# Economic impacts of livestock production in Sweden
## - An input-output approach

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# Executive summary

This study uses a disaggregated input-output (IO) table of Sweden to assess the economic impacts of different production lines within Swedish agriculture. Focus has especially been placed on the differences between different types of livestock production and the differences between livestock and arable productions. Swedish agriculture was divided into the production lines, or sectors, cattle (milk and beef), pig, poultry and egg, sheep, mixed livestock production, cereals and mixed farm production, and the importance and potential of each one of them were assessed.

To enable such a detailed analysis we first developed and applied a method for disaggregating the single agricultural account in the Swedish IO table. To do so we disaggregated the inputs and outputs of all production lines identified in the study. We used farm accounting data for Sweden together with sector specific data from Statistics Sweden and Agriwise to determine the purchases and sales of different farm types. Within the so called Make-Use framework of the IO table we allowed different farm types to produce more than one output to take the normal heterogeneity of farm production into consideration.

Turning the IO table into an IO model we analyzed the various interdependencies in the economic system and determined the relative impact and potentials of different sectors. In particular, output, employment and income multipliers, together with elasticities were calculated and analyzed. In this process we developed the already existing measure of elasticities to better capture the relative importance of sectors with limited final demand. Livestock production lines are generally more integrated in the system of intermediate sales and purchases compared with cereal production. This means that these production lines offer a greater potential in generating output throughout the economy, if the final demand for these products was to increase exogenously.

Among the livestock production lines, poultry and egg production seem to be the most input-intensive; however this production line uses labour to a small extent. Combining the multipliers with the relative size of production lines to derive measures of elasticities we find that significant production lines are cattle (milk and beef), cereals and mixed farming.

The output, employment and income multipliers, as well as the elasticities, calculated in this study offer a basis for decisions related to sector priorities and regional and rural development. It is however utterly important that the results are interpreted in the right way and that the reader understands that production lines with great output generating potential might for example not perform as well in generating employment. Furthermore generating employment can be measured from different perspectives. That is, a sector can generate employment from one more person employed in the sector or from exogenous increase in the demand for the product of the production line. Results might differ substantially.

## Acknowledgements

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Uppsala March 10, 2009
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# 1. Introduction

In this study, our interest is to assess the impacts of the major livestock production lines[1] in the Swedish economy, as compared to cereal production and other agricultural production lines. Agriculture in Sweden is a relatively small sector when comparing value added and output with other sectors in the economy. However, being one of the primary sectors, agriculture contributes to the secondary (manufacturing) and tertiary (services) sectors of the economy by passing on products for value adding in later stages of the economy. Furthermore agriculture, as opposed to some other primary sectors, requires a substantial amount of intermediate products in its production and in this respect agriculture can be assumed to interact to a large extent with the rest of the economy.

The characteristics of the interactions of agriculture with the rest of the economy will most likely differ between different production lines within the agricultural sector. To successfully formulate agricultural, rural or regional policy, these interactions would be informative for policy makers.

Although the usefulness of rural policy that is focused on the agricultural sector was questioned in Gullstrand (2004), the Swedish Government Official Report (SOU) 2006:101 considered agricultural production of e.g. food, fibers, energy, tourism and landscapes as strategic areas for rural growth. Furthermore, the EU rural development policy program 2007 – 2013 strongly emphasizes the importance of the agricultural sector to serve as a platform for rural development.

In a time when agricentric views are often posed against multisectoral development objectives, it is vital that decision makers know how firms in different production lines contribute to the overall economy. Livestock production, with its possibilities to create job openings around the year, should hold a unique position in comparison to cereal production when it comes to creating rural employment. Therefore, understanding how each one of the traditional livestock production lines contribute to the economy, in comparison to each other and to cereal production and other agricultural production would be one piece of useful information to policy makers.

In Swedish official statistics, such as the *Yearbook of Agricultural Statistics*, the economic contribution of the Swedish agricultural production is described in terms of employment and production value. However, the statistics focus only on direct contribution of the agricultural production lines and leave out the important indirect economic effects of both the sector itself and of different production lines within the sector. Livestock production, for instance, contributes directly to the economy through the selling of animal products and through the buying of production inputs. These activities stimulate other economic activities which in turn lead to yet other economic activities and so on within the economy.

Input-output (IO) multiplier analysis is a tool that takes direct, indirect and sometimes induced effects into account. *Direct effects* are the obvious linkages in the economy which can be determined by studying the sector's direct interdependencies. *Indirect effects* take into consideration the fact that the direct linkages extend when one direct

[1] Throughout the report, the concepts *production lines* and *farm types* are used interchangeably.

effect gives rise to direct effects in new sectors and so on. Indirect effects thus capture a chain of events when a direct effect has taken place in one or more sectors. Indirect effects eventually become so small that they lose their economic importance. *Induced effects* take into consideration the fact that a direct stimulation in one sector increases labour earnings in that sector and hence consumption by households. Consumption leads to direct stimulations in another sector and so the multiplier effect is augmented.

Direct, indirect and induced effects provide insights into the role of particular production sectors in the Swedish economy. Such analysis answers the question of how a sector of the economy interacts with other sectors of the economy, either backward in the sense of purchases from other sectors or forward in the supply to downstream sectors.

The aim of this study is twofold. First we aim at investigating the role of agriculture in the Swedish economy by taking multiplier effects into consideration. Second, we aim at investigating the direct, indirect and induced effects of separate livestock production lines in the Swedish economy in relation to cereals and other agricultural production lines. In particular, the roles of the farm types, or production lines, cattle (milk and beef), pig, poultry, sheep, mixed livestock, cereal production and mixed farm production are investigated. The division of farms into production lines builds on their degree of specialization (according to the labour needs) in each production line. The considered production lines represent the main livestock production lines in Swedish agriculture, and are defined in accordance with official Swedish statistics (Statistics Sweden, 2008). The products, or commodities of the considered production lines were aggregated into ten products defined as follows: 1. milk, 2. beef, 3. pig, 4. poultry and egg, 5. sheep, 6. cereals, 7. other crop, 8. forage, 9. other animals and 10. agricultural services. This is explained in some detail further on.

This study contributes to the existing literature on sector analyses in two ways. First, the study contributes by providing a disaggregated input-output multiplier analysis of the Swedish agricultural sector, with a particular focus on livestock production. No such disaggregated IO studies of the Swedish agricultural sector existed previously. The present study allows us to conclude on how different livestock production lines contribute to the entire Swedish economy and to evaluate the relative importance and potential of the livestock production lines in relation to cereals and other agricultural production. Second, the study contributes to the existing literature by outlining a practical way of disaggregating the system. The academic literature on this area is limited and only a few studies (e.g. Leat and Chalmers, 1991; Roberts 1994; Eiser and Roberts 2002) have attempted to disaggregate a sector in an existing input-output table.

The rest of the report continues as follows. In Section 2, previous IO analyses are reviewed. In Section 3, the input-output method is described in detail. Section 4 provides a description of the data. Section 5 presents a description of considerations in the disaggregation of the agricultural sector in the Swedish IO table. Section 6 presents and discusses our findings and, finally, Section 7 concludes the report.

