CENTRAL BUREAU OF STATISTICS
The Netherlands
Department of National Accounts

BACKWARD AND FORWARD LINKAGES WITH AN APPLICATION TO THE DUTCH AGRO-INDUSTRIAL COMPLEX

R. Harthoorn*)

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Summary

Some industries induce production in other industries. Besides the familiar backward linkages, in some cases induction through forward linkages may be assumed. However, a straight forward combination of both linkages will lead to some incorrect results because part of production will be twice accounted for. By introducing the concept of "selection vectors" an elegant method is developed for combining the linkages while at the same time avoiding this pitfall. In addition, by introducing pseudo-industries the effects of the consumption of capital goods can be calculated conveniently. These methods have been applied to determine the influence of Dutch agriculture on the Dutch economy. It was assumed that part of the food processing industry as well as a part of the export of services bij wholesale trade can be regarded as forward effects of agriculture.
For 1981 the influence is measured in terms of value added and Labour force.

1. Introduction

Input-output analysis is often used to study the linkages between output levels of different industries. It assumes a linear relation between the output of an industry and its purchases from other industries. Clearly, under this assumption changes in an industry's output are directly translated into changes in its suppliers' output. This is called a backward linkage. But the linkage may also be the other way around: output of an industry may influence the industries of which it is the main supplier. This is referred to as a forward linkage.

The input-output literature concentrates on backward linkages and pays little attention to the forward ones. This is an unsatisfactory situation, because forward linkages may be of considerable importance too. In some cases the forward linkage is quite as direct. Thus, the output of the Dutch sugar industry varies directly with the size of the sugar-beet harvest. But even when the linkage is not quite as direct as that, the existence of a supplying industry may be a necessary condition for the existence for another industry because of the external economics required to achieve profitability for the latter. This is true whenever transport costs are high relative to the value of the commodity concerned. For this reason, the existence of a sizeable food-processing industry is unlikely in the absence of a highly developed agriculture: imports of unprocessed agricultural products are no viable alternative source of supply because of the relatively high costs of transport. This is borne out by the fact that the value of global international trade in unprocessed products does not exceed one tenth of the value of world agricultural production.

For this reason, the existence of a forward linkage between agriculture and food-processing industries is undeniable: one may consider the two to form a distinct agro-industrial complex. In The Netherlands this complex is of considerable importance: though being one of the most densily populated countries in the world, its balance of trade in agricultural products displays a huge surplus. This is made possible by the highest agricultural labour productivity in the world.

Consequently, it is important to analyse the backward and forward linkages of Dutch agriculture: the actual contribution of Dutch agriculture to national product and balance of trade is even greater than is evident from an inspection of just the data on agriculture, because of the linkages. However, our approach

has wider applicability: whenever it is reasonable to assume the existence of both backward and forward linkages between groups of industries, the method presented in this paper can be employed to analyse them.

Allowing for forward linkages is asking for trouble. We can take it for granted that part of the effects of the forward linkages will - directly or indirectly - also be an integral part of the effects of the backward linkages of the industry we have singled out for our study. (From now on we will refer to this industry as the core industry.) So when we add the effects of both backward and forward linkages the possibility exists that some effects could be twice accounted for. The situation becomes even more complicated when we recognize that the effects of forward linkages in their turn will induce effects of backward linkages. Now these effects will include the direct consumption of the core industries but, next to it, there also happens to be an indirect consumption of goods and services originating from that same core industry. Here the afore-mentioned problem pops up again.

In this paper we have developed a simple and lucid method to avoid this problem. In sections 2 and 3 we introduce the concept of selection vectors; this leads to a rather radical simplification of the notation. In section 4 a birds-eye view is given of a generalization of the calculations. "Consumption" of fixed capital is being payed attention to in section 5. By enlarging the input-output tables with a number of rows and columns we introduce so-called "pseudo-industries", representing the input and output "structure" of several categories of capital goods. They make it possible to estimate in an easy way the effects related to the consumption of capital goods.From section 6 on, the application to the Dutch agro-industrial complex is discussed. We take a close look at its influence on the processing industries, the trade balance and employment.In section 9 the results are summed up.

2. Notation

Throughout the text capital letters A, I, L, ... denote matrices, small letters t, u, v, ... denote column vectors. (There is one exception: the capital letter S represents a set. see below.) The hat (~) is used on small letters to indicate the diagonal matrix which can be formed by means of the vector. The identity matrix is represented by I; the summation vector i is a vector with all elements equal to 1. Matrices and vectors of technical coefficients have the tilde sign (~) added, e.g. $\tilde{A}$ and $\tilde{t}$. Throughout the text the matrices will be assumed to have the appropriate dimensions. A glossary and

a list of symbols and relations is to be found at the end of this paper.

We now introduce the concept of selection vectors and rest vectors. Their elements can only take the values 0 or 1. These vectors will behave as a kind of "switch", which will let through or block certain "commodity flows". The elements of the selection vectors are defined as

$$s_m(j) = 1 \text{ for } j \in S_m$$
$$= 0 \quad " \quad j \in S_m \;,\; m \geq 0 \;,$$

where S_m is the subset m of industries in the input-output table. Which industries are elements of which subset depends on the specific choice of the core industry and its matching forward linkages. The subsets are disjunct. The rest vectors are the complement of the sum of those selection vectors of which the subscripts are equal to or lower than m:

$$r_m = i - \sum_{j=0}^{m} s_j$$

To all practises and purposes the rest vectors behave as selection vectors.

