujac, H., La hiérarchie des industries dans un tableau des échanges interindustriels, Revue Economique, Vol. 2 (1960), pp. 169-238.

5. Masson, D., Méthode de triangulation du tableau européen des échanges interindustriels, Revue Economique, Vol. 2 (1960), pp. 239-257.

6. Simpson, D. and Tsukui, J., The Fundamental Structure of Input-Output Tables, an International Comparison, The Review of Economics and Statistics, Vol. 47 (1965), pp. 434-446.

7. Korte, B. and Oberhofer, W., Triangularizing Input-Output Matrices and the Structure of Production, European Economic Review 2 (1971), pp. 493-522.

8. Helmstädter, E., Produktionstruktur und Wachstum, Jahrbücher der Nationalökonomie und Statistik 169 (1957), pp. 173-212.

9. Helmstädter, E., Produktionstruktur und Wachstum (Zweiter Teil), Jahrbücher der Nationalökonomie und Statistik 169 (1957), pp. 427-449.

10. Helmstädter, E., Die geordnete Input-Output Struktur, Jahrbücher der Nationalökonomie und Statistik 174 (1962), pp. 322-361.

11. Helmstädter, E., The Hierarchical Structure of Interindustrial Transactions, in: International Comparisons of Interindustry Data; Industrial Planning and Programming, Statistical series 2 (1969), United Nations (New York), pp. 231-243.

12. Lamel, J., Richter, J. and Teufelsbauer, W., Patterns of Industrial Structure and Economic Development, European Economic Review 3 (1972), pp. 47-63.

13. Drabek, Z., A Comparison of Technology in Centrally-Planned and Market-Type Economies, European Economic Review 25 (1984), pp. 293-318.

14. Harthoorn, R., Backward and Forward Linkages, An Application to Dutch Agricultural Industries, Paper presented at the Eighth International Conference on Input-Output Techniques (Sapporo, 1985).

15. Hack, D.B., Factor Costs, Excess Demand, and Price Expectations in a Dynamic Input-Output Submodel of Inflation, Paper presented at the Seventh International Conference on Input-Output Techniques (Innsbruck, 1979).

16. A System of National Accounts, Studies in Methods, Series F no 2, Rev 3, United Nations (New York, 1968).

A Intermediate matrix A_c^*, enlarged with the column vector c of consumption on the right hand side and a corresponding row of zero's at the bottom.

A^* Intermediate matrix of the total input-output table; it includes competitive imports and the consumption of capital goods.

$\bar{A}^*$ Intermediate input coefficients, including competitive imports and consumption of capital goods.

A_c^* The part of the intermediate matrix A^*, which describes the intermediate consumption needed for the production of the final consumption.

A_d^* Intermediate matrix, domestic production.

$\tilde{A}_i$ Enlarged matrix with input coefficients and the vector with each industry's share in total final consumption, respectively.

A_m^* Intermediate matrix, competitive imports.

$\tilde{A}_o$ Enlarged matrix with output coefficients: the shares of intermediate users and final consumption.

$\tilde{A}_v$ Matrix with cumulated value added coefficients.

$\tilde{a}$ Vector with normalized transformations.

c Consumption vector extended with a zero element.

c^* Consumption vector.

$\tilde{H}$ Matrix with numbers of transformations.

$\bar{H}_b$ Matrix with the normalized numbers of backward transformations.

$\bar{H}_f$ Matrix with the normalized numbers of forward transformations.

$\tilde{H}^l$ Matrix with the labour-added weighted numbers of transformations.

$\bar{H}_b^l$ Matrix with the normalized numbers of labour-added weighted backward transformations.

$\bar{H}_f^l$ Matrix with the normalized numbers of labour-added weighted forward transformations.

$\tilde{H}^v$ Matrix with the value added weighted numbers of transformations.

$\bar{H}_b^v$ Matrix with the normalized numbers of value added weighted backward transformations.

$\bar{H}_f^v$ Matrix with the normalized numbers of value added weighted forward transformations.

$\bar{h}_b$ Vector with the numbers of backward transformations (from scratch).

$\bar{h}_f$ Vector with the numbers of forward transformations (to consumption).

$\bar{h}_s$ Vector with the total lengths of the production chains.

$\bar{h}_b^a$ Vector with the normalized numbers of backward transformations (from scratch).

$\bar{h}_f^a$ Vector with the normalized numbers of forward transformations (to consumption).

$\bar{h}_s^a$ Vector with the normalized total lengths of the production chains.

$\bar{h}_b^l$ Vector with the labour-added weighted numbers of backward transformations (from scratch).

$\bar{h}_f^l$ Vector with the labour-added weighted numbers of forward transformations (to consumption).

$\bar{h}_s^l$ Vector with the labour-added weighted total lengths of the production chains.

$\bar{h}_b^v$ Vector with the value added weighted numbers of backward transformations (from scratch).

$\bar{h}_f^v$ Vector with the value added weighted numbers of forward transformation (to consumption).

$\bar{h}_s^v$ Vector with the value added weighted total lengths of the production chains.

$\bar{h}_r^{z,d}$ Vector with the numbers of the domestic production chains (r = b, f, s: backward, forward, total length respectively) related to a basket of goods z (z = c, m, x: consumption, imports, exports respectively).

$\bar{h}_r^{z,t}$ Vector with the number of the production chains (r = b, f, s: backward, forward, total length respectively), including domestic and imported contributions, related to a basket of goods z (z = c, m, x: consumption, imports, exports respectively).

I Unit matrix.

i Summation vector.

l Employment vector extended with a zero element.

$\tilde{l}$ Extended vector with employment coefficients.

l^* Employment vector.

l_c^* Vector with the employment in each industry needed to generate the final consumption.

m Imports vector.

p_r^z Vector with the ratios of the domestic contributions to part r (r = b, f, s: backward, forward, total length respectively) of the production chains related to a basket of goods z (z = c, m, x: consumption, imports, exports respectively).

$\bar{q}$ Vector with the relative positions in the production chains.

$\bar{q}^a$ Vector with the relative positions in the normalized production chains.

$\bar{q}^l$ Vector with the relative positions in the labour-added weighted production chains.

$\bar{q}^v$ Vector with the relative positions in the value added weighted production chains.

r Symbol indicating that either b (backward), f (forward) or s (total length) should be substituted.

S_b^z Average number of backward transformations for a basket of goods z (z = c, m, x: consumption, imports, exports respectively).

S_f^z Average number of forward transformations for a basket of goods z (z = c, m, x: consumption, imports, exports respectively).

S_q^z Average position for a basket of goods z (z = c, m, x: consumption, imports, exports respectively).

S_s^z Average total length of the production chains for a basket of goods z (z = c, m, x: consumption, imports, exports respectively).

t Vector of total production related to consumption, extended with a zero element.

t^* Vector of total production.

t_c^* Vector of total production related to consumption.

u Unit vector, all elements are zero except the last one, which equals one.

v Value added vector extended with a zero element.

$\tilde{v}$ Extended vector with value added coefficients.

v^* Value added vector.

$\tilde{v}^*$ Vector with value added coefficients.

v_c^* Vector with the value added created during production related to consumption.

$\tilde{w}$ Vector with labour-added coefficients.

x Exports vector.

z Symbol indicating a particular vector representing a basket of goods; z = c, m, x: consumption, imports, exports respectively.

Available Occasional Papers

		Author(s)
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