## 2. Examples of previous input-output analyses[2]

A wide range of input-output (IO) analyses have been carried out over the last decades, focusing on both developing and developed countries. Sector analyses have focused on a broad range of primary (e.g. agricultural and forestry), secondary (manufacturing) and tertiary (services) sectors, and some models have incorporated environmental linkages effects (e.g. Loizos et al., 2000). Previous studies of disaggregated IO tables include own designs such as Eiser and Roberts (2002), Doyle et al. (1997), Roberts (1992) and Leat and Chalmers (1991) as well as analyses of available disaggregated national or regional tables such as Cai et al. (2005) or Stilweel et al. (2000). Regional models have been used to accentuate the specific characteristics of urban and rural areas (e.g. TERA, 2008 and Doyle et al., 1997) and more recently regional IO tables have been used together with other economic models to create larger interregional models (e.g. Madsen and Jensen-Butler, 2004 and 2005). In what follows of this section, we briefly describe previous works that builds on IO approaches, to show typical applications and uses of this model.

In the United States IO analysis is a frequent tool to analyze the economic impact of different sectors, especially within the different states.[3] For instance, Hodges et al. (2006) concluded that the agricultural, food and natural resource sectors in the economy in Florida directly contributed for 3.2% to the Gross State Product (GSP). Further, the authors found that the considered sectors employed 4% of the total labour force. If also the induced effects were considered, the contribution to the GSP was 7.4%, and the total employment was 7.9% of the labour force. Deller (2004) analyzed the impact of agriculture in Wisconsin, and concluded that a 1% increase in demand of agricultural products would give rise to induced effects of 0.8% in the other sectors of the economy. Further, they concluded that one new job opening in the agricultural sector resulted in 1.3 new job openings in the other sectors of the economy. NOAA (National Oceanic Atmospheric Administration) (2006) described a regional IO model for US North East commercial fishing to be used for impact assessment relating to backward linkages due to revenue changes in harvesting and processing of fish. Cai et al. (2005) studied the linkages between fisheries sectors and the Hawaiian economy and found strong linkages and potential economic impacts of technical regulations in this sector. Cai et al. (2006) studied the tourism sector in Hawaii and found a few large backward linkages (hotels and air transports) and some evidence that forward linkages in other industries depend heavily on tourism.

Johnson and Kulshrestha (1982) studied the importance of 12 different farm sectors in the Saskatchewan economy. They applied the method of exogenous output of a specific sector (rather than the standard demand driven analysis) and found (although sectors appeared to be quite similar) the grain sectors to have the highest output multipliers while cattle sectors might have higher income potential.

Johns and Leat (1988) applied a regional IO table to study the Grampian region in Scotland with an emphasis on the agribusiness and food sectors. They concluded that

[2] In the literature review, we focus on IO studies which are of relevance to agriculture.
[3] In the US IO analysis has been facilitated by the IMPLAN project which allows disaggregated and regionalized analysis using software based IO models. See Lindahl and Olson (2004).

falling agricultural output would have large backward and forward effects for the farm supply, food processing and marketing industries. Midmore (1991) showed the usefulness of input-output models in analyzing the agricultural sector. Roberts (1994) studied the effects of further reducing the milk quotas in the UK and concluded that reducing the quotas, and thereby also the milk production, would have the largest impact on the suppliers of production inputs, apart from the impact on the farmers themselves. In total, a 3% reduction of the milk quotas would imply a reduction of 4300 – 6700 jobs in the economy. Roberts (1995) investigated the linkages between UK agriculture and the wider economy and concluded that they were relatively small. Her results showed that differences between agricultural commodities are driven by the structure of production and the distribution of factor income. Further, cattle, milk, sheep and other livestock have the highest total (direct, indirect and induced) multipliers. Cereals, potatoes, pigs, poultry and egg had average multipliers whereas wool production had lower multipliers. Doyle et al. (1997) analyzed the effects of agricultural support on farm output as well as the regional economy in Scotland. By analyzing output forecasts in an input-output framework spatial projections were made using a gravity model and a geographical information system. They concluded that support payments do increase regional income (by a factor of two) but that a considerable proportion of economic benefits leak into urban areas. Helming and Peerlings (2003) analyzed the effects of EU dairy policy, more specifically the effects of decoupling on Dutch agriculture and economy. They found that decoupling of income support and milk quota abolishment stimulated the milk production but that the total effects on Dutch GDP were limited whereas income effects for individual industries could be large.

As far as Sweden is concerned, one early example of IO analysis of agriculture is Rabinowicz (1982) who studied the relative importance of the primary sectors in a particular region (Lycksele) compared to secondary and tertiary sectors. This study showed that the primary sectors are important, but that their activities are often linked to suppliers and customers in urban areas. This implies that the indirect effects of growth of the agricultural sector are found in areas with higher growth and employment. More recently one aspect of the EU-financed CARERA project (2008) was to investigate the employment impacts of agricultural policy reforms in Östergötland (a Swedish NUTS 3 region) using a regionalized IO model and multiplier analysis. Decoupling of agricultural support favors cost minimization with regard to intermediate inputs, and some sectors outside agriculture are affected indirectly as demand for some inputs decrease. This causes a multiplier effect but the total effects are small and linkages are weak with the regional economy; thus output and employment effects are small in the short run.

Midmore (1993) offers a cautionary discussion about using IO multipliers to forecast agricultural policy impacts. He presents evidence that there may exist an upward bias in multipliers related to the agricultural complex and discusses the problem of structural change and input-output substitutability which is highly relevant in the agricultural sector.

Applications outside the agricultural sector include e.g. Psaltopoulos (1995) who studied the importance of the forest industry, in relation to other primary production in Scotland and found the potential for stimulating the rural economy to be significant. Further, Eiser & Roberts (2002) investigated how different types of forest contributed to the economy of Scotland. They concluded that afforestation had a positive impact on the total Scottish economy, even if arable land was afforested. Stilwell et al. (2000) studied the importance and structure of the mining sector in South Africa. They concluded that mining multipliers were mainly similar to other sectors in the country and that mining activities showed weak linkages with other sectors of the South African economy. In a developing country context Kweka et al. (2003) estimated the multipliers associated with tourism in Tanzania. Strong linkages were found between tourism and rest of the economy but employment effects seem to be weak. In an attempt to incorporate externalities in an IO analysis Loizou et al. (2000) constructed a regional IO model for central Macedonia in Greece. The multiplier analysis pointed to a tradeoff between economy and environment, with particularly high pollution output multipliers for *water and electricity*, *metals and minerals* and *oil* products. Among the agricultural sectors, *maize* and *cotton* seemed to have large negative impacts.

Finally, a few larger projects have recently utilized the IO techniques (among other methods) to assess and evaluate the impacts of agricultural and rural development policies in regions of Europe. The above-mentioned CARERA project (2006-2008) investigated the employment effects in EU rural areas from common agricultural policy (CAP) reforms (Mattas et al., 2008). The TERA project (2008) integrated geographical analysis and IO methods to study factors influencing creation and survival of enterprises in EU rural areas. REAPBALK project (2001-2004) used IO models of Balkan nations to assess the implications for inter-sectoral rural employment patterns of policy changes at the domestic and EU level (Bonfiglio et al., 2004).