To visualize the composition of the subsets S_m we may consider the example that wil be elaborated in section 6. We start with the ranking number of the selected industries, here restricted to agriculture only. So the subset S_0 contains only one element: agriculture. The subset S_1 has as its elements the industries which form the first forward linkage: the slaughtering and meat-processing industry, the dairy industry, the fish, vegetables and fruit processing industry (restricted to its consumption of domestic agriculture products) and the sugarindustry; the subset S_2 has as its elements the wholesale and retail industry (again restricted to products which originated from the industries in S_0 and S_1).

3. The method

The production, needed for the delivery of one unit of output of an industry can be represented by the well-known Leontief inverse. The fraction of the output of the core industry can easily be selected

$$\tilde{s}_0 (I - \tilde{A})^{-1} \qquad (1)$$

It goes without saying that this output induces effects which are due to

backward linkages. The direct consumption of products stemming from other industries can be expressed by

$$\hat{r}_o \tilde{A} \hat{s}_o (I - \tilde{A})^{-1} \tag{2}$$

However, we also have to take into account the indirect consumption of the core industry. The presence of the Leontief inverse in (2) indicates that all input flows, direct and indirect, which run through the industry, have already been taken into account. This has also led to the possibility that a flow will be twice accounted for. It is easy to avoid this trap: from the matrix of technical coefficients we only need to erase all industries which are elements of S_o. This can be achieved by applying the rest vectors

$$\hat{r}_o \tilde{A} \hat{r}_o \tag{3}$$

Using the thus adjusted Leontief inverse the direct and indirect input flows are now correctly expressed by

$$(I - \hat{r}_o \tilde{A} \hat{r}_o)^{-1} \tag{4}$$

The next step is to calculate the part of the cumulated consumption of other industries which can be attributed to the cumulated consumption (1) of the core industry. This can be achieved by multiplying (2) and (4)

$$(I - \hat{r}_o \tilde{A} \hat{r}_o)^{-1} \hat{r}_o \tilde{A} \hat{s}_o (I - \tilde{A})^{-1} \tag{5}$$

Formula (5) represents the effects belonging to the backward linkages.

We now introduce the matrix U_o to represent the output of, all industries, is needed by the core industry for its production of goods and services for final consumption. U_o is obtained by adding (1) and (5) and multiplying the result by the final consumption matrix Y

$$U_c = \{\hat{s}_o (I - \tilde{A})^{-1} + (I - \hat{r}_o \tilde{A} \hat{r}_o)^{-1} \hat{r}_o \tilde{A} \hat{s}_o (I - \tilde{A})^{-1}\} Y \tag{6}$$

Suppose that certain industries consume goods and services produced by the core industry and of which it can safely be assumed that they depend completely on the existence of the core industry. We could consider these industries as the first forward linkage of the core industry. Because of the interdependence between all industries that part of the effects of the forward linkage is also

included in the cumulated inputs of the core industry. (As such these cumulated inputs are calculated according to standard procedures.) This part is at once an effect of a forward linkage and of a backward linkage. Now, if we want to establish the importance of the core industry we have to get rid of this part. This comes down to the elimination of all direct and indirect inputs of the core industry before we are to calculate the cumulated technical coefficients, i.e. we have to base the calculations on the adjusted Leontief inverse (4). Utilizing the selection vector s_1 we easily obtain the "proper" effects belonging to the first forward linkage

$$\hat{s}_1 (I - \hat{r}_0 \tilde{A} \hat{r}_0)^{-1} \tag{7}$$

Expressions (7) and (1) have similar interpretations. The effects of the backward linkages induced by the effects of the first forward linkage can be calculated in the same way. The coefficients of the direct inputs which originate from other industries (excluding the industries in S_0 and S_1!) and which are part of (7) can be expressed by (cf.(2))

$$\hat{r}_1 \tilde{A} \hat{r}_1 (I - \hat{r}_0 \tilde{A} \hat{r}_0)^{-1} \tag{8}$$

Likewise, when we want to calculate the indirect input flows we have to exclude all industries of both subsets: so in order to calculate the cumulated consumption the calculations have to be based on the matrix

$$\hat{r}_1 \tilde{A} \hat{r}_1 \tag{9}$$

Quite similar to the way we calculated (4) and (5) we are now able to compute the cumulated inputs which originated from the remaining industries. Here it involves the inputs which go with expression (8)

$$(I - \hat{r}_1 \tilde{A} \hat{r}_1)^{-1} \hat{r}_1 \tilde{A} \hat{s}_1 (I - \hat{r}_0 \tilde{A} \hat{r}_0)^{-1} \tag{10}$$

The direct and indirect output U_1 should be considered as <u>exclusively</u> an effect of the first forward linkage, including the effects of the associated backward linkage

$$U_1 = \{\hat{s}_1 (I - \hat{r}_0 \tilde{A} \hat{r}_0)^{-1} + (I - \hat{r}_1 \tilde{A} \hat{r}_1)^{-1} \hat{r}_1 \tilde{A} \hat{s}_1 (I - \hat{r}_0 \tilde{A} \hat{r}_0)^{-1}\} Y \tag{11}$$

