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Importance of agro-food chains in EU regions: a cross-section analysis

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1. Introduction

Input-output analysis is concerned with studying the interdependence of the producing and consuming units in an economy and with showing the interrelations among different sectors which purchase goods and services from other sectors and which in turn produce goods and services which are sold to other sectors. The various economic flows are set out in an input-output table which is specially designed to provide a concise and systematic arrangement of all economic activity within a state or region (O'Connor and Henry, 1976).This paper examines one aspect of the fundamentals of the input-output theory, namely the assumption of *homogeneous production.* That assumption suggests that each industry produces only one commodity and each commodity is produced by only one industry. Each commodity has its typical input structure, regardless of which industry is the producer ('commodity technology'). A commodity is a collection of goods and services and each industry is assumed to produce products that are characteristic to it. Hence, no secondary production should exist. Konijn (1994) remarked that the validity of this assumption is influenced to a large extent by the *classification* of industries used. In the compilation of input-output tables, industries must be classified in such a way that the assumption of homogeneous production is best satisfied. Usually, however, industry-based definitions of industries ('industry technology') are applied in empirical studies because most data are available on industry level, whereas just limited data are available for commodity flows. Both commodity and industry technology are assumptions about 'how' commodities are produced. Konijn and Steenge (1995) stated that these technology assumptions are not used to construct industry-by-industry tables, in which assumptions are only made on the origins and destinations of products. Hence, they consider the traditional construction method to be incorrect. In their opinion, the application of the commodity technology assumption for calculating an input-output table must be described as a transformation process of secondary products. If that assumption is correct, then the transformation procedure must result in non-negative values for the input-output table. However, the existence of more technologies for one product could be an important reason for the emergence of negative values. In this case, the problem of negatives is a classification problem. The amount of negatives can be reduced by choosing another commodity classification, and therefore Konijn and Steenge noted that it seems more realistic to let technology depend on a *production process*. They consider a production process as a process that transforms goods, services and primary inputs into other goods and services. A set of production processes with more or less homogeneous input structures can be aggregated, and called an *activity*; industries are disaggregated into as many commodities as there are ways to produce them. They developed an activity technology model on which, for instance, a Dutch input-output table was compiled for 1990.

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For a correct input-output analysis the rows and columns of the input-output table must be defined as homogeneously as possible. The *input structure* of products especially requires an accurate classification, because that is relevant for the derivation of input-output coefficients (which describe the technology of an economy in a certain period). For example, the Dutch input-output table, which is annually compiled by the Dutch Central Bureau of Statistics (CBS) with a delay of three years, contains 60 industries. Traditionally, agriculture, horticulture and forestry constitute one row and column in this table. Aggregating these primary activities implies a direct relation between, for instance, the demand for flowers and the production of cattle feed, due to a single input structure. For example, an incline in the demand for flowers will trigger extra production by the agricultural sector. Because livestock farming and horticulture are both included in this sector, the demand for cattle feed will be directly increased (also due to the assumption of fixed coefficients). Of course, such a linkage could be considered as nonsense. Inputs for animal farming differ from inputs for horticultural activities. Obviously, the assumption of homogeneous production is not valid for the agricultural industry in the national input-output table. It might be concluded that this type of table is not an useful tool for solving agricultural policy questions.

Since 1958 the Agricultural Economics Research Institute (LEI) has constructed so-called *agricultural input-output tables* (AIOT), which show homogeneity in terms of inputs for all different agricultural activities. Due to the strong linkages between agriculture and food industry in practice, LEI has also improved the degree of homogeneity for processing industries (Van Leeuwen en Verhoog, 1995). This paper will not discuss that disaggregation procedure because it has been applied to the Dutch input-output table in particular. On the other hand, most input-output tables for EU member states are constituted with aggregated primary activities too. To analyze the competitiveness of the agro-food industry in EU regions, it would be interesting to use input-output tables which are based on heterogeneous agro-food activities. Until recently, a harmonised set of AIOT's was never constructed for *all* fifteen EU member states. This was because of its labour intensiveness, which must be seen as a drawback of the disaggregation technique. The model compilation is difficult to describe in a unique model because a mix of statistics and model building must be applied. Nevertheless, section 3 will summarise the procedure followed in construction harmonised AIOT's for all EU member state as well as for the EU15 as a whole. Based on the AIOT's, section 2 will describe *agro-food chains,* which consist of primary industries, industries that process primary products (upstream linkages) and industries that deliver inputs directly and indirectly to primary and processing industries (downstream linkages). A serious question arises whether AIOT's are useful to measure the importance of agro-food chains for both national and EU economies. Therefore, section 4 will not only account for the competitiveness of the agro-food chain in and among EU regions, but will also make a short analysis of its dynamics.

2. Agro-food chains

2.1 Importance of homogeneous agro-food industry

There are two reasons to transform the industry based input-output table into a partial homogeneous agricultural input-output table. The first is the previously mentioned theoretical point regarding the homogeneity assumption (see section 1). The second is the feasibility of measuring policy impacts on the agro-food sector on the basis of an input-output table. We have already remarked that agriculture, horticulture and forestry are mainly constituted as one row and one column in an industry based input-output table. This primary sector, however, generates quite heterogeneous commodities with different input and output structures. For example, in 1997 horticulture under glass absorbed 77% of total agricultural energy use, whereas pig farming used about 8%. On the other hand, 45% of total cattle feed costs were intermediate inputs for pig farming, while horticulture had no such expenditures (Van Leeuwen, 1999). The previous section already pointed out the false relation between an increase in demand for flowers and the production of cattle feed. Applying demand analyses to an insufficiently aggregated input-output table - e.g., due to a reduction in cattle numbers – will miscalculate the impact on the agro-food sector's energy use. Thus, a disaggregated input-output table will achieve more accurate outcomes compared with an aggregated table. In addition to theoretical reasons for defining homogeneous agricultural activities in an input-output table, the commodity or activity approach of agricultural and environmental policies argue for a practical reason. A milk quota system or a policy to achieve environmentally acceptable phosphate losses are concentrated on particular (groups of) commodities or activities (like dairy livestock or intensive animal farming). Thus, an input-output table will only be useful for policy analysing if it separates heterogeneous primary activities.

In general, the feasibility of input-output analysis to measure primary activities effectively and to identify those characteristics associated with policy changes is often limited by available data at the desirable level. We have constructed a harmonised and consistent set of input-output tables for all EU15 countries. The matter of consistency was particularly important regarding the implementation of all EU member states in the Global Trade Analysis Project (GTAP), which is scheduled for the end of 2000 (Van Leeuwen, 2000). As a result, the harmonised EU tables will not only be comparable on EU level, but also on a world wide level. We have based the split of the agro-food sector on specialised data bases like SPEL/EU [1)] and FAO supply utilization accounts (SUA) (see section 3). Around the concept of activities available in these data bases, the original input-output tables are disaggregated into 14 primary activities (table 1). In the course of time both the nature and the extent of linkages between agricultural sub-sectors have changed. The strength and nature of such linkages depend on factors like agricultural support policies or policies influencing the choice of technology. These factors have a critical impact on determining the size and the composition of agro-food based industries as well as on setting its employment potential.