### 2.1 Implications from previous studies

It is evident that input-output models have been used extensively to analyze the entire agricultural sector, as well as other parts of the economy. Such tools have also been used to model various implications of agricultural policy reforms and rural development programs. From an early American study we see that crop sectors have the largest multipliers, whereas later European research evidently finds livestock to have greater potential. This might point to either a difference between sectors in different regions or nations, or it might highlight an evolution of livestock production over time. That is, the livestock sector might make use of more compound feed and technology in the production process and hence become more integrated into the intermediate input supply chain. If at the same time crop production becomes more input efficient, this would lead to higher multipliers for livestock over time compared to grain. In the present study we will investigate the difference between livestock and crop production in Sweden today. The choice of IO as a method for analyzing the agricultural sector is often motivated by the possibility to perform the analysis at a low cost, short time and by using actual available data. Compared to other models, the IO model is possible to use in short time for ex ante analysis and although the model is constrained by some economic assumptions there is no need to borrow data or supply/demand elasticities from other studies. This has made the IO table an attractive and well proven choice in applied work. Even though much has been done, it is also evident that many studies focus on the agricultural sector as such, while more analysis is needed at a disaggregated level. No research has been conducted in Sweden during the latest 25 years on the impacts of various production lines and it is in this respect that this study fills a substantial gap in the literature.

# 3. A description of the input-output methodology

In this section we describe the input-output methodology and its underlying assumptions.

Input-output analysis, originally due to Wassily Leontief in the late 1930s, is a way of analyzing the economic interactions between sectors in an economy. This analysis is based on IO tables which show what inputs one specific sector needs from both itself and from other sectors, as well as to what sectors the outputs from one specific sector are sold and finally consumed. Classic texts on IO modeling are Leontief (1966) Miller and Blair (1985) and Ten Raa (2005), who thoroughly describe the use of IO modeling and its technical properties.

The IO model assumes that the economy of a country or region can be divided into a specific number of well-defined sectors. The sectors can be larger or smaller depending on the level of aggregation. For instance, in the official Swedish IO table, the activities of all agricultural firms are aggregated into one sector: agriculture, whereas it may sometimes, as in this study, be desirable to disaggregate a larger sector into smaller segments. The IO model is static in the sense that the flows between sectors are measured for one particular period of time.

### *3.1 Underlying assumptions*

IO modeling is based on three central assumptions about the economy. All of these serve to simplify the model to make the analysis easier to be carried out. The outcome of an IO analysis should always be judged in relation to these assumptions.

- *Each sector produces only one good*

The first assumption is that each sector, or production line, produces only one good. This assumption implies that the flows of goods associated with firms producing two or more goods must be allocated to two or more production lines. Each production line can be considered as an individual firm that interacts with other individual firms. Thus, IO modeling does not take the possible benefits of joint production into consideration.

- *Fixed proportions/fixed coefficients of production*

The second assumption is that the production uses inputs in fixed proportions. This implies constant returns to scale, which means that the use of inputs is proportional to the outputs of the firm, regardless of firm size. Put in another way: if inputs are doubled, so are outputs. Even though constant returns to scale may be argued to make a simplified description of reality, micro-economic theory shows that it is the long-run equilibrium for firms assuming perfect competition.

- *No lack of capacity*

The third assumption is that there is no lack of capacity within the economy. This implies that the economy is assumed to immediately satisfy the need of extra production inputs. For instance, if more labour is demanded, it is immediately supplied.

Furthermore it is often pointed out that IO tables in their standard format take no account of positive or negative externalities that might accrue to production sectors of the economy. Some studies, as we described in the previous section, have incorporated for instance carbon emissions from production as to take into consideration how scaling up or down production affects the environment (Loizou et al., 2000). It would be possible to further develop these approaches.

### *3.2 The input-output model*

Input-output tables show the economy in terms of either industries or commodities. In the extended Make and Use format, which is further described below, industries and commodities are depicted in a rectangular table, but in the IO format either industries or commodities are chosen as the unit of analysis. That is, the accounts show either industries or commodities as activities of the economy. The Swedish table, for instance, is built using a commodity-commodity framework. Assume that an economy can be divided into $n$ sectors of either industries or commodities (either defined as aggregated sectors, or where one or more sectors have been disaggregated into several production lines). A standard IO table including also demand and value added could take the form as in Table 1 with:

- $z_{ij}$: Product flow from sector *i* to sector *j*. i.e. products from *i* to *j* with the payments "flowing" in the opposite direction.
- $Y$: Final demand divided into household consumption ($C$), Investments ($I$), Government purchases ($G$) and exports ($E$).
- $L$: Labour compensations.
- $N$: Other value added payments, e.g. taxes, capital or land payments.
- $M$: Imports
- $X$: Total outlays and total output.

**Table 1. Basic structure of an IO table**

| | | Processing sectors 1 | Processing sectors 2 | Final demand (Y) | | | | Total output (X) |
|---|---|---|---|---|---|---|---|---|
| Processing sectors | 1 | $z_{11}$ | $z_{12}$ | $C_1$ | $I_1$ | $G_1$ | $E_1$ | $X_1$ |
| | 2 | $z_{21}$ | $z_{22}$ | $C_2$ | $I_2$ | $G_2$ | $E_2$ | $X_2$ |
| Payment sectors | Value added | $L_1$ | $L_2$ | | | | | $L$ |
| | | $N_1$ | $N_2$ | | | | | $N$ |
| Imports | | $M_1$ | $M_2$ | | | | | $M$ |
| Total outlays | | $X_1$ | $X_2$ | $C$ | $I$ | $G$ | $E$ | |

Let $X_i$ denote the total production of sector *i,* and let $Y_i$ represent the total final demand for the output of sector *i,* i.e. the consumption of the goods from sector *i*. Production, final demand and intersectoral flows are all measured in monetary units. Thus, the production of sector *i* can be obtained as follows:

$$X_i = z_{i1} + z_{i2} + \ldots z_{ii} + \ldots z_{in} + Y_i \tag{1}$$

Equation (1) shows that the production of sector $i$ is used as input into the other sectors in the economy and in the sector itself, and for final demand.

By realizing that equation (1) can be extended to all sectors in the economy, the activities of the total economy can be summarized by the following set of linear equations.

$$
\begin{aligned}
X_1 &= z_{11} + z_{12} + \ldots + z_{1j} + \ldots + z_{1n} + Y_1 \\
X_2 &= z_{21} + z_{22} + \ldots + z_{2j} + \ldots + z_{2n} + Y_2 \\
&\vdots \\
X_i &= z_{i1} + z_{i2} + \ldots + z_{ij} + \ldots + z_{in} + Y_i \\
&\vdots \\
X_n &= z_{n1} + z_{n2} + \ldots + z_{nj} + \ldots + z_{nn} + Y_n
\end{aligned}
\tag{2}
$$

By extracting the information in the $j$th sector of the economy modeled in equation (2), we get the following column vector.

$$
\begin{pmatrix}
z_{1j} \\
z_{2j} \\
\vdots \\
z_{ij} \\
\vdots \\
z_{nj}
\end{pmatrix}
\tag{3}
$$

The vector in equation (3) shows the purchases by sector $j$ from the other sectors in the economy. This implies that the vector represents the magnitude and origin of all intermediate production inputs to sector $j$. However, some inputs are missing in this vector, such as labour, capital and imported inputs. These are considered as other final payments by sector $j$ and are part of value added (except imports of intermediate goods).