The reasoning applied to the calculations of (7) to (11) can be repeated for second and higher order forward linkages. For the effects of the n^{th} forward

linkage we find

$$U_n = \{\hat{s}_n (I - \hat{r}_{n-1} \tilde{A} \hat{r}_{n-1})^{-1} + (I - \hat{r}_n \tilde{A} \hat{r}_n)^{-1} \hat{r}_n \tilde{A} \hat{s}_n (I - \hat{r}_{n-1} \tilde{A} \hat{r}_{n-1})^{-1}\} Y \qquad (12)$$

4. A generalization

In section 3 our starting point was a group of industries, which we had singled out for our study. We especially wanted to look into the possibility to quantify the effects of the first and higher order backward and forward linkages. It is possible to generalize this concept by ordering all industries according to a previously defined hierarchy.

Let us assume that an economy can be represented by a laminated sphere, which can be peeled off layer by layer. Each layer contains a number of industries. For every layer we can determine its output plus the output by other industries. Of course the output, imputed to layers already peeled off in an earlier stage should be disregarded. Example of layers could be a division in agriculture, industry, services and government.

Suppose we have a series of layers, numbered 0 to n. This implies of course that

$$\sum_{m=0}^{n} s_m = i \qquad (13)$$

The total output of that economy could be represented by

$$U = \sum_{m=0}^{n} U_m$$

$$= \sum_{m=0}^{n} \hat{s}_m (I - \hat{r}_{m-1} \tilde{A} \hat{r}_{m-1})^{-1} + (I - \hat{r}_m \tilde{A} \hat{r}_m)^{-1} \hat{r}_m \tilde{A} \hat{s}_m (I - \hat{r}_{m-1} \tilde{A} \hat{r}_{m-1})^{-1} \qquad (14)$$

where $r_{-1} = i$

The total value added can then be given by

$$v = \hat{\tilde{v}} U i \qquad (15)$$

5. Capital goods

Until now we have avoided the problem of the input of capital goods. But in almost every industry capital goods are used. They last only a certain amount of time and after this period they have to be replaced in order to maintain the level of production. This is usually referred to as "consumption of fixed capital" and, if valued at current pries, can be considered as a standard for replacement investments.

Since we want to take the consumption of capital goods into account we have to consider three kinds of cumulated effects to enable us to calculate this cumulated consumption:

1. the use of capital goods during the consumption of commodities which have been consumed - directly or indirectly - in behalf of the core industry;
2. the use of capital goods during the production of capital goods;
3. the cumulated use of commodities (none of them capital goods) during the production of capital goods;

One should be aware that many kinds of mixed forms are possible.

The calculation of the combined cumulated effects can be simulated by adjusting the original IO-table. Therefore, we have to extend the IO-table with a number of "pseudo-industries". The rows of these industries contain the inputs of capital goods, i.e. depreciation by industries. The Dutch IO-table distinguishes four categories of capital goods: buildings, other construction works, transport equipment and other equipment.

The rows are very similar to the "normal" rows in the intermediate block: the normal rows also show consumption of a certain type of commodities, viz. the commodities produced by the industries concerned.

In our IO-table the columns of the pseudo-industries represent a kind of input structure. The capital goods are found on the rows of the industries which produce them. The columns also contain inputs like retail services, transport costs, business services etc. It goes without saying that column totals should equal row totals.

By introducing the concept of pseudo-industries we make sure that only replacement investments will be recorded. Since little is known about the existing stocks of capital goods we have assumed that the composition of a basket of replacement capital goods (i.e. the inputs in a certain column of a pseudo-industry) is similar to its original composition.

We denote the thus constructed matrix as A^+. From this extended matrix, we can reconstruct the original matrix A by applying the selection vectors s_a.

$$A = \hat{s}_a A^+ \hat{s}_a \tag{15}$$

Here $s_a(j) = 1$ for $j \in$ all industries except pseudo-industries
$= 0$ for $j \in$ pseudo-industries

Employing the extended matrix A^+ we can repeat the calculations of sections (3), ending up with a matrix U_m^+, which represents inputs of capital goods. So now we can calculate the effects attributed to the consumption of capital goods.

$$U_m^k = U_m^+ - U_m \tag{16}$$

The calculations for U_m^+ were made with the help of the intermediate matrix A^+ from (15). By extending the matrices of (16) with dummy rows and columns they will take on the same dimensions as the matrices in other expressions.

6. An application to the Dutch agro-industrial business

Agricultural production has a special place in the Dutch economy.
Before the second world war a large part of the Dutch labour force was employed in agriculture. After the war this situation rapidly changed. Mechanization and rationalization (and in the eighties computerization!) made their inroads on the number of people employed and very soon only a small part of the labour force was still directly involved in the production of foods. In spite of this, the Netherlands remained a major agricultural producer and even became the second largest food-producing country in the world. Considering the small and evershrinking agricultural area this can only be attributed to the highest agricultural production per capita in the world.

Its influence on the trade balance is already obvious if one just looks at the exports of raw agricultural products. However, this influence goes a lot deeper: in fact the difference between the present-day trade balance and a fictitious one which would have no Dutch production at all would really demonstrate its tremendous impact on the trade balance. (Of course the absence of any agricultural production is a hypothetical case: a great number of consequences, of the absence of a Dutch agriculture would be irreversible.