Table 1. GTAP sector classification for primary activities

1. Paddy rice	6. Sugar beets	11. Milk
2. Wheat	7. Plant fibers	12. Wool
3. Cereals	8. Crops n.e.c.	13. Forestry
4. Vegetables and fruit	9. Cattle and sheep	14. Fishery
5. Oilseeds	10. Pigs and hens	

In addition, the composition of agricultural output is another important issue in an AIOT. In 1997 approximately 50% of Dutch agricultural and horticultural production was either sold in the primary industry itself or supplied to the food industry and to other branches of industry. That was more than 20 percentage points less than in 1970. The cause of the decrease of these intermediate supplies lies above all in the increased importance of

1) SPEL/EU-model: Sectorales Produktions- und Einkommensmodell der Landwirtschaft der Europäischen Union (Sectoral Production and Income Model for the European Union). This model is in accordance with the European System of Integrated National Accounts (ESA).

horticulture within the agricultural sector. In comparison with livestock and arable farming, the processing link in the production column is weaker for horticulture. In 1997 livestock farming sold 86% of its production as intermediate supplies, while arable farming sold only 36%. Moreover, 43% of primary production was directly exported, which was more than twice as much as in 1970. Exports of the horticulture produced under glass amounted to over 95% and that of the other horticultural production to 73%, as against some 49% of arable production and about 10% of livestock production. A relatively small part (approximately 4%) of agricultural and horticultural production was supplied in unprocessed form to the consumer (e.g., potatoes, flowers, tomatoes). Linkages of primary activities with processing industries are strong, but not to the same extent for each activity. Therefore, a further classification in *processing activities* could improve the homogeneity of the input-output table (table 2).

Table 2. GTAP sector classification for food processing activities

1. Beef, sheep and goat meat manufacturing	5. Processed rice manufacturing
2. Pork and poultry meat manufacturing	6. Sugar manufacturing
3. Oils and fats manufacturing	7. Food nec manufacturing (incl. feed stuffs)
4. Dairy products manufacturing	

Although the Dutch AIOT identifies 14 food processing activities, we have not chosen for that number in the EU input-output tables. Our classification followed the GTAP data base, which distinguishes just 7 activities.

2.2 Definition of agro-food chains

This paper defines the agro-food chain as industries in the primary sector, the industries that process primary products (upstream linkages), and the industries that deliver inputs directly or indirectly to primary and processing industries (downstream linkages). We have distinguished seven sub chains, each representing a particular primary production activity:

- *dairy chain*: dairy farming, dairy manufacturing;
- *bovine and sheep chain*: cattle farming, sheep farming, beef manufacturing, sheep meat manufacturing, and goat meat manufacturing;
- *pigs and hens chain:* pig and hen farming, pork manufacturing, poultry manufacturing;
- *arable chain*: arable farming, sugar factories, fat and oil manufacturing, other food manufacturing, beverage and tobacco manufacturing;
- *horticulture chain*: vegetable and fruit holdings, vegetable and fruit manufacturing;
- *forestry chain:* forestry;
- *fishery chain*: fishery, fish manufacturing.

All disaggregated activities on primary and processing level are added up over the various agro-chains. In addition to primary and upstream linkages in the chains, downstream agro-food activities also serve as an important component. In 1997 the Netherlands sold 46% of the primary sector output to final consumers (by way of export and consumption), compared with 72% of its processed food products. Moreover, intermediate inputs accounted to 48% of gross agricultural and horticultural inputs, as against 39% for the economy as a whole (CBS, 1999). Because of such significant linkages of the primary sector with other sectors of production, it would be interesting to analyse the importance of agro-food chains for an economy. Input-output analysis is a good tool to measure the magnitude of backward (or downstream) and forward (or upstream) linkages of an industry. Harthoorn (1988) developed a method, based on standard input-output analysis, to isolate the inter-industry transactions in the agro-food sector from an input-output table (see appendix A). This method was applied in section 4 to illustrate the importance of EU agro-food chains in terms of gross value added and employment.

3. Method of constructing agricultural EU input-output tables

3.1 Collecting national input-output tables

This section summarises the procedure followed in constructing harmonised agricultural input-output tables for each member state in the EU as well as for the entire EU15 in agreement with GTAP version 5. Depending on the country, national statistical offices have an ongoing programme to compile input-output tables in annual, bi-annual or longer intervals. The amount of information reflected in these national tables varies among countries. In addition, Austria's most recent table refers to the year 1983, while Luxembourg and Greece delivered no table at all. In general, flows are expressed in millions of national currency, while those of Spain and Italy are expressed in 1,000 millions of national currency.

Another source for national input-output tables of the EU member countries constitutes the input-output table data base of Eurostat. In co-operation with the national statistical offices of the member states, Eurostat has the intention to compile five-yearly input-output tables which are harmonised in accordance with the European System of Integrated National Accounts (ESA). Up to now, the most recent tables available at Eurostat are for the year 1995 and they include estimated matrices for domestic production of goods and services, imports from EU member states, and imports from third countries. Estimates are based on the so-called EURO method, an iterative balancing procedure developed by Beutel (1999). The underlying idea of this approach is to use official Eurostat statistics as macro targets for iteration, together with the most recent version of a national input-output table. The column and row vectors of intermediate use and final demand are derived as endogenous variables, rather than accepted as exogenous variables from unspecified sources. This new updating method for input-output tables avoids arbitrary changes of important input coefficients, which sometimes occur if more traditional updating procedures are applied. The outcome of this approach is a harmonised set of input-output tables for the individual member states for the year 1995, with the exception of Belgium, Luxembourg, and Greece[1)]. The tables cover 25 sectors, with flows expressed in value terms using millions of ECU.

3.2 Mapping national sector classifications to GTAP classification

Single region input-output tables often reflect an industry by industry structure. One of the main tasks in preparing a GTAP input-output table concerned the mapping of the national sector classification to the GTAP sector classification (GSC). Several source sectors were too aggregated to match the GTAP sector breakdown, in which cases we imposed a split. We will only pay attention to the disaggregation of the agro-food industry here, although some other industries were split too (Van Leeuwen, 2000).

[1)] In the case of Belgium that was no real problem because a 1995 table was supplied by the Limburgs Universitair Centrum LUC-Diepenbeek.

Primary industry
A more or less aggregated sector group in the national input-output tables referred to primary industry, which had to be divided among agriculture, forestry and fishery at a first stage. The input-output tables for Denmark, France, Italy, the Netherlands, Portugal, United Kingdom, Sweden and Finland provided the preferred primary split in its original form (group A). The German table showed a split between agriculture (inclusive of horticulture) on the one hand, and forestry and fishery on the other (group B). Tables for Austria, Belgium, Ireland and Spain presented only one input-output structure for agriculture, forestry and fishery as a whole (group C). We disaggregated the production value and the value added of the primary industry on the basis of the economic accounts for agriculture and forestry (Eurostat, 1998). Those accounts were prepared by the statistical offices of the member states in accordance with a common methodology, and contain information on final output, intermediate consumption and gross value added for agriculture and forestry per member state. Intermediate flows on both the input and the output side of the primary industry were disaggregated on the basis of break-down information from group A.

At a second stage, we had to split up the agricultural sector into 12 activities on the basis of Eurostat's SPEL/EU-model and FAO/SUA's. SPEL is especially suitable to distinguish *agricultural inputs*, whereas FAO/SUA's delivers information to classify *agricultural outputs*. SPEL contains information for revenues and costs of 49 production activities (35 crop, 13 animal production activities and a category for fallow land) on both EU member state and EU15 level for the period 1975-1997. The procedure started with drawing up an input-output framework into which these data were placed. All SPEL activities produce commodities that are either used by agriculture itself or flow to processing industries, exports or consumption. For example, a large part of cereal production is directly used as feed by animal activities, while another part is used by the processing industry for flour production. Because some SPEL activities produce more than one product (e.g., the activities 'dairy cows' and 'other cows' produce both milk and bovine meat), their inputs were allocated to two or more products (e.g., to the GTAP commodities 'bovine cattle meat' and 'raw milk') in proportion to their production value in SPEL. The same method was applied to the SPEL activity 'ewes and goats', which produces the GTAP commodities 'wool' and 'meat'. Then, the SPEL activities 'grass grazing', 'other root crops', 'fodder plants on arable land' and 'fallow land' don't belong to the GTAP classification. According to SPEL, their outputs are completely used by animal activities to produce animal products. Because agriculture uses the four activities as inputs, they were allocated to the animal activities in proportion to the use of fresh and ensilaged fodder. As a result of this method, certain amounts of fertiliser and pesticides are added as inputs for the milk production.