However, to further investigate the linkages within the economy and to find out the effects of an exogenous shock to the demand in one or more sectors, we are often interested in calculating input-output coefficients or "requirement coefficients". Such coefficients show each industry's use of intermediate inputs from other sectors to produce the industry outputs. They are calculated as the ratio of input to output in each sector. Obviously, inputs can be described either as in Table 1 with domestic inputs and imported intermediate inputs separately, or aggregated as use of inputs regardless of their origin. Coefficients describing use of inputs regardless of origin are denoted "technological coefficients" whereas coefficients describing domestic flows are denoted "trade coefficients". As trade coefficients are the relevant measure for analysing impacts in most instances in a region or nation, since the technological coefficients disregard leakages of impacts abroad, coefficients below refer to trade coefficients. Denote the coefficient for the use of sector *i* products in the production of sector *j* as $a_{ij}$, then

$$a_{ij} = \frac{z_{ij}}{X_j} \tag{4}$$

By using the above coefficients, system (2) can be re-written in the following way:

$$\begin{aligned}
X_1 &= a_{11}X_1 + a_{12}X_2 + \ldots + a_{1i}X_i \ldots + a_{1n}X_n + Y_1 \\
X_2 &= a_{21}X_1 + a_{22}X_2 + \ldots + a_{2i}X_i \ldots + a_{2n}X_n + Y_2 \\
&\vdots \\
X_i &= a_{i1}X_1 + a_{i2}X_2 + \ldots + a_{ii}X_i \ldots + a_{in}X_n + Y_i \\
&\vdots \\
X_n &= a_{n1}X_1 + a_{n2}X_2 + \ldots + a_{ni}X_i \ldots + a_{nn}X_n + Y_n
\end{aligned} \tag{5}$$

System (5) can then be used to find an answer to what happens to the system if a demand shock occurs to one or more sectors. This is pursued by first moving all *X* terms to the left-hand side:

$$\begin{aligned}
X_1 - a_{11}X_1 - a_{12}X_2 - \ldots - a_{1i}X_i - \ldots - a_{1n}X_n &= Y_1 \\
X_2 - a_{21}X_1 - a_{22}X_2 - \ldots - a_{2i}X_i - \ldots - a_{2n}X_n &= Y_2 \\
&\vdots \\
X_i - a_{i1}X_1 - a_{i2}X_2 - \ldots - a_{ii}X_i - \ldots - a_{in}X_n &= Y_i \\
&\vdots \\
X_n - a_{n1}X_1 - a_{n2}X_2 - \ldots - a_{ni}X_i - \ldots - a_{nn}X_n &= Y_n
\end{aligned} \tag{6}$$

Thereafter, the *X*s in each row are grouped together, generating the following system of equations:

$$\begin{aligned}
(1-a_{11})X_1 - a_{12}X_2 - \ldots - a_{1i}X_i - \ldots - a_{1n}X_n &= Y_1 \\
-a_{21}X_1 + (1-a_{22})X_2 - \ldots - a_{2i}X_i - \ldots - a_{2n}X_n &= Y_2 \\
&\vdots \\
-a_{i1}X_1 - a_{i2}X_2 - \ldots + (1-a_{ii})X_i - \ldots - a_{in}X_n &= Y_i \\
&\vdots \\
-a_{n1}X_1 - a_{n2}X_2 - \ldots - a_{ni}X_i - \ldots + (1-a_{nn})X_n &= Y_n
\end{aligned} \tag{7}$$

This is a linear equation system with *n* unknown *X*s. A solution to the equation system may be possible to find. Matrix A, and vectors X and Y can be defined as follows:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1i} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2i} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{ni} & \cdots & a_{nn} \end{bmatrix}, \quad X = \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix}, \quad Y = \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} \tag{8}$$

Further, define an identity matrix $I_n$, of size $n \times n$. Equation (7) can now be written as follows in matrix form:

$$(I_n - A)X = Y \tag{9}$$

Equation (9) has a unique solution for X if $(I_n - A)$ is non-singular. The solution to equation (9) is thus:

$$X = (I_n - A)^{-1} Y \tag{10}$$

The formula $\Delta X = (I_n - A)^{-1} \Delta Y$ shows how a change in final demand (ΔY) affects total supply (ΔX) through backward linkages in the form of multipliers, $(I_n - A)^{-1}$. This relationship is sometimes denoted the Leontief inverse.

### *3.2.1 The Make and Use Input-Output system*

The traditional IO table which has been described above is constructed by classifying the producing industries or final products into the sector or product group which describes their major economic activity. However, sometimes industries produce more than one product from the input mix they utilize. These more detailed economic transactions are presented in the Make and Use matrices of an IO system (sometimes the Make matrix is referred to as a Supply matrix, e.g. in the Swedish national accounts). This expanded system has as its classification the *(n)* products produced by the *(m)* industries, and the products used by industries and the final demand accounts. In its most basic form this system is presented as in Table 2.

**Table 2. Basic structure of an IO framework based on Mmake and Uuse matrices**[4]

| | *Product (n)* | *Industry (m)* | *Final Demand* | *Total Output* |
|---|---|---|---|---|
| *Product (n)* | | *Use matrix (U)* | *Y* | *Q* |
| *Industry (m)* | *Make matrix (M)* | | | *X* |
| *Payment sectors* | | *W* | | |
| *Total inputs* | *Q'* | *X'* | | |

In Table 2 the Make matrix (of size $m \times n$) shows the different outputs produced from all the different industries in the system. This table usually has its major elements in the main diagonal. The Use matrix (of size $n \times m$) similarly to the IO system records the use of different inputs by the various industries in the economy. *Y* is the final demand matrix from the traditional IO table, W is the final payment matrix and *Q* and *X* register total input and output.

[4] Sometimes the product and industry accounts are depicted in the opposite order.

This Use/Make approach to representing the economy is useful when it is assumed that sectors in the economy are heterogeneous in their output mix, which is often the case for farming sectors. Farms usually produce more than one homogeneous output and if the farm sector is to be disaggregated the possibility of allowing for diversification within the Make matrix enriches the analysis.

In order to analyze the economy in the IO framework described above it is possible to move from the Make and Use system to the sector-by-sector or product-by-product framework. In so doing we have to use coefficient matrices from the expanded system and merge them into a traditional coefficient table based on production technology assumptions. The two most prevailing technology assumptions are the commodity assumption (CTA) and the industry assumption (ITA) (Miller and Blair, 1985). The former assumes that the input combination is identical for a commodity regardless of in which industry the commodity is produced. The latter assumes that an industry produces its mix of outputs utilizing inputs in the same proportion across them of all. These are two rather extreme assumptions and some hybrid approaches do exist where the practitioner is allowed to divide the Make table into sectors to be treated with the CTA and ITA respectively. Swedish national accounts IO tables are constructed based on the Make and Use tables and the creation of a transaction matrix based on the ITA.