Therefore we have to be very careful if we want to study any changes in imports and exports).

This difference is the starting-point of our study. Firstly, we will consider the expected changes in imports and exports. A change in imports consists of two components: an increase in the imports of agricultural products to compensate the "wipe-out" of domestic production and a decrease in imports of agricultural products which normally would be needed for the industry "agriculture" itself. (An example of the last component would be fodder, imported for domestic livestock.)

The first component can be assumed to equal the value of the domestic consumption: in case domestic production drops to zero, the customer will simply turn to imported products. Most probably imported goods will be slightly more expensive but, considering the low price elasticity of agricultural products, the rise in prices would not lead to a substantial decrease in consumption. The second component to be considered is the drop in imports of inputs for agriculture that would result when production of agricultural goods would be reduced to zero. The effects on the trade balance are to be measured in terms of the net value added at market prices.

The total contribution of Dutch agriculture to the trade balance now consists of this net value added that would be lost if all agricultural products would have to be imported and, in addition, the cumulated net value addid created in the production of exported agricultural products. Here we emphasize the concept of net value added since we take into account the effects resulting from the consumption of capital goods.

Until now we have used the term "agricultural products" rather loosely. It is time to define it properly:

1. Consider the output of the agricultural sector itself. We define its primary effect to be the cumulated value added of the agricultural production in the Netherlands (Note that this includes more than just the direct imports and exports of agricultural products: it also includes agricultural products, incorporated in goods and services of other industries, which in their turn are destined for final consumption or exports.)
2. a number of industries are dependent on products of the domestic agriculture to such an extent, that we can consider their output as being induced by the Dutch agriculture. We can consider them as the first forward

linkage of the Dutch agriculture. Examples have already been given in section 2. Here we take the view that domestic food-processing industries have to rely on strong "external economies", determined by the existence of a domestic agriculture: without this agriculture none of these industries could hope to survive. Just compare the transport costs of sugar with those of sugar beets. We will also pass by the fact that some of these industries, now that they are firmly rooted in the economy of the Netherlands, are in the position to determine the harvests that should be cultivated. The interdependence between agriculture and several other industries is of significance; we regret that, because sufficient data is lacking, we were not able to pursue this subject.

3. there is a third activity induced by agricultural production that may be considered as a (second) forward linkage: the services of the wholesale industry needed for the exports of agricultural goods and products of the domestic food processing industries. Without exports this activity would not happen. On the other hand, services in behalf of consumption by households and government do not cause forward effects. If the domestic agricultural production would be replaced by imports, there would still be a lot of trading in these products. Here we neglect the fact that trade services would increase slightly because in some cases these services would have to be expanded to replace trade that now takes place directly between producer (farmer) and consumer. (A good example is the direct trade of potatoes to households, which in the Netherlands can be up to 20% of the volume of the farmers' potato crops.)

Since in our calculations in this section we only consider the effects, induced by exports and consumption, on the trade balance, the matrix Y will include only two column vectors

$$Y = (x,c) \tag{17}$$

In section 3 we have derived the formulae concerning the output of several industries, induced by direct effects and effects caused by forward linkages. We now calculate the value added by multiplying the (diagonal) coefficient matrix $\hat{\tilde{v}}$ with these formulae.

In this way we find the direct effect, excluding the impact of the use of capital goods on the calculations

$$V_o = \hat{\tilde{v}}\, U_o \tag{18}$$

and for the effect due to the firstforward linkage

$$V_1 = \hat{\tilde{v}}\, U_1 \tag{19}$$

The corresponding contributions, which can be related to the consumption of capital goods are

$$V_0^k = \hat{\tilde{v}}\, (U_0^+ - U_0) \tag{20}$$

$$V_1^k = \hat{\tilde{v}}\, (U_1^+ - U_1) \tag{21}$$

The second forward linkage, as formulated in this section, has a less general form than the formula in section 3. Here it includes only a limited part of the direct exports of wholesale trade services; services which are incorporated in the remaining part of the exports or in consumption are <u>not</u> accounted for. As a consequence the analogon of (8) in expression (12), indicating which part of the production of the core industry is incorporated in final demand categories, has to be substituted by these exports.

We now suppose that the matrix of final demand includes only the vectors x (exports) and c (consumption)

$$\sigma\,(x,0) \tag{22}$$

The vector σ is defined as

$$\begin{aligned} 0 < \sigma(j) < 1 \text{ for } j = 30 \text{ (the row of the wholesale trade)} \\ \sigma(j) = 0 \text{ for } j \neq 30 \end{aligned} \tag{23}$$

This vector indicates the part of the direct exports of wholesale trade services that can be considered as services rendered to the exports of agricultural products. Thus the effect of the second forward linkage can be expressed as

$$V_2 = \hat{\tilde{v}}\, (I - \hat{\tilde{r}}_1 \tilde{A} \hat{\tilde{r}}_1)^{-1} \quad \hat{\sigma}\,(x,U) \tag{24}$$

Here the second part of expression (23) is absent, because by definition exports of wholesale trade services are not incorporated in goods and services supplied by other industries.