Next, we used the SPEL input-output framework to disaggregate the agricultural sector in the EU input-output tables. Total agricultural inputs in those tables were divided on the basis of the SPEL inputs for each GTAP activity. In the case that SPEL showed insufficient input detail, the same input item was applied to disaggregate different cost components in the input-output table. E.g., SPEL's 'variable and overheads other inputs' were applied to distinguish expenditures on both 'textiles' and 'financial services' over agricultural activities. Hereafter, we focused on the split of *agricultural output*, to which the SPEL supply balance sheets offered information on domestic usage, exports, imports and stock changes. In many cases, however, SPEL gave no clear indication whether the products originated directly from farm or from processing industries. Therefore, it was not evident whether, for example, 'grain export' should be considered as 'grain' or as processed grain ('flour'). This indistinctness was solved by using the FAO/SUA's, which contain detailed information on what part of each product is processed, consumed or exported. Such SUA's are available for nearly 250 raw and 750 processed agricultural commodities on a time series basis for individual countries. We converted the processed commodities backward into raw material equivalent by dividing them by the extraction rate (e.g., flour per unit of wheat). This procedure was executed with the special software program AGDAT (Keyzer et al., 1994). Then, two separate balances were drawn up for each product: one balance for the raw commodity itself and one for the processed commodities in raw material equivalent. Because some products in GTAP (e.g., 'cereal grains nec') includes several products in the SUA's ('oats', 'barley', 'maize', etc.), the different commodity flow in raw material equivalent were valued against their trade prices and aggregated to the GTAP classification.

Food processing industry

Because the food processing industry has strong links with the primary industry, the next step concerns the split up of food processing industry into 7 activities. Some EU member states like Austria, Denmark, Finland and the Netherlands have sufficient detail on the processing industry in their original input-output table (group A). On the other hand, the food industry in the United Kingdom, Sweden, France and Spain is for the greater part in GSC concordance, with the exception of the meat processing industry (group B). This industry should be split into a 'bovine cattle, sheep and goat, horse meat products' industry and a 'meat products nec' industry. To make that distinction, detailed information on the meat processing industry from group A was used as proxy. The food processing industry in Belgium, Germany, Ireland, Italy, and Portugal (group C) was either expressed as a whole or on a three sector level ('meat', 'dairy' and 'other food' industry). To reach the preferred GSC break, the available disaggregated food industry structure in groups A an B again served as proxy. Finally, none of the EU member states reflected the rice processing industry in its original form. We approximated its input structure on that of the food products industry, while its output structure was estimated on the basis of SUA data.

Import matrix

To be in line with the GTAP classification, agro-food imports required further detail. SPEL offers information on agricultural imports of both 'seeds and seedlings' and 'animals', which are used to split up the import side of agriculture. For simplicity, we assumed that the producers of agricultural inputs belong to the same sector as the buyers of agricultural inputs. For example, 'seed' bought by the domestic 'wheat' activity originates from the foreign 'wheat' activity, and 'animals' imported by the domestic 'animal' activity originate from foreign 'animal' origin. The other agricultural imports were allocated in proportion to the domestic usage of such inputs.

Similarly, with the exception of agricultural imports, imports of the processing industry were allocated in proportion to their domestic usage. Agricultural imports of the dairy and meat processing industry were lowered somewhat in favour of agricultural imports of the food products industry, because the feed industry, which belongs to the food products industry, requires a relatively larger amount of imported cereals and cereal supplements.

Primary costs

The last step in the agricultural disaggregation procedure referred to the primary cost components. First, disaggregation of the non-commodity taxes for agriculture was based on Common Agricultural Policy (CAP) subsidy data in SPEL. Second, rents on agricultural land were calculated in proportion to the area used for each agricultural commodity. We allocated the total area of the SPEL activities ‘grass grazing’, ‘other root crops’, ‘fodder plants on arable land’ and ‘fallow land’ in proportion to the use of fresh and ensilaged fodder by the animal activities. Third, compensation for labour was disaggregated in proportion to the gross value added of the SPEL agricultural sectors. Finally, compensation for capital input was calculated as a residual by subtracting all the inputs calculated so far from gross output value.

3.3 Updating the national input-output tables to a common base year

After having transferred the national input-output tables to a common valuation and to a common GSC, the tables were brought to a common base year. The update method is partly based on the RAS method, and partly on a more pragmatic update approach (see scheme 1). Especially due to the focus of Eurostat estimates on 1995, that year was chosen as our base. Hence, the tables for the Netherlands, Germany, Belgium and Finland required no further adaptation on top of the results in section 3.2. On the other hand, the Spanish table refers to the year 1994, the Portuguese table to 1993, the Danish, French and Italian tables to 1992, the Irish and British tables to 1990, the Swedish table to 1985 and Austria’s to 1983. According to Beutel (1999), these national tables served earlier as the basis for the Eurostat’s 1995 updates together with official macro economic statistics. In turn, we have stretched out the 25 sector Eurostat tables to the GTAP sector classification with help of those national tables. Some Eurostat sectors were much too aggregated to reach the GTAP break down (like ‘textiles and clothing, leather, footware’), but other sectors had the same concordance (like ‘paper and printing products’ and ‘building and construction’) or even hadto be aggregated (like ‘inland transport services’ and ‘auxiliary transport services’) to map GSC. The second and third situation gave no real problems, whereas the first situation required additional estimates. The highest aggregated sectors in question were split up on the basis of their proportional share in the national table version (old base year, but a more extended classification). In mathematical terms, the applied disaggregation is denoted in equation (1) for the intermediate usage of domestic products.

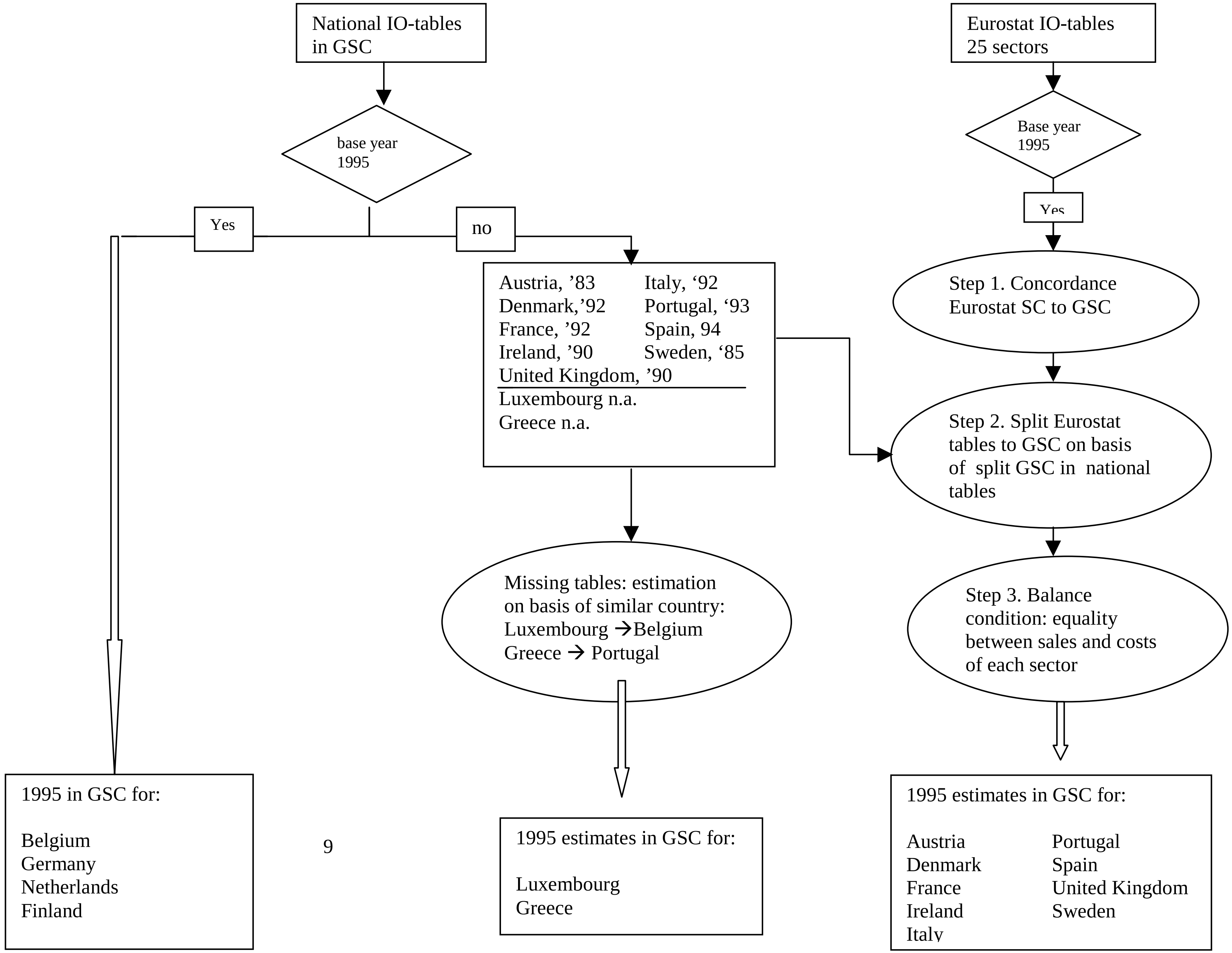
$$a_{ij}^{r,95,gsc} = \left(a_{ij}^{r,b,gsc} / \sum_{i=1}^{f} \sum_{j=1}^{h} a_{ij}^{r,b,gsc}\right) * a_{fh}^{r,95,eur} \qquad (1)$$