Theoretically this involves calculating coefficient matrices based on the Make and Use matrices. Let the coefficient matrix, $D_{m,n}$, for the Make matrix be made up of the following elements:

$$m_{ij} = \frac{M_{ij}}{Q_j} \tag{11}$$

which show the proportion of commodity $j$ produced by industry $i$. Let us define the coefficients in the $B_{n,m}$, matrix, associated with the Use matrix, according to equation (12):

$$u_{ij} = \frac{U_{ij}}{X_j} \tag{12}$$

which show the quantity of commodity $i$ used in the production of one unit of $j$ industry output.

The coefficient matrix $A_{n,n}$ of the traditional IO system of product-by-product accounts is derived as $A_{n,n} = B_{n,m} \times D_{m,n}$ under the ITA assumption and can then be used to infer the transactions table or calculate the Leontief inverse. The coefficient matrix $E_{m,m}$ of the traditional system of industry-by-industry accounts is derived under the ITA as $E_{m,m} = D_{m,n} \times B_{n,m}$ and can be used in the same way as the A-matrix to calculate industry by industry multipliers.

### *3.3 Open and closed models*

In the model outlined above final demand (Y) is exogenous and not part of the interrelated production system. The final demand consists of the purchases from the households, the government, private investments and exports. For households, it is questionable to treat this component of the economic system as an exogenous element in impact analysis. Indeed, households earn incomes from the other sectors in the economy, which are used to purchase goods from producing sectors. Therefore, one may argue that the labour income and consumption of the households should be "added" to the *X* matrix in equation (10). This would imply adding one more row and one more column to matrix *X*; hence making wages and household final demand endogenous to the model. The additional row would show how the labour earnings, i.e. wages and other fringe benefits, are distributed. The consumption column would show what goods and services households purchase. This procedure is called *closing* the IO model with respect to the households. A model which disregards these induced effects of household earnings and consumption is denoted as *open*.

When the model is closed with respect to the households the following row is added to the *X* matrix:

$$\left(l_1 \; l_2 \; \dots \; l_n\right) \tag{13}$$

The row vector in equation (13) represents the payments received by the households. Then the following column is added, which represents the monetary flows from the households to the other sectors in the economy, i.e. the first column of matrix Y representing household spending.

$$\begin{pmatrix} c_1 \\ c_2 \\ \vdots \\ c_n \end{pmatrix} \tag{14}$$

Finally, an element in (13) and (14) is added which represents the purchases of labour from the households, i.e. the payments from the households to itself.

A row and a column are thus added to equation (2). If the steps in equation (3) – (10) are followed with the new equation, the following solution is obtained:

$$\overline{X} = (I - \overline{A})^{-1}\overline{Y} \tag{15}$$

Equation (13) represents the solution to a closed model and we indicate this new system with an "over bar" when presenting structural equations and multipliers.

### 3.4 Multipliers

There are many types of multipliers in IO analysis: open multipliers (sometimes denoted simple), closed multipliers (sometimes denoted total), Type 1 multipliers and Type 2 multipliers. Many choices in what to measure also exist: output multipliers, income multipliers, employment multipliers, value added multipliers, etc. Open multipliers, which originate from the open model, show the direct and indirect linkages within the system. Closed multipliers, which originate from the closed model, shows the direct, indirect and induced effects and hence take into consideration the labour earnings and spending by households. Type 1 and 2 multipliers are analogous to these open and closed multipliers but show the multiplier effects in relation to direct effects. This means that these multipliers use as denominator the direct effect in the sector for which the multiplier is calculated. For employment multipliers type 1 and 2 multipliers are based on the labour use per unit of output in the sector. Similarly for income, the increase in output will create a direct effect based on the coefficient of wages in the coefficients matrix.

If the elements of the Leontief inverse are denoted $\alpha_{ij}$, the open output multiplier for a sector in $(I - A)^{-1}$ can be calculated by summing the elements in the sector's column. Thus the multiplier of sector *j* is defined as:

$$O_j = \sum_{i=1}^{n} \alpha_{ij} \qquad (16)$$

If the elements in equation (15) are called $\overline{\alpha}_{ij}$, the closed output multiplier for a sector in $(I - \overline{A})^{-1}\overline{Y}$ can be calculated by summing the elements in the sector's column. Thus, in the same way as above:

$$\overline{O}_j = \sum_{i=1}^{n+1} \overline{\alpha}_{ij} \qquad (17)$$

#### 3.4.1 Employment effects

The multipliers can be used to calculate employments effects, sometimes denoted employment multipliers. This is done by dividing the physical employment (actual number of employees) of a sector, $e_i$, with total output of the sector, $X_i$. This gives us the physical labour use, i.e. labour per output:

$$w_i = e_i / X_i \qquad (18)$$

The open employment multiplier $E_j$ is obtained by multiplying equation (18) with the open output multiplier $\alpha_{ij}$ and summing over the rows, in the following way:

$$E_j = \sum_{i=1}^{n} w_i \alpha_{ij} \qquad (19)$$

The closed employment multiplier $\overline{E}_j$ is obtained in a similar way as for $E_j$, the only difference being that equation (18) is multiplied with the closed output multiplier $\overline{\alpha}_{ij}$.

### 3.4.2 Income effects

Household income multipliers are calculated as the total value of household income (from employment in all sectors) resulting from a monetary unit exogenous increase of final demand in one sector. We use the closed economy coefficients for household income, denoted $a_{n+1}$, for all sectors *i,* and multiply it with either the column of open economy or closed economy multipliers for the investigated sector *j*, i.e. $\alpha_{ij}$ for all *i*. Using the open or closed multipliers we basically determine whether we want to include the circular flow of increased household income and demand on production (induced effect) or if we just want the direct and indirect effect. Using the closed economy multipliers we actually calculate the same value as the one we can find in the *n+1* row of the multiplier matrix of the closed economy ($\alpha_{i+1,j}$). This *n+1* multiplier is the effect of a unit increase in exogenous demand in each sector. This number is larger than the open economy multiplier effect since the induced effect is considered. For the open economy the calculation of the household income multiplier is:

$$H_j = \sum_{i=1}^{n} a_{n+1,i}\alpha_{ij} \qquad (20)$$

This multiplier as well as the closed economy multiplier determines which sector has the potential to create the maximum household income from an exogenous increase in demand. If we are interested in rural development and rural household income this multiplier is an important indicator.

As mentioned above, type I (or type II) multipliers measure the effects in relation to the direct effect caused in the sector under study. For employment and income these indicators are calculated as:

$$EE^{MS} = E_j / w_j \qquad (21)$$

$$IE^{MS} = H_j / a_{n+1,j} \qquad (22)$$

## 3.5. Input-Output methods as an analytical tool

IO multipliers are commonly used to assess the importance of a certain sector in the economy or for analyzing impacts of different supply/demand shocks or policy scenarios. Multipliers show the effect on output due to an exogenous change in demand for one or more sectors. Based on this measure various approaches have been followed to account for the fact that multipliers do not take into consideration the relative size of the sectors, for example their relative output size. Due to the interest in output based, and output driven measures, a discussion has been going on about the appropriateness of multiplying demand driven multipliers with output values or changes thereof. Tanjuakio et al. (1996) analyzed the agricultural sector in Delaware using output driven economic contribution analysis. They acknowledge that an analysis using output as the basis for measurement suffers from double counting, because the output of a sector already takes into consideration contributions and linkages of other sectors in the economy. By setting the purchasing coefficients (what we have referred either technological or trade coefficients) for the analyzed sector to zero it is proposed that the double counting is reduced. Leung et al. (1997) commented on this approach and stated that the removal of appropriate coefficient will reduce but not overcome the double counting.