In the same way we can calculate the effect including the use of capital goods

$$V_2^k = \hat{\tilde{v}} \{ (I - \hat{r}_1 \tilde{A}^+ \hat{r}_1)^{-1} - (I - \hat{r}_1 \tilde{A} \hat{r}_1)^{-1} \} \hat{\sigma} (x,0) \qquad (25)$$

Special attention has been paid to the impact of the EC policy on the value added of agricultural products by its way of handling levies and subsidies. The 3544 mln guilder balance of these levies and subsidies, awarded by the European Orientation and Quarantee Fund for Agriculture, should be added to the value added recorded in the standard Dutch IO-table. In particular, the value added recorded for the industries receiving these net subsidies on their products should be raised bij the amount of these subsidies. As a consequence the figures for these industries differ from those published in the IO-table.

Several corrections were needed to determine the effects of the consumption of capital goods on agriculture and the food-processing industries. The corrections concern the production of investment good by the agricultural and food processing industries.

7. The trade balance

The results of our calculations are summarized in the tables 1 and 2. They give a survey of the value added that can be imputed to agriculture, as far as the products are embodied in the baskets of consumption or exports. The baskets can be considered as a representative measure of the importance of the agro-industrial complex.

In table 1 the generation of the value added by industry is displayed; here we have distinguished between the various forward linkages and the generation of value added that can be related to the consumption of capital goods. Every column contains both direct and indirect effects. In the first seven columns the value added of the various industries which can be related to the cumulated exports of agricultural products is shown. Of course a large part (71%) of the generated value added shown in the first column can be attributed to agriculture but the contribution to other industries, e.g. the wholesale industrie (9%) cannot be neglected. In column 2 estimates are displayed for the value added generated by those replacement investments that can be connected to column 1. This amounts to nearly 5% of the total generated value added of the investments by industries (one fourth part of it stems from the building construction industry alone). The value added generated by the direct and indirect exports of products of the food-processing industry is represented by

column 3. Except for the four processing industries, the value added is particularly generated by the wholesale trade. In column 4 we have estimated the value added generated by the "consumption" of the capital goods, that can be related to column 3.

In column 5 we find the value added that can be related to the trade services that were needed to export the agricultural products. The wholesale trade takes up 80% here! We have to take into account that the deviations can be very large. Finally in column 6 we find the value added generated by the replacement investments of the trade services.

In column 7 we find the sum of the columns 1 through 6: this is the value added induced in the Netherlands by the exports of agricultural products. With 43% agriculture dominates the picture. Due to lack of data we were not able to calculate the contribution abroad of the Dutch transports industry to the generation of the value added. It must be considerable, considering the fact that the transport industry in the Netherlands already induces 3.1 mld guilders of value added.

The columns of the consumption have been calculated in the same way. There is one exception: the analogon of the columns 5 and 6 has been omitted. If we would replace domestic production by imports, we still would have to trade agricultural products; thus, the part of the wholesale trade that can be related to the domestic consumption of agricultural products should not be considered as induced by Dutch agriculture.

The contributions by industry to the trade balance can be found in column 15. The total of column 13 gives an indication of the contribution of agriculture to the trade balance. This amounts 8,6% of the net domestic product. In column 15 we also find the answer to the question of the significance of the agriculture-induced production to the various industries. Of course the grain-processing industry is (with 60%) largely dependent on agriculture. The demand for fodder is the main reason. All together we find that 9% of the value added generated in the Netherlands can be attributed to agriculture. Another conclusion we can draw from table 1 is that agricultural production is highly important for other Dutch industries. More than 55% of the value added, generated by the production of agricultural products for exports and consumption, is induced in other industries.

Table 1 clearly showed the importance of agriculture for a number of Dutch industries. Table 2 shows us the interdependence of the agro-industrial complex and, more over, quantifies the direct and indirect effects.

Seven groups are represented, all subdivided into three sows: direct, indirect and capital. Direct is not always direct in the strict sence of the word: whenever quotes appear consumption by the processing industry is included.

The first three groups concern the products of agriculture proper, the next two products of the processing industry and finaly the generation of value added for exports in the trade services is shown.

Altogether the exports of products of agricultural origin generated - directly and indirectly - a value added of 18000 mln guilder in 1981. The contribution of agriculture itself was only 17% (for consumption this figure was even lower, 11%).

8. Employment

Substituting the vector v of net value added by the vector l of employment in the expressions (17)-(20), (23) and (24), we obtain the matrices L_m and L_m^k for the induced employment. Analogous to table 2, we find in table 3 the employment per industry related to agricultural exports and consumption. More than half a million person-years are involved; this is about 11% of the Dutch labour force. Right away we notice that here the contribution of agriculture itself (51%) is considerably higher than in the case of value added (44%). Induced employment in the wholesale trade is remarkable too (73000 person-years). Relatively important contributions can be found in the slaughtering and meat industry (24000), the dairy industry (71000), the grain processing industry (11000), the construction industry (14000), banking (12000) and business services (14000). In contrast to its contribution to value added the employment contribution of oil and gas exploration is negligible, which is not surprising considering the capital-intensive character of the industry.

9. Conclusion

If we want to know the forward linkages of a certain effect it is advisable to calculate them including the matching backward linkages. We can avoid the pitfall that flows are twice accounted for by introducing the concept of selection vectors.