where

$a^{r,95,gsc}_{ij}$ = intermediate usage of domestic products by sector i (with i=1,..,f) from sector j (with j=1,…h) in region r for 1995, GSC
$a^{r,b,gsc}_{ij}$ = intermediate usage of domestic products by sector i from sector j in region r for base year b, GSC
$a^{r,95,eur}_{fh}$ = intermediate usage of domestic products by sector group f from sector group h in region r in 1995, Eurostat sector classification

We applied the above equation to each sector group in the Eurostat table that required more concordance with GSC. For example, the sector group ‘textiles and clothing, leather, footware’ in the Eurostat input-output table (denoted as $a^{r,95,eur}_{fh}$) was split up into the GTAP sectors‘textiles’, ‘wearing apparel’, ‘leather products’ and ‘wood products’ (denoted as $a^{r,95,gsc}_{ij}$). This same procedure was followed to break down the import matrix, the final demand, and the value added (respectively equations (2), (3) and (4)).

Scheme 1. Updating procedure for EU input-output tables



$$ai_{ij}^{r,95,gsc} = (ai_{ij}^{r,b,gsc} / \sum_{i=1}^{f} \sum_{j=1}^{h} ai_{ij}^{r,b,gsc}) * ai_{fh}^{r,95,eur} \qquad (2)$$

$$d_{ig}^{r,95,gsc} = (d_{ig}^{r,b,gsc} / \sum_{i=1}^{f} d_{ig}^{r,b,gsc}) * d_{fg}^{r,95,eur} \qquad (3)$$

$$b_{kj}^{r,95,gsc} = (b_{kj}^{r,b,gsc} / \sum_{j=1}^{h} b_{kj}^{r,b,gsc}) * b_{kh}^{r,95,eur} \qquad (4)$$

Here, ai_{ij} denotes the intermediate usage of imports by sector i from sector j, d_{ig} denotes the final demand for category g of sector i, and b_{kj} refers to the value added of category k in sector j. Next, the sectoral balance condition in the input-output table was checked for equality between each sector's total sales and total costs. If that condition was not satisfied, balance was achieved via adjustments to the final demand component 'changes in stocks'.

3.4 Missing tables

Except for Luxembourg and Greece, input-output tables were available for 13 EU member states. However, we intended to construct a complete EU15 data base inclusive of Luxembourg and Greece. To reach that goal, we estimated their input-output tables partly relying on specific country data and partly by using other member states' data. It was assumed that the Greek input-output structure approximated that of Portugal, because both countries show a common economic structure. In 1995, gross domestic product amounted to 87 billion ECU for Greece and 78 billion ECU for Portugal, while total population numbered 10.5 million in Greece and 9.9 million in Portugal. Both countries are situated in the south of Europe and are relatively less developed in terms of economic activity. In addition, we inserted specific Greek data on sectoral value added and sectoral production value into the 'borrowed' input-output structure. Afterwards, total sales and total costs for each Greek sector were balanced, whereby the agricultural sector was still considered as an aggregate. The agricultural disaggregation procedure into the desired GTAP classification was handled in common with that of other member states (see section 3.2).

For Luxembourg, we applied the same approach. However, with the execption that Belgium and Luxembourg were estimated as a pair instead of making a separate table for Luxembourg. This was primarily due to Luxembourg's small economic role compared with that of other EU member states. Another reason to consider Belgium and Luxembourg together is the point that international trade data are only available for the pair of countries together. Moreover, agricultural statistics like SPEL/EU and the FAO/SUA's reflect data for the two states likewise. Therefore, it was reasonable to view the macro economic situation of both countries as a whole, and not on an individual level. The construction of the Belgium-Luxembourg input-output table was assumed to be based on the Belgium input-output structure in 1995. Then, specific Luxembourg data for items like sectoral value added and sectoral production value were added. Finally, total sales and total costs for each sector in the extended table were balanced, whereby the agricultural sector was split up in the usual way.

3.5 Constructing the EU15 input-output table

This section focuses on the compilation of a data base for the EU15 as a whole, which will be based on the individual member state tables constructed in the previous steps. The method brings the national input-output tables in concordance with the 57 GSC and updates the tables to the year 1995. At this stage, tables were still expressed in millions of national currency, with the exception of Spain and Italy (thousand millions of national currency). Before adding up to one EU table, national tables were converted to ECU's. Then, the national input-output tables io^r (with r=1,…,s) expressed in ECU were added up to a table for the EU as a whole in equation (5).

$$io_{n+m+k,n+g}^{eu,95,gsc} = \sum_{r=1}^{s} io_{n+m+k,n+g}^{r,95,gsc} \qquad (5)$$

where $io_{n+m+k,n+s}$ denotes a GSC formatted input-output table with *n* domestic sectors, *m* import sectors, *k* primary categories, and *g* final demand categories.

A remark is in place with respect to the treatment of EU trade. Trade in the national input-output tables is performed as the aggregates of trade in EU countries (intra-trade) and trade with third countries (extra-trade). Therefore, we simply calculated EU trade as the sum of total imports and exports of the individual member states. This fits GTAP's manner of treating intra-EU trade, because that model regards intra-imports as imports and not as domestic usage. That will permit the GTAP user to include a flexible number of individual EU member states in the aggregation module. A 'rest of EU' data base was calculated then as the difference between the original EU15 table and the chosen number of individual member state tables. Of course, a split up of intra and extra EU trade would theoretically give a better underpinned EU15 table.

4. Analysis of agro-food chains in EU countries

4.1 Theoretical background

According to Porter (1990), the success or failure in an international economic area depend on:

- quality of production factors (climate, geographic location, labour, capital, telecommunication infrastructure, advanced research centres, etc.);
- presence of a highly sophisticated and highly critical domestic consumer demand as a driving force for industrial specialization and innovation;
- presence of extended sectoral networks of related and supporting industries, serving as domestic stimulators;
- economic order (forms of industrial organization, degree of competetiveness).