Oosterhaven and Stelder (2002) also questioned the approach of multiplying traditional multipliers with output. As multipliers show the total effect on output due to exogenous changes in final demand, multiplying such multipliers by output values involves double counting. As stated by Oosterhaven and Stelder (2002, p 534) *"when the claims of all sectors in an economy are added an (implicit) estimate of the total size of the economy will result that is many times larger than its actual size"*. A new "net" multiplier was proposed to account for these problems; this multiplier takes into consideration which part of a certain sectors output can be considered to be exogenous. de Mesnard (2002) offers an alternative approach based on output multipliers where a *change* in output is transmitted through the corresponding column of the requirement matrix, a process which does not require the analyzed sectors output to be exogenous. Dietzenbacher (2005) interprets both net multipliers and output multipliers (output multipliers still refers to exogenous *changes*) and offers a ranking of sectors based on whether more value added is created in all sectors from final demand in a sector compared to the value added in the same sector originating from final demand in all other sectors. Sharma et al. (1999) provided a simple example of the double counting associated with using *total* output together with traditional multipliers (along the same lines of Oosterhaven and Stelder, 2002, above); they continue to analyze the agricultural sector based on a final demand based approach.

As a basis for analyzing supply and demand shocks, as well as policy scenarios, the traditional IO model has sometimes been completely adapted to allow for output changes. This is an approach to overcome the inherent demand driven features of the Leontief system. This procedure amounts to making the output of one or more sectors exogenous (Johnson and Kulshrestha, 1982; Roberts, 1994; Papadas and Dahl 1999; Eiser and Roberts, 2002). Multipliers from such a model are sometimes denoted output-output multipliers and show how an output change in one or more sectors affect the endogenous output of other sectors in the economy. One obvious drawback of such an approach is the exogenous output of the sector(s) which are analyzed. That is, if the agricultural sector is assumed to increase its output, no feedback effects are allowed to the sector itself. The approach of de Mesnard (2002) as mentioned above uses the traditional multipliers but allows for a transmission of the output shock based on relevant column elements in the requirements matrix. This allows output of the studied sector to remain endogenous in the analysis.

Traditional demand-based analysis has also been further developed to take into account the specific characteristics of a sector. Among the methods used in the literature are the hypothetical extraction of sectors (West, 1999), the decomposition of output responses (Sharma et al., 1999) and the analysis based on relative size of sectors final demand in relation to multipliers (elasticities proposed by Mattas and

Shrestha, 1991). Elasticities are an attractive measure since it captures the percentage change in the total economy output originating from a percentage change in final demand of a certain sector. The approach used by Mattas and Shrestha (1991) was to calculate a measure of IO elasticities (MS-IO) which are based both on the multipliers and demand and output for each sector. In matrix notation the output elasticity is defined as

$$OE^{MS}{}_j = \sum_{i=1}^{n} \alpha_{ij} y_j^* \tag{23}$$

where $$y_j^* = y_j \Big/ \left( \sum_{i=1}^{n} X_i \right) \tag{24}$$

$y_j$ is final demand and $X_i$ is the vector of outputs. Hence the IO elasticities take into consideration both the interdependencies as depicted in the multiplier matrix and the relative importance of these interdependencies in the economic system.

However, some sectors, notably some of the agricultural sectors, produce a small fraction of their output for final demand. In such instances measuring the importance of a sector using elasticities might give a misleading impression. One approach for capturing the “relative elasticities” between agricultural production lines could be to decompose the elasticity for the food and beverage sector.

Following the rationale behind the MS elasticity we realize that the total $OE^{MS}$ for food and beverages is made up of the final demand of food and beverages (relative to total economy output) and the column of multiplier coefficients between the sector and its intermediate purchases. A large share of these purchases are made from the agricultural primary producers, others are from secondary and tertiary sectors of the economy. Hence an increase of final demand for products of food and beverages will be transmitted into purchases from agriculture, capturing the relative size of different agricultural production lines and the interactions of these activities backward in the economy. If we multiply $y^*$ with the multiplier coefficient for the interaction between food and beverages and cereals we should be able to measure the way in which a one percent increase in final demand for food and beverages transmits into an increase in output of the entire economy due to the extra purchases of cereals made by the food complex. The interpretation of decomposing the elasticity of the food and beverage sector is that when the final demand for food and beverages increase by one percent the output of the economy will increase with some magnitude. Part of this increase is attributable to the increase in purchases of the sector from various agricultural production lines. These production lines then use intermediate products in their production and so on and so forth. Hence the importance of the production lines in delivering to the food and beverage sector, as well as their intermediate use of products in producing outputs, are taken into consideration with this decomposition.

Following this line of thinking, under the assumption that agricultural commodities are primarily absorbed by the food sector, we should be able to determine the relative importance of production lines based on elasticities. We conclude from data obtained from Statistics Sweden that 92% of all intermediate sales of agricultural products are made by the food and beverage sector. Remaining sales are mainly hides and skins, (potatoes, eggs and flowers) to hotels and restaurants and fodder to horse stables of recreational nature. Vegetables, fruit and flowers are directly consumed by the households but such products are mainly (to 91.5%) imported to Sweden from abroad. Vegetables and eggs are consumed directly also out of domestic production, but only to a total of 5% of total production. For other agricultural products the sales to households are negligible. Exports are only 6% of the Swedish production value. Hence an analysis of the agricultural production lines made by decomposed elasticities of the food and beverage sector should provide a good complement to the multipliers.

We acknowledge the different methods and problems mentioned above. We have analyzed the disaggregated IO model based on multipliers (output, employment and income), decomposed elasticities and a hypothetical change framed as a percentage increase in output, based on Dietzenbacher (2005). Strictly analyzing multipliers is a common approach when analyzing the *economic potential* of certain sectors of an economy (Cai et al., 2006; Kweka et al., 2003; Stilwell et al., 2000; Tanjuakio et al., 1996; Roberts, 1992; Johns and Leat, 1988). The decision to include a potential shock, which in this case is linked to the size of the sectors, as well as the elasticities, is based on the wish to capture the relative size of different sectors. We believe that in the interest of studying economic potential these approaches present a true analysis of the sectors in question without potential problems of double counting.

# 4. Data

In this study, the Swedish input-output tables, Supply table and Use table for 2005 were used. These were the most recent tables available. In the input-output tables as well as the Supply and Use tables, agriculture is aggregated into one single sector. To fulfill the aim of this research we needed to disaggregate the sector into different production lines. Mainly farm accounting data, obtained from Statistics Sweden, were used to disaggregate production within the agricultural sector. However, this dataset contains too few observations on specialized poultry and sheep farms to be a meaningful basis to disaggregate these two production lines. Instead, Agriwise, a database consisting of gross margin budgets for different agricultural production lines in Sweden, constructed by the Department of Economics, Swedish University of Agricultural Sciences (available at www.agriwise.org) was used to get information about the purchases and sales of these two production lines.