An application of the method to Dutch agriculture makes its importance clearly visible. Its contribution to the trade balance amounted up to 9% (28 mld guilder) of the 1981 net national income. However, a larger part of the net value added, induced by Dutch agriculture, is created in other industries. Besides agriculture itself and the food-processing industries the net value added induced in wholesale trade and in oil and gas exploration is important. Furthermore, about 9% of the induced value added can be related to the induced production of replacement investments. The dependence of banking and gas distribution on agriculture is also above average.

Employment produces a similar picture. For every person-year in agriculture a person-year is induced in some other industry. Especially in the wholesale trade a large number of person-years (73000 = % of its total labour force) is induced.

Glossary

backward linkages	the indirect effects as far as they are induced in the supplying industries; the effects which can be related to the cumulated consumption of capital goods are included
core industries	the industries we have singled out to study, especially their backward and forward linkages; in this paper the Dutch agriculture has been brought into focus
cumulated effects	the sum of direct and indirect effects
direct effects	the effects that can be related to the production of particular goods and services; in this paper they concern the focused industries
effects	examples of effects are employment, value added etc.
forward linkages	the direct effects related to processing of and/or consuming of goods and services by its buyers as far as this results from the production of these commodities, plus the related linkages minus the primary effects related to the commodities to be processed
induced effects	the sum of primary effects and forward linkages
indirect effects	the effects related to the production of commodities that can be linked to the cumulated consumption of an industry; here it excludes the consumption of capital goods. It should be noted that indirect effects can also occur within the industry itself
primary effects	the sum of direct effects and backward linkages

List of symbols and relations

A		intermediate consumption
$\tilde{A}$	$\tilde{A} = A\,\hat{t}^{-1}$	intermediate input coefficients
A^+	$A = \hat{s}_a A^+ \hat{s}_a$	intermediate consumption, supplemented by the consumption of capital goods
$\tilde{A}^+$	$\tilde{A} = \hat{s}_a \tilde{A}^+ \hat{s}_a$	intermediate input coefficents, supplemented with the input coefficients of the vector of the capital goods
c		consumption vector
I		identity matrix
i		summation vector
L_m	$L_m = \hat{l}\, U_m$	employment attributed to the primary effect (m=0) or the m^{th} forward effect (m>0); excluding the consumption of capital goods
l		vector of employment
$\tilde{l}$	$\tilde{l}' = l\,\hat{t}^{-1}$	vector of the employment coefficients
n		number of the forward effects
r_m	$r_m = i - \sum_{j=0}^{m} s_j$	rest vector for the m^{th} effects
S_m		m^{th} subset of industries
s_o		vector which selects the core industry
s_m		vector which selects the industry belonging to the m^{th} forward effect
s_a		vector which selects the usual industries from a set that has been extended with pseudo-industries

t	$t = A^{+} i$	vector with the total production of each industry
U	$U = \sum_{m=0}^{n} U_m$	the induced production, broken down by industries and the final demand categories
U_m		production (consumption) belonging to the primary effect (m=0) or the m^{th} forward effect (M>0); excluding the consumption of capital goods
U_m^k	$U_m^k = U_m^+ - U_m$	production (consumption) related to the primary effect (m=0) or the m^{th} forward effect (m>0) as far as they are related to the consumption of capital goods
U_m^+		production (consumption) related to the primary effect (m=0) or the m^{th} forward effect, including the consumption of capital goods
V_m	$V_m = \hat{\tilde{v}}\ U_m$	generation of value added related to the primary effect (m=0) or the m^{th} forward effect, excluding the consumption of capital goods
V_m^k	$V_m^k = \hat{\tilde{v}}\ U_m^k$	generation of value added related to the primary effect (m=0) or the m^{th} forward effect of the consumption of capital goods
v		vector of the generated value added
$\tilde{v}$	$\tilde{v} = v\ \hat{t}^{-1}$	vector of the value added coefficients
x		vector of the exports
Y		matrix of the final demand categories (m our calculations only exports and consumption are taken into account)
σ		vector which extracts the relevant exports of trade services from the vector of the exports of goods and services

Table 1. Agriculture-induced value added, by industry, The Netherlands 1981.