Porterian types of analysis have accentuated the importance of economic networks or that of sectoral linkages. Input-output analysis seems very suitable for describing or detecting sectoral dependencies and can serve as a useful tool for the international comparison of production structures (Dietzenbacher et al., 1993). Studies of this type have often been based on national input-output tables for different countries and we have applied the same approach. In this paper we want to answer the following questions:

- *how important is the agro-food chain both on national and EU level?*
- *how important are backward and forward linkages for different types of primary activities?*

We based the study on a cross section competitiveness analysis for all member states of the EU15 in 1995 (section 4.3). Additionally, we made a short investigation of the changing structure of employment in some EU member states in section 4.2. Terluin et al. (1999) analysed the development of employment in *rural EU regions* (OECD, 1994) against the background of a downward trend in the agricultural labour force. Based on the performance of non-agricultural employment growth in the 1980s and early 1990s, rural regions were distinguished into ‘leading’ and ‘lagging’ regions. The most striking difference between leading and lagging regions was the increase in employment in the manufacturing sector in the leading regions, whereas employment in that sector tended to decline in the lagging regions. In addition, employment in services increased in most of the leading regions at a higher rate than in the lagging regions. At last, leading regions tended to show a smaller decline in agricultural employment than lagging regions. Instead of rural regions, this paper has tried to distinguish EU countries into ‘leading’ and ‘lagging’ member states based on non-agricultural employment growth in the first half of the nineties. A complete set of EU employment data was available for 1995, whereas previous to this data were only available five states.

4.2 Dynamics of EU agro-food chains

We have analysed the economic significance of the agro-food chain for two years in the 90s in terms of value added and employment (tables 3 and 4).

Table 3. Gross value added (factor costs, million ECU) in EU agro-food chains

	United Kingdom	Sweden	Ireland	Spain	Nether-lands	Italy	Germany	Austria
1990								
agro-food chain	45594	9269	6011	49554	26853	56548	83045	9861
% in nat. econ.	*6.7%*	*7.9%*	*19.0%*	*12.6%*	*13.3%*	*8.6%*	*6.5%*	*8.9%*
1995								
agro-food chain	51874	7623	7103	36464	33081	59058	109346	6799
% in nat. econ.	*7.1%*	*4.8%*	*16.3%*	*9.3%*	*12.2%*	*7.7%*	*6.4%*	*4.6%*

Table 4. Employment (1.000 working units) in EU agro-food chains

	United Kingdom	Sweden	Ireland	Spain	Netherlands
1990					
agro-food chain	1865	361	264	2092	689
% in nat. econ.	*7.0%*	*8.4%*	*22.8%*	*15.8%*	*13.2%*
1995					
agro-food chain	1763	300	275	1830	683
% in nat. econ.	*6.9%*	*7.3%*	*21.9%*	*14.3%*	*12.7%*

Both tables show falling shares in the importance of the agro-food chains for the national economy between 1990 and 1995. Because the decline of value added was stronger than that of employment, labour productivity of the agro-food chains declined in the early 1990s. Figure 1 shows the growth rates of value added for national economy, agro-food chain, primary sector, non agro-food chain, and non primary sector in eight EU member states. The value added of both primary sector and agro-food chain tends to decline in most countries, whereas that of the other sectors tend to increase. The strength of the developments, however, differs among member states.

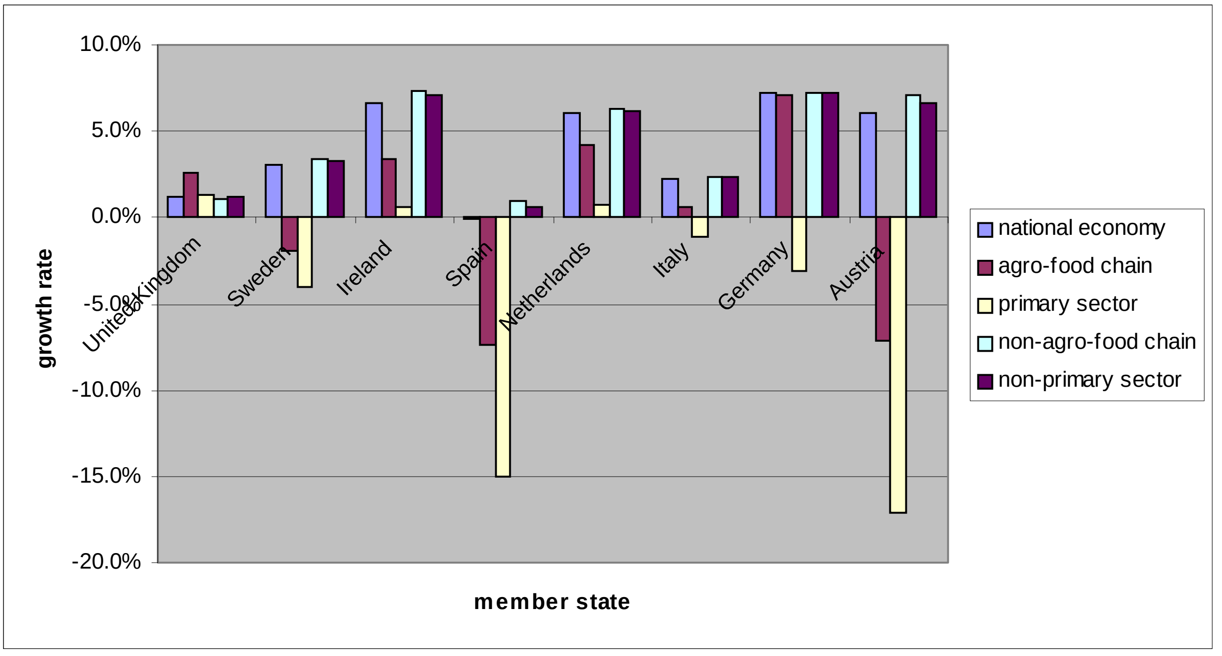


Figure 1. Growth rate of value added in EU agro-food chains, 1990-1995

Figure 2 shows the growth rates of employment in the United Kingdom, Sweden, Ireland, Spain and the Netherlands in the period 1990-1995. In general, labour force decreased, but the fall in employment growth of agro-food sectors was much higher than that of manufacturing and services sectors. According to the findings of Terluin et al., the Netherlands and Ireland could be considered as ‘leading’ member states. Their non primary and non agro-food chain employment increased in the early nineties, while the decline in agricultural employment was lower than in the other countries. The non-agricultural working force of the United Kingdom, Sweden and Spain declined, which reflects a characteristic of a ‘lagging’ member state.