Besides these data sources, national accounts and sectoral data from the farm census survey were used to improve the disaggregation of the agricultural sector. These data were particularly useful for disaggregating sales from the agricultural sector and for determining production flows of different farm outputs. Background data for the national IO table were also useful in determining flows of agricultural products to other sectors of the economy as well as agricultural production of other sectors. Wages in each production line were calculated with data on the number of persons working in each production line and information on overall wages in the entire agricultural sector. This implies the assumption that wages are the same across production lines, which is plausible. Figure 1 shows the different data sources used in this study, as well as their interactions. In what follows, we describe in some more detail the main data sources used in this study.

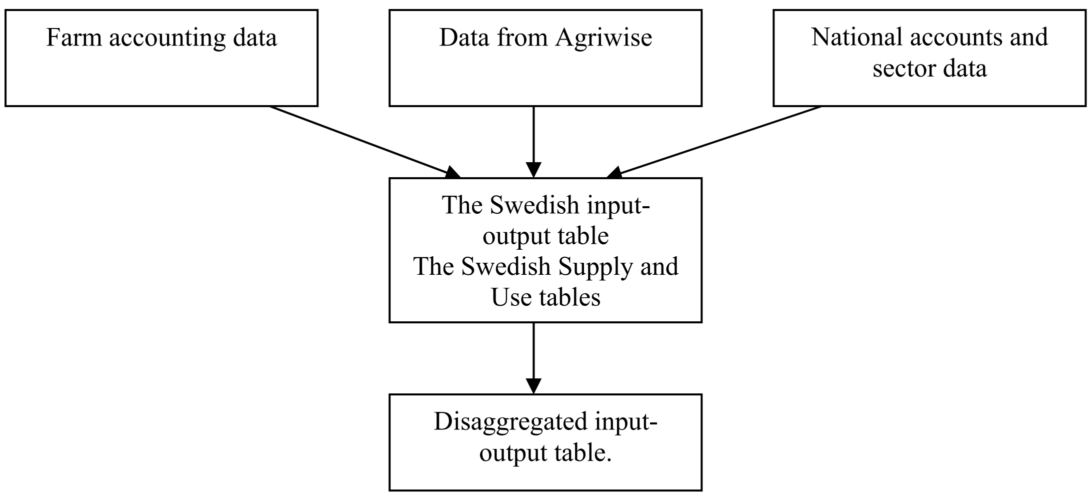


**Figure 1. Data sources in the study and their interactions**

### 4.1 The Swedish input-output table

The national IO table was obtained from Statistics Sweden and refers to the year 2005. It is a symmetric table which is derived from national Use and Make matrices. The industries and commodities are divided into 59 accounts[5] using the standard SNI-2002 classifications. The IO table is of commodity-commodity class and is produced using an industry technology assumption. The final demand components include one type of household and one type of government consumption. The national table can be broken down into one IO table recording only domestic flows, or transactions, and one IO table recording only international trade. Hence there is the possibility to work only with domestic flows and distinguish imports separately, something we have done in our analysis. Working with the domestic table we take into account that domestic firms use domestic inputs as well as imports. As it is, the table includes only one sector for agriculture which is aggregated with hunting. This sector will be disaggregated in the analysis to fully model the differences in farm types within the nation.

### 4.2 The Swedish farm accounting data network

The Swedish farm accounting data network consists of detailed profit and loss statements and balance sheets of about 1000 private Swedish farms with a size of at least 8 ESU[6]. The dataset also contains some additional data such as the number or hours worked at the farm, harvest, information about inventories etc. Statistics Sweden is responsible for collecting the data. The main purpose of the data is to be the basis of the European data network called Farm Accountancy Data Network (FADN), where detailed accounting data are collected from the member states.

An important issue for us is that the Swedish farm accounting data network mirrors the essential aspects of Swedish farming. Given the size restriction, of 8 ESU the total population of interest for the farm accounting data collection amounted to 29 000 farms in 2005. This can be compared to the total population of farms in Sweden, which amounted to about 76 000 farms in 2005. A farm is then defined as a holding with more than two hectares of arable land. However, 40 500 of these farms use less than 800 standardized working hours (Statistics Sweden, 2007). Even if standardized hours do not necessarily reflect the actual need of work at the farm, these farms cannot be considered as needing a full-time operator (Statistics Sweden, 2007). If the definition of a full-time farm operator is set to at least 1600 standard hours per year, there are about 20 000 farms run by full-time operators in Sweden (Statistics Sweden, 2007). Thus, even though the population of the farm accounting data is much smaller than the whole population of farms in Sweden, we believe that it still reflects the essential aspects of Swedish farming.

[5] Due to confidentiality, data restrictions and lack of activity the national IO can be effectively defined as consisting of 53 industries and 53 commodities.

[6] ESU (European Size Unit) is a measure of farm size used within the EU, based on standardized gross margins in different production lines. 1 ESU = 1200 Euros. 1 ESU corresponds to about 1.3 hectares of cereals or 1 cow (Defra, 2008)

### 4.3 Agriwise

Agriwise (www.agriwise.org) is a data base containing a collection of gross margin budgets for different production lines and regions within Swedish agriculture. Each budget contains detailed information about required input quantities and prices in specific productions. The data base is constructed and run by the Department of Economics, Swedish University of Agricultural Sciences, and the main purpose of the data base is to be a farm management tools for farmers, farm advisory services and banks.

# 5. Considerations in the disaggregation of the agricultural sector

To analyze the impact of specific production lines within agriculture, or activities or products of other sectors which are aggregated, it is necessary to break down relevant rows and columns of the IO table. Thus, if the modeler is interested in analyzing the specific multipliers of milk or milk producers it would be necessary to model that production line both with respect to input use and deliveries of products. Historically disaggregated tables have been constructed or analyzed for different sectors ranging from mining in South Africa (Stilwell et al., 2000), forest activities in Scotland (Eiser and Roberts, 2002), agriculture in the UK (Doyle et al., 1997; Roberts, 1992; Leat and Chalmers, 1991) and fishing on Hawaii (Cai et al., 2005). Besides Eiser and Roberts (2002), Doyle et al. (1997), Roberts (1992) and Leat and Chalmers (1991) it is difficult to find examples of applied disaggregation where the researchers have disaggregated the tables themselves.

As described in Midmore and Harrison-Mayfield (1996) IO coefficients are basically average values describing the quantities of inputs used in production of a commodity or industry. Determining these coefficients based on farm accounting data or other external sources amounts to allocating coefficient values for different inputs to different commodities or industries in the sector under disaggregation. Thus, for a certain farm type producing only forage and a crop it is essential to know how much of the fertilizers are used for producing forage and how much is used for the crop. One way of deriving these coefficients is by econometric estimation. The purpose of such estimation is to allocate the respective inputs to specific outputs of the farm. These approaches are described in e.g. Midmore and Harrison-Mayfield (1996) or Moxey and Tiffin (1994). More recent advances in such estimation include Léon et al. (1999) and Peeters and Surry (2002) who estimate input coefficients based of farm revenues (output) using maximum entropy estimation methods.