	Export 1)							Consumption 1)					Total		Dependency % 3)
	Primary 2)		Forward linkages 2)				Total Column 1-6	Primary 2)		Forward 1, 2)		Total Column 8-11	Column 7+12	in %	
	Agriculture		Processing industry		Wholesale trade			Agriculture		Processing industry					
	excl. cap.	capital	excl. cap.	capital	excl. cap.	capital		excl. cap.	capital	excl. cap.	capital				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	million Dfl.														
Agriculture, horticulture and forestry	7706	74	-	-	-	-	7780	4485	46	-	-	4531	12311	45	100
Fishing	0	0	7	0	0	0	8	0	0	6	0	6	13	0	4
Crude petroleum, natural gas production	491	28	183	8	24	3	736	286	17	140	6	448	1184	4	5
Other mining and quarrying	7	2	9	1	0	0	19	4	1	6	1	12	31	0	7
Slaughter houses, meat processing	11	0	879	0	-	-	891	6	0	636	1	644	1534	6	100
Manufacture of dairy products	24	0	773	0	-	-	798	14	0	554	0	568	1366	5	99
Canning, processing of fish, fruit etc.	1	0	193	0	0	0	194	0	0	148	0	149	343	1	97
Grain processing industry	407	4	0	0	0	0	411	237	2	0	0	239	650	2	68
Sugar industry	22	0	198	1	-	-	221	13	0	177	1	191	412	1	94
Flour process., cocoa, beverages, tobac.	12	0	12	0	1	0	25	7	0	9	0	16	41	0	1
Margarine, starch and other food	66	1	9	0	0	0	76	38	0	7	0	46	122	0	11
Wool, cotton, textiles, cloth., leather	2	2	1	1	0	0	6	1	1	1	1	3	9	0	0
Wood and furniture industry	9	26	2	12	2	3	54	5	15	2	9	31	85	0	5
Paper and cardboard industry	82	12	93	4	43	2	236	48	7	68	3	127	363	1	6
Petroleum industry	19	2	6	0	3	0	30	11	1	5	0	17	46	0	2
Chemical basic and final products ind.	58	4	9	1	2	1	75	34	2	6	1	44	118	0	3
Rubber and plastic products industry	15	5	23	1	3	1	48	9	3	17	1	30	78	0	6
Building materials, earthenware, glass	16	12	9	3	1	1	42	9	7	7	2	25	67	0	4
Basic metal industry	5	5	10	2	0	1	22	3	3	7	1	14	36	0	2
Manufacture of metal products	48	55	85	24	7	7	225	28	32	62	18	140	366	1	8
Machinery	16	68	7	33	1	8	134	9	40	5	25	79	213	1	5
Electrotechnical industry	9	62	5	31	1	7	116	5	36	4	23	68	184	1	3
Manufacture of motor vehicles	2	22	1	5	0	7	38	1	13	0	4	18	56	0	6
Manufacture of other transport equipment	2	38	1	9	1	12	63	1	22	1	7	30	93	0	5
Instruments, optical goods, other ind.	5	8	1	4	0	1	18	3	4	1	3	11	29	0	2
Electricity generation	58	10	32	4	11	2	116	34	6	24	3	66	182	1	7
Gas distribution	82	3	18	1	3	0	108	48	2	13	1	64	171	1	13
Water supply	12	1	6	1	2	0	21	7	1	5	0	13	34	0	4
Construction and installation	142	231	36	48	11	23	492	83	135	27	36	281	772	2	4
Wholesale and retail trade	696	197	264	67	1853	38	3116	405	115	193	50	764	3880	14	10
Hotels, restaurants, cafes etc.	13	3	5	1	7	0	30	8	2	4	1	14	44	0	1
Repair of consumer goods	81	7	20	2	16	1	127	47	4	15	2	68	195	1	7
Sea and air transport	5	3	2	1	5	1	16	3	2	1	1	7	23	0	1
Other transport and allied industries	78	38	51	15	158	6	345	45	22	41	11	119	464	2	5
Communication	111	15	41	5	48	3	223	65	9	31	4	108	331	1	6
Banking	-17	-1	-7	0	-4	0	-30	-10	-1	-5	0	-16	-47	0	10
Insurance	80	5	15	1	13	1	115	47	3	11	1	62	117	1	4
Real estate, business services	247	131	213	40	71	15	717	144	76	156	30	407	1123	4	8
Government	52	17	35	5	6	3	118	30	10	25	4	70	188	1	0
Social services	21	4	19	1	3	1	48	12	2	14	1	30	78	0	1
Health and veterinary services	106	2	1	0	0	0	109	62	1	1	0	63	172	1	1
Culture, sports, recreation, other serv.	26	7	26	2	12	1	75	15	4	19	2	40	115	0	1
Total	10823	1104	3294	337	2306	146	18010	6300	646	2444	253	9643	27654	100	9

1) Both immediate and after processing in other industries.
2) Includes backward effects.
3) In percentages of the total value added by industry.

Table 2. Agriculture-induced value added distiguished in direct and indirect, The Netherlads 1981.

	Exports 1)					Consumption 1)					Total of
	Agri-culture	Process-sing indu-stries	Whole-sale trade	Other indu-stries	Total of columns 1 - 4	Agri-culture	Process-sing indu-stries	Whole-sale trade	Other indu-stries	Total of columns 6 - 9	columns 5 + 10
	1	2	3	4	5	6	7	8	9	10	11
	million Dfl.										
PRIMARY											
1. Unprocessed agricultural products.											
A. Direct	3056	-	-	-	3056	1024	-	-	-	1024	4080
B. Indirect	183	26	314	970	1493	61	9	98	335	503	1996
C. Capital	31	0	89	344	464	11	0	28	118	157	621
2. Agricultural products incorporated by the processing industries.											
A. "Direct"	3579	-	-	-	3579	2393	-	-	-	2393	5972
B. Indirect	543	33	368	1266	2210	361	22	249	849	1481	3691
C. Capital	39	0	104	446	589	27	0	71	299	397	986
3. Agricultural products incorporated by other industries.											
A. "Direct"	140	-	-	-	140	219	-	-	-	219	359
B. Indirect	205	3	14	123	345	427	4	58	192	681	1026
C. Capital	4	0	4	42	50	8	0	17	67	92	142
FORWARD											
4. Products of the processing industries.											
A. Direct	-	1684	-	-	1684	-	1137	-	-	1137	2821
B. Indirect	-	149	234	842	1225	-	99	157	570	826	2051
C. Capital	-	2	59	229	290	-	2	43	155	201	491
Products of the processing industries incorporated by other industries.											
A. "Direct"	-	95	-	-	95	-	165	-	-	165	260
B. Indirect	-	115	30	145	290	-	114	36	166	316	606
C. Capital	-	0	8	39	47	-	0	7	45	52	99
6. Trade services associated with exports of agricultural products.											
A. Direct	-	-	1363	-	1363	-	-	-	-	-	1363
B. Indirect	-	-	29	340	369	-	-	-	-	-	369
C. Capital	-	-	29	81	110	-	-	-	-	-	110
7. Trade services associated with exports of the processing industries.											
A. Direct	-	-	452	-	452	-	-	-	-	-	452
B. Indirect	-	-	9	113	122	-	-	-	-	-	122
C. Capital	-	-	9	27	36	-	-	-	-	-	36
Total	7780	2104	3116	5010	18010	4531	1552	764	2796	9643	27654