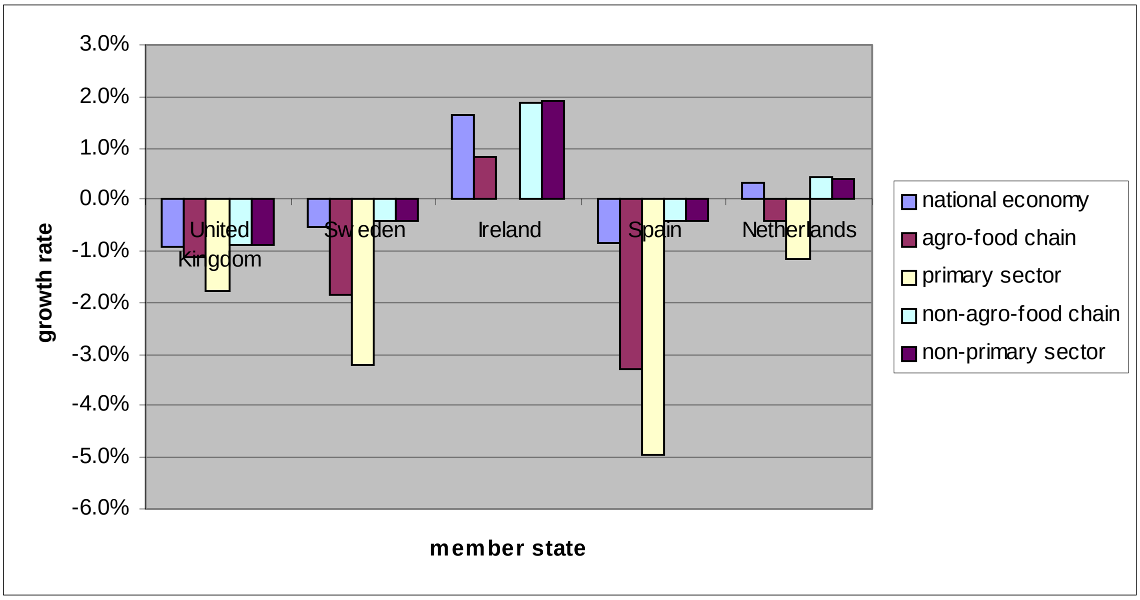


Figure 2. Growth rate of employment in EU agro-food chains, 1990-1995

4.3 Cross section analysis of agro-food chains

For the year 1995, we made a Porterian analysis of the importance of the primary sector and its upstream and downstream linkages in terms of value added and employment (table 5).

Table 5. Value added (f.c., million ECU) and employment (1.000 working units) in EU, 1995

	Value added of agro-food chain *	*share in EU15 agro-food chain*	*share in national value added*	Employment of agro-food chain	*Share in EU15 agro-food chain*	*Share in national employment*
Austria	8478	*2.0%*	*5.7%*	305	*2.2%*	*8.9%*
Belgium-Luxembourg	12028	*2.8%*	*5.8%*	242	*1.8%*	*6.4%*
Denmark	12902	*3.0%*	*11.1%*	255	*1.9%*	*10.2%*
Finland	9367	*2.2%*	*10.7%*	219	*1.6%*	*11.3%*
France	87788	*20.7%*	*8.5%*	2087	*15.4%*	*9.3%*
Germany	87619	*20.6%*	*5.1%*	1933	*14.2%*	*6.8%*
Greece	14031	*3.3%*	*19.9%*	1052	*7.7%*	*23.7%*
Ireland	7050	*1.7%*	*16.2%*	245	*1.8%*	*19.5%*
Italy	53390	*12.6%*	*7.0%*	2405	*17.7%*	*10.9%*
Netherlands	23625	*5.6%*	*8.7%*	500	*3.7%*	*9.3%*
Portugal	8929	*2.1%*	*13.8%*	825	*6.1%*	*18.7%*
Spain	38854	*9.1%*	*10.6%*	1673	*12.3%*	*13.1%*
Sweden	8756	*2.1%*	*5.5%*	256	*1.9%*	*6.2%*
United Kingdom	52145	*12.3%*	*7.1%*	1592	*11.7%*	*6.2%*
EU15	424962	*100.0%*	*7.4%*	13589	*100.0%*	*9.5%*

* Exclusive of tobacco and drinks.

The value added of the EU15 agro-food chain amounted to 425 billion ECU, while 13,5 million persons worked full-time in agricultural related activities. Two third of the value added was earned in France, Germany, Italy and the United

Kingdom. Together with Spain, these countries account for nearly 70% of total EU employment in the agro-food chain.

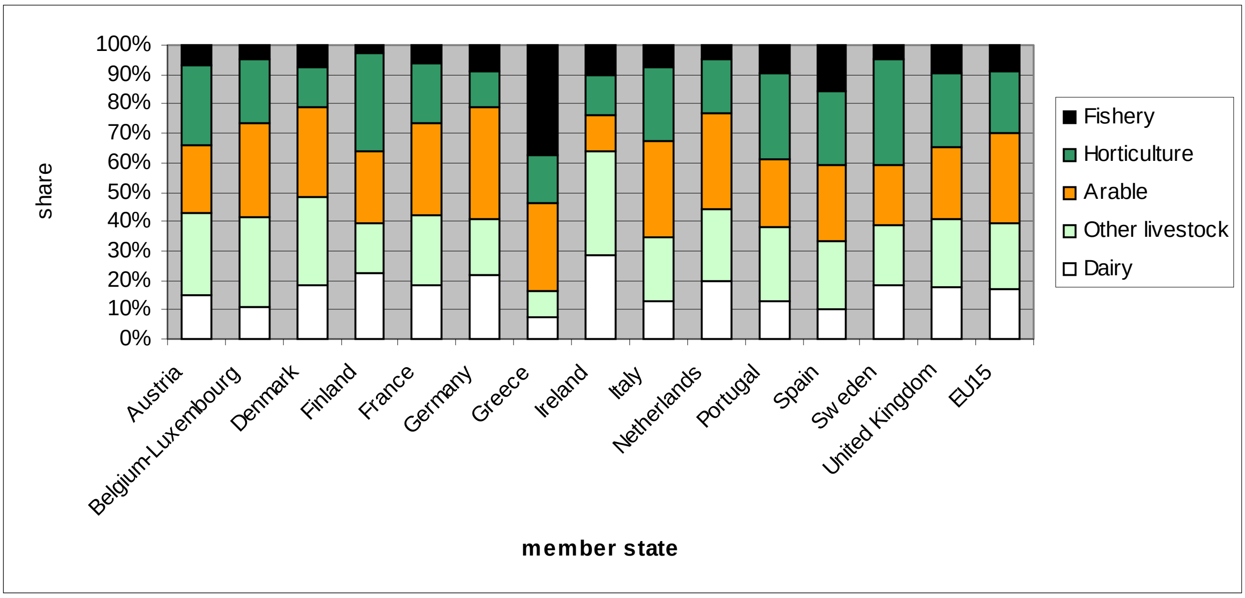


Figure 3. Share of sub-chains in value added of EU agro-food chain, 1995

Another goal of our analyses concerned the economic importance of sub-groups for the agro-food chain like the livestock chain or the arable chain (figure 3). In 1995, with a share of 40% the dairy farming chain and the other livestock farming chain generated most to the value added of the EU agro-food chain. After this, the shares of arable farming, horticulture and forestry, and fishery chains were calculated at respectively 30%, 20%, and 10%. The figure shows the great spread in the contribution of different production types to the value added of the agro-food chains. For example, livestock related activities were relatively important in Ireland with a share of more than 60%, while the fishery chain generated nearly 40% of the Greek value added.

We also distinguished employment of the agro-food chains into sub-groups (figure 4). In 1995, with a share of 35% the livestock chain contributed most to the employment of the EU agro-food chain. This was followed by shares of arable farming, horticulture and forestry, and fishery chains with respectively 29%, 27% and 10%. Comparing the employment percentages with the value added percentages reflects the spread in labour productivity of the sub-chains. In general, labour productivity was relatively high in the livestock chain, but relatively low in horticultural related activities.

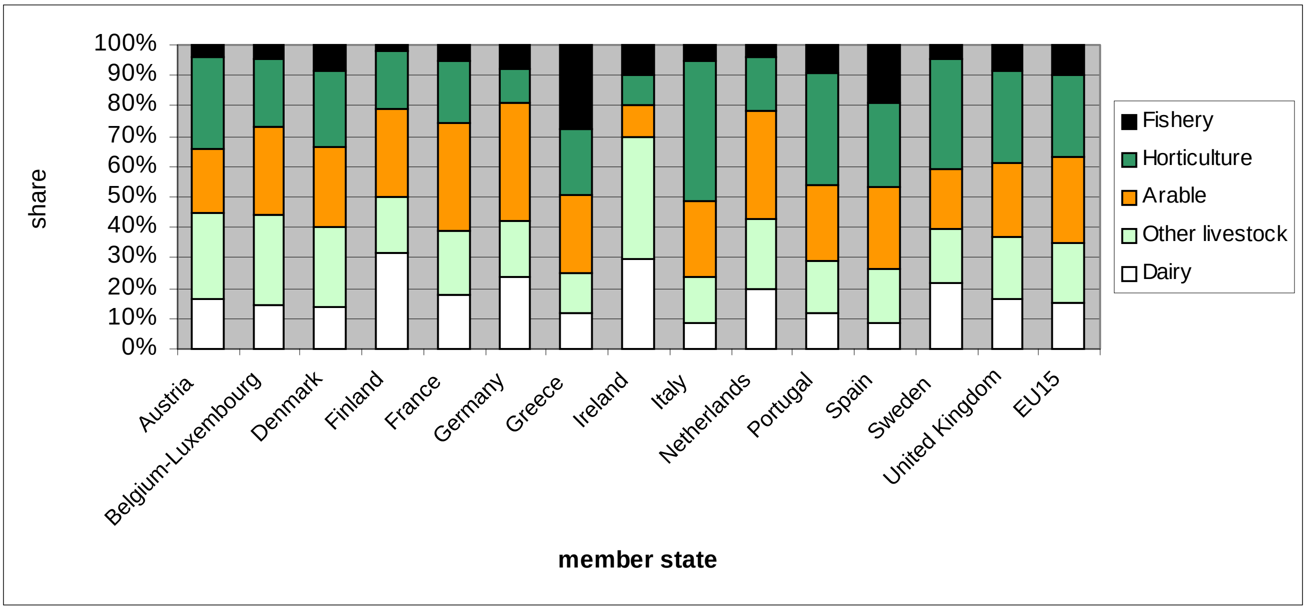


Figure 4. Share of sub-chains in employment of EU agro-food chain, 1995

4.4 Export and import dependency

Exports

In 1995, nearly one quarter of the value added and the employment of the EU agro-food chain had links with export activities. Again, the spread in export dependency of the national agro-food chains was significant (figure 5).

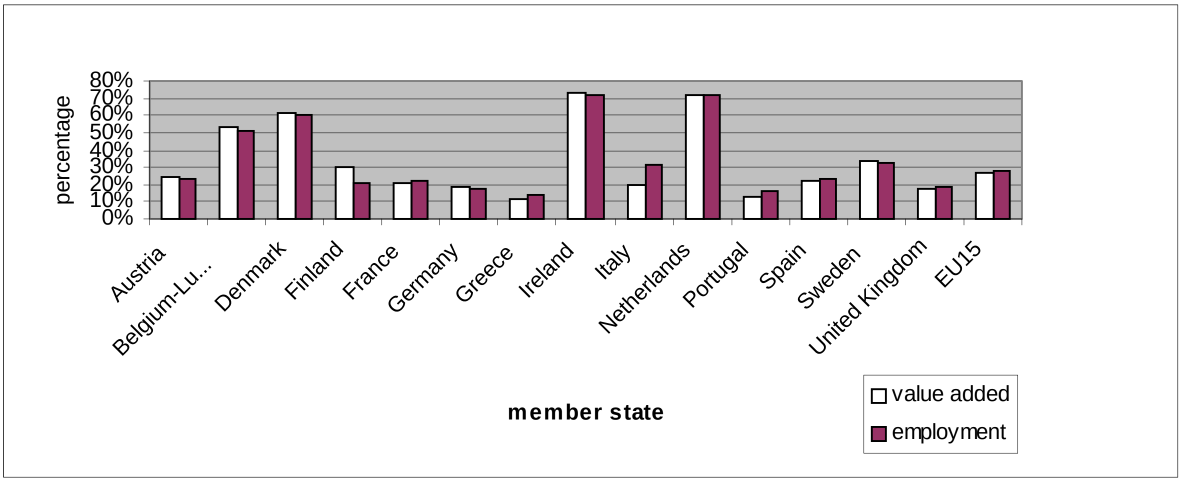


Figure 5. Export dependency of EU agro-food chain, value added and employment,1995

With 70% the foreign export market was especially important for agro-food products in the Netherlands and Ireland, compared with a share of just 10% for agro-food products in Greece and Portugal. Although a significant part of EU exports had to do with exports to other EU countries, we made no distinction into intra EU and extra EU exports (see section 3.5). Appendix B shows the export dependency of the value added that was contributed by national sub-chains. For example, export activities generated nearly 80% of value added of the Dutch arable farming chain, while in Ireland exports contributed three quarters of the value added of the dairy sector.

Imports
The international dependency of agro-food chains refers not only to exports, but also to imports (table 6). Compared with its contribution to the employment in the entire EU15, imports are particularly important for the agro-food chain in Germany and the Netherlands with respectively 20% and 11% (as against 14.2% and 3.7% for employment). More than the half of Dutch imports by the agro-food chain consists of oils, fats, grains, vegetables and fruit.

Table 6. Import value (million ECU) of EU agro-food chains, 1995

	Import value of agro-food chain *	*share in EU15 agro-food chain*	*share in national imports*
Austria	2621	2.4%	3.6%
Belgium-Luxembourg	7389	6.8%	5.4%
Denmark	4009	3.7%	10.0%
Finland	1625	1.5%	5.7%
France	13473	12.4%	5.4%
Germany	21725	20.0%	5.5%
Greece	1504	1.4%	6.5%
Ireland	2977	2.7%	9.7%
Italy	15958	14.7%	8.2%
Netherlands	11955	11.0%	8.4%
Portugal	2293	2.1%	7.7%
Spain	6048	5.6%	6.8%
Sweden	3168	2.9%	5.4%
United Kingdom	14030	12.9%	5.6%
EU15	108775	100.0%	6.2%

* Exclusive of tobacco and drinks.

4.5 Composition of agro-food chains

The agro-food chain is defined as the whole of economic activities in EU member states that are connected with agricultural products. It includes the primary sector, the processing industry (forward linkages), and the firms supplying the two sectors (backward linkages). The Harthoorn method was applied to illustrate the importance of components in the agro-food chain in terms of gross value added and employment in 1995 (figures 6 and 7).

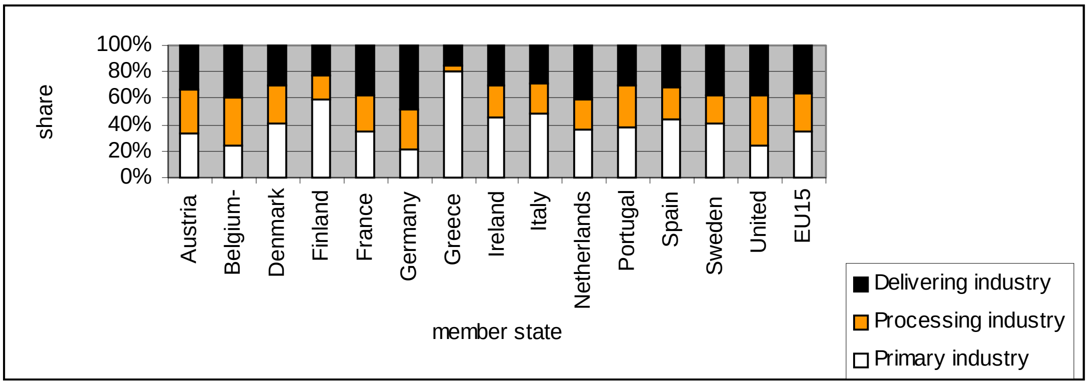


Figure 6. Composition of value added in EU agro-food chains, 1995

With a share of 40% the supplying industries (like feeding stuff industries or business services) contributed most to the value added of the agro-food chain. In addition, this market segment generated little more than 30% to the employment of the agro-food chain. The primary industry accounted for nearly 30% of the EU agro-food chain's value added, whereas it was responsible for more than 50% of total employment. It could be concluded that labour productivity in the primary industry is less than one half of the productivity in the supplying industries.