1) Both immediate and after processing in other industries.

Table 3. Agriculture-induced employment, by industry, The Netherlands 1981.

	Export 1)							Consumption 1)					Total	
	Primary 2)		Forward linkages 2)				Total Column 1-6	Primary 2)		Forward l. 2)		Total Column 8-11	Column 7+12	in %
	Agriculture		Processing industry		Wholesale trade			Agriculture		Processing industry				
	excl. cap.	capi-tal	excl. cap.	capi-tal	excl. cap.	capi-tal		excl. cap.	capi-tal	excl. cap.	capi-tal			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	1000 person-years													
Agriculture, horticulture and forestry	167	2	-	-	-	-	169	97	1	-	-	98	268	51
Fishing	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crude petroleum, natural gas production	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other mining and quarrying	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Slaughter houses, meat processing	0	0	14	0	-	-	14	0	0	10	0	10	24	4
Manufacture of dairy products	0	0	12	0	-	-	12	0	0	8	0	9	21	4
Canning, processing of fish, fruit etc.	0	0	5	0	0	0	5	0	0	4	0	4	9	2
Grain processing industry	7	0	0	0	0	0	7	4	0	0	0	4	11	2
Sugar industry	0	0	2	0	-	-	2	0	0	2	0	2	4	1
Flour process., cocoa, beverages, tobac.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Margarine, starch and other food	1	0	0	0	0	0	1	1	0	0	0	1	2	0
Wool, cotton, textiles, cloth., leather	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood and furniture industry	0	1	0	0	0	0	1	0	0	0	0	1	2	0
Paper and cardboard industry	1	0	2	0	1	0	4	1	0	1	0	2	7	1
Petroleum industry	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemical basic and final products ind.	1	0	0	0	0	0	2	1	0	0	0	1	2	0
Rubber and plastic products industry	0	0	0	0	0	0	1	0	0	0	0	1	2	0
Building materials, earthenware, glass	0	0	0	0	0	0	1	0	0	0	0	1	1	0
Basic metal industry	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Manufacture of metal products	1	1	2	1	0	0	5	1	1	1	0	3	8	2
Machinery	0	1	0	1	0	0	3	0	1	0	0	2	4	1
Electrotechnical industry	0	1	0	0	0	0	2	0	1	0	0	1	3	1
Manufacture of motor vehicles	0	1	0	0	0	0	1	0	0	0	0	0	1	0
Manufacture of other transport equipment	0	1	0	0	0	0	2	0	1	0	0	1	2	0
Instruments, optical goods, other ind.	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Electricity generation	1	0	0	0	0	0	1	0	0	0	0	1	2	0
Gas distribution	1	0	0	0	0	0	1	0	0	0	0	1	2	0
Water supply	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Construction and installation	3	4	1	1	0	0	9	2	2	0	1	5	14	3
Wholesale and retail trade	13	4	5	1	35	1	59	8	2	4	1	14	73	14
Hotels, restaurants, cafes etc.	0	0	0	0	0	0	1	0	0	0	0	0	1	0
Repair of consumer goods	2	0	0	0	0	0	3	1	0	0	0	2	4	1
Sea and air transport	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other transport and allied industries	2	1	1	0	4	0	8	1	0	1	0	3	11	2
Communication	2	0	1	0	1	0	3	1	0	0	0	1	5	1
Banking	4	0	2	0	1	0	8	3	0	1	0	4	12	2
Insurance	1	0	0	0	0	0	1	1	0	0	0	1	2	0
Real estate, business services	3	2	3	0	1	0	9	2	1	2	0	5	14	3
Government	1	0	1	0	0	0	2	0	0	0	0	1	3	1
Social services	0	0	0	0	0	0	1	0	0	0	0	1	2	0
Health and veterinary services	2	0	0	0	0	0	2	1	0	0	0	1	3	1
Culture, sports, recreation, other serv.	1	0	1	0	0	0	2	0	0	0	0	1	3	1
Total	217	20	53	6	44	3	343	126	12	39	5	182	524	100

1) Both immediate and after processing in other industries.
2) Includes backward effects.

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		Author(s)
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