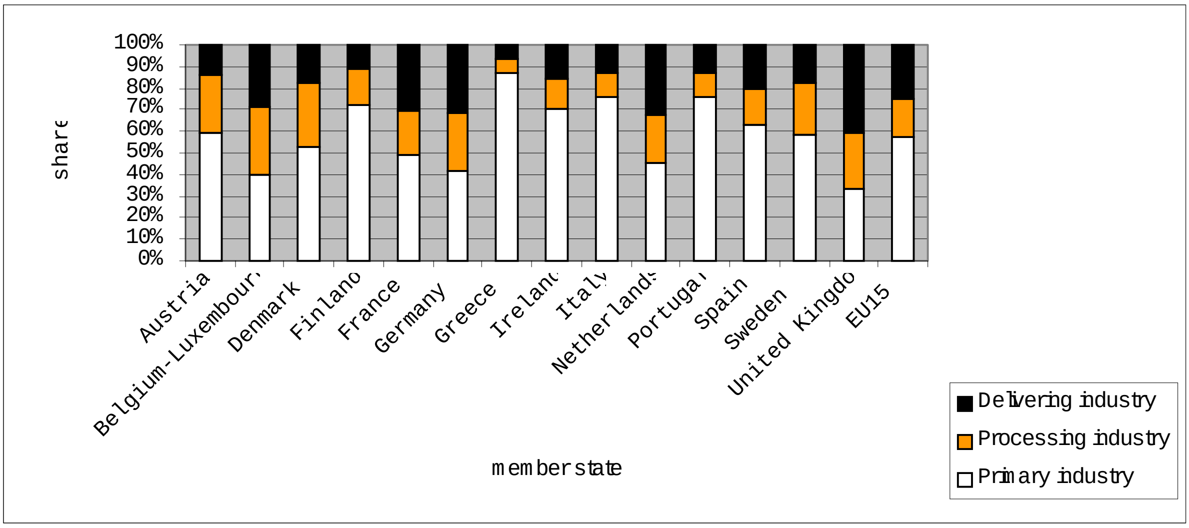


Figure 7. Composition of employment in EU agro-food chains, 1995

Figure 7 shows the spread in the composition of the agro-food chains in terms of employment. The importance of the primary industry is particularly high in countries like Greece, Spain and Italy in comparison with countries like Germany and the United Kingdom. On average, the food industries contributed respectively 28% and 18% to the EU agro-food chain in terms of value added and employment. The food processing industry played an important role for the value added of the agro-food chain in the United Kingdom (38%) and in Belgium-Luxembourg (36%).

5. Conclusions

This study described a procedure to construct harmonized EU input-output tables, in particular homogeneous tables for its agro-food industries. We addressed homogeneity in terms of inputs and outputs for some different agro-food activities. The validity of the assumption of homogeneous production, one of the fundamentals of input-output theory, can be considered as a classification problem. The original national input-output tables present unrealistic relations between different agricultural activities because inputs for occupations within animal and arable farming were not split off inputs for horticultural occupations. Therefore, the breakdown of agricultural industry into 14 activities and that of processing industries into 7 activities improved input-output analysis. With help of specialized agricultural data bases, we transformed agro-food data into more homogeneous activities.

On basis of AIOT's, a number of agro-food chains could be distinguished, each of which all represents a specific agricultural production activity. Herewith, a suitable tool was created to analyse the importance of various activity groups for both the agro-food sector and the national economy in terms of income and employment. Finally, the input-output tables under consideration provided a way to measure the importance of primary, processing and delivering linkages in the EU agro-food chain. It could be concluded that activity based AIOT's can be applied to analyse the impacts of agricultural and environmental policies.

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Appendix A. Harthoorn method

Harthoorn (1988) developed a method that makes it possible to isolate inter-industry transactions from an input-output table by defining selection and residual vectors. The elements of these vectors can take the values 0 (an activity flow is blocked) or 1 (an activity is accepted). The elements of the selection vectors are defined as:

$$s_m(n) = \begin{cases} 1 & \forall n \in S_m \\ 0 & \forall n \notin S_m \end{cases} \tag{1}$$

where s_m is the *selection* vector, and S_m is the subset m of industries in the input-output table. Assume that the bovine cattle farming sector forms the subset S_0, and the beef processing sector forms the subset S_1. Now, the *residual* vector r_0 is the complement of selection vector s_0, while vector r_1 is the complement of the sum of both selection vectors. Therefore,

$$r_0 = i - s_0 \tag{2}$$

$$r_1 = i - s_0 - s_1 \tag{3}$$

where i is the summation vector (vector with ones). If a hat is put above a vector, that vector becomes a diagonal matrix. The total production value of the bovine farming chain can now be calculated as

$$\begin{aligned} y = (\,& \hat{s}_0(I - A)^{-1} + (I - \hat{r}_0 A \hat{r}_0)^{-1} \hat{r}_0 A \hat{s}_0 (I - A)^{-1} \\ & + \hat{s}_1(I - \hat{r}_0 A \hat{r}_0)^{-1} + (I - \hat{r}_1 A \hat{r}_1)^{-1} \hat{r}_1 A \hat{s}_1 (I - \hat{r}_0 A \hat{r}_0)^{-1}\,) f \end{aligned} \tag{4}$$

where y is the vector with cumulative production value for the bovine farming chain, f the vector with final demands, and A the matrix with input coefficients. The first part of equation 4 expresses the bovine farmers' production value, the second part is the production value linked to input deliveries to bovine farming. The third part contains the production value of beef processing industries, while the last part is the production value linked to input deliveries to beef processing industries.

Appendix B.	*Dependence of national sub-chains on exports, in terms of Value Added*								
Member state	**Dairy**	**Bovine & sheep**	**Pigs & hens**	**Arable farming**	**Horticul-ture**	**Rice**	**Fishery**	**Forestry**	**Total**
Austria	28.1%	19.1%	21.3%	29.6%	20.2%	0.0%	15.9%	29.8%	24.0%
Belgium-Luxembourg	63.4%	50.7%	46.7%	58.9%	46.5%	0.0%	58.6%	29.9%	53.3%
Denmark	41.7%	69.3%	68.0%	63.3%	53.1%	0.0%	78.3%	62.7%	60.9%
Finland	16.1%	10.0%	26.7%	23.4%	13.6%	0.0%	11.6%	64.5%	30.6%
France	16.3%	23.9%	14.6%	29.6%	15.6%	20.2%	21.3%	19.2%	21.3%
Germany	16.6%	21.9%	21.7%	19.7%	12.2%	0.0%	16.4%	17.3%	18.3%
Greece	4.8%	3.6%	4.3%	17.8%	29.9%	34.9%	1.0%	81.2%	11.7%
Ireland	75.9%	76.4%	71.0%	71.2%	70.2%	0.0%	61.9%	7.1%	72.7%
Italy	8.0%	10.9%	20.6%	22.5%	24.0%	34.0%	16.2%	64.2%	19.4%
Netherlands	64.3%	69.7%	72.8%	78.3%	73.1%	0.0%	68.2%	3.6%	72.4%
Portugal	5.2%	4.2%	4.6%	14.4%	11.9%	9.2%	12.1%	46.4%	12.3%
Spain	5.5%	8.1%	7.8%	20.8%	30.6%	21.1%	39.6%	21.4%	21.5%
Sweden	4.2%	21.0%	24.7%	27.8%	16.2%	0.0%	21.9%	81.3%	33.2%
United Kingdom	13.6%	14.6%	12.3%	22.7%	15.3%	0.0%	24.9%	38.8%	17.5%
EU15	21.4%	24.0%	25.3%	31.5%	24.8%	28.0%	25.5%	32.0%	26.5%