Another approach which is more straightforward is to disaggregate the farm sector in the Make and Use system. In so doing the different farm types are allocated input coefficients and production shares. In the Use matrix farm types are assigned coefficients for all commodities they use as inputs to their production. In the Make matrix the same farm types are assigned production shares of all commodities in the commodity accounts. That is, each farm type may produce more than one product. Finally, in order to analyze the system it is necessary to use either one of the assumptions in section 3.2.1 (CTA or ITA) to allocate inputs to outputs in either the commodity or industry version of the model.

To disaggregate the agricultural sector in the national IO table we proceed in a similar way as Roberts (1992) and Leat and Chalmers (1991) by focusing on the Make and the Use matrices. While Roberts (1992) disaggregates the agricultural account in an SAM (social accounting matrix) framework we only focus (as did Leat and Chalmers, 1991) on the various interlinkages between agriculture and the rest of the IO table. We have disaggregated the agricultural sector of the national IO into seven distinct production lines as well as ten specific products that these production lines produce;

see Table 3[7]. The typology or specialization of the farms was determined with the same model as the one used by the Swedish Board of Agriculture and Statistics Sweden for official statistics. This means calculating the number of standardized labour hours used for each production line in a farm, based on the volume of the production line in that particular farm. A farm is considered to be specialized in a particular production line if at least 67% of its standardized labour hours belong to that production line. The procedure is described in detail in a report from Statistics Sweden (2001).

**Table 3. Agricultural production lines and products in the disaggregated tables**

| | |
|---|---|
| **Production lines** | 1. Cattle (milk and beef), 2. Pig, 3. Poultry and Egg, 4. Sheep, 5. Mixed Livestock, 6. Cereals, 7.Mixed Farming |
| **Products** | 1. Milk, 2. Beef, 3. Pig, 4. Poultry and Egg, 5. Sheep, 6. Cereals, 7. Other Crop (mainly potatoes and sugar beets), 8. Forage, 9. Other animals (mainly horses and animals for fur production), 10. Agricultural services |

As explained above, we use farm accounting data and information from Agriwise, together with other national sources to disaggregate specific parts of the Make and Use framework.

Farm accounting data for the year of the national IO table was used to determine coefficients for the input use of the different production lines with regard to products from other sectors of the economy as well as agricultural products. Specific data from Statistics Sweden was used to determine deliveries to key recipients of agricultural products, i.e. deliveries of milk, beef, cereals etc. to dairies, slaughterhouses and food processors. Farm accounting data were also utilized to determine the relative shares of each farm type's production of disaggregated products, that is, to determine how much of the milk was produced by specialized milk farms as opposed to other production lines. Data from Agriwise were used to disaggregate some parts of the table for Poultry and Egg, and Sheep farms due to limited coverage of the farm accounting data.

### *5.1 Disaggregating the Use matrix*

To illustrate what were the key elements of this disaggregation we refer to Table 4 to illustrate the specific composition of the disaggregated Use matrix.

Partition 1 of the disaggregated Use matrix refers to the use of agricultural products as inputs in the different production lines referred to as agricultural industries. Examples include the use of animals purchased from other farms as input to production or the use of seed or forage. Agricultural commodities are produced by farms as well as industries outside the farm sector. As an example the processed seed is produced outside the farm sector but is still referred to as an agricultural commodity (by convention of the national IO table). The actual production of specific commodities is

[7] We also distinguish processed seed as an agricultural commodity and an input which we need to model explicitly. But this product is supplied to agriculture from firms in another sector of the IO table. Therefore we do not report multipliers for this commodity and we have excluded it from Table 3.

dealt with in the disaggregated Make matrix. In the original Use matrix this part of the matrix was limited to one cell, in the disaggregated system this comprises 77 cells[8].

**Table 4. The components of the Use matrix after disaggregating the agricultural sector**

| | *Agricultural industry* | *Non-agricultural industries* |
|---|---|---|
| *Agricultural commodities* | **1. Use of agricultural commodities by the farm sector**<br><br>(Data obtained from the farm accounting data network and Agriwise) | **3. Use of agricultural commodities as inputs by non-agricultural industries**<br><br>(Data obtained from Statistics Sweden) |
| *Non-agricultural commodities* | **2. Use of non-agricultural commodities as farm inputs**<br><br>(Data obtained from the farm accounting data network, Statistics Sweden and Agriwise) | **4. Non-agricultural commodities used as inputs by non-farm sectors.**<br><br>(Data obtained from Statistics Sweden) |

Source: Adapted from Roberts (1992)

Partition 2 of the Use matrix refers to commodities which were earlier utilized by the single agricultural sector as inputs to production. In the expanded system these commodities has been assigned different coefficients with regard to the seven production lines. This disaggregation is based on the FADN data, data from Statistics Sweden and the Agriwise tables.

Partition 3 of the disaggregated Use matrix refers to the use of agricultural products as inputs into non-agricultural industries. The major flow to be disaggregated in this part of the matrix was the deliveries of agricultural commodities to the food processing and producing industries. Data from Statistics Sweden revealed the types of agricultural products supplied (within the aggregated agricultural commodity) to the aggregated food and beverages sector in the IO table, and this information was used to distinguish specific flows. Other important flows (i.e. to the textile, leather, wool, hotel, restaurant and recreational sectors) were disaggregated using similar data.

Partition 4 of the Use matrix is the same partitioned matrix of flows as the original non-agricultural commodities to non-agricultural industries section of the aggregated Use matrix.

### 5.2 Disaggregating the Make matrix

Disaggregating the Make matrix amounts to determining the flows within partitions 5, 6 and 7 of the disaggregated Make matrix depicted in Table 5. In partition 5 we are interested in the way agricultural production lines produce different products denoted as agricultural products. This includes to what extent the cattle farm produces a mix of milk, cattle for slaughter, pigs, cereals etc. To this end we used the farm accounting

[8] That is, it shows the purchases of our 10 commodities and seed by our 7 farm types. That is 11 commodities used by 7 farm types, hence 77 interactions which were initially depicted in one cell.

data. In partition 6 we allow for non-agricultural industries to produce products which we have defined to be agricultural. For instance, seed which is prepared by farm cooperatives, which are classified as non-agricultural firms, is recorded in this part of the Make matrix. Agricultural firms are allowed, in partition 7, to produce non-agricultural goods. For instance, agricultural firms produce transport services (snow mowing etc) as well as energy. Partition 8 is again a non-modified section of the original Make matrix.

**Table 5. The components of the Make matrix after disaggregating the agricultural sector.**

| | *Agricultural commodities* | *Non-agricultural commodities* |
|---|---|---|
| *Agricultural industries* | **5. Agricultural commodities produced by agricultural firms**<br><br>(Data obtained from the farm accounting data network, Statistics Sweden and Agriwise) | **7. Non-agricultural commodities produced by agricultural firms**<br><br>(Data obtained from the farm accounting data network, Statistics Sweden and Agriwise) |
| *Non-agricultural industries* | **6. Agricultural commodities produced by non-agricultural firms**<br><br>(Data obtained from Statistics Sweden) | **8. Non-agricultural commodities produced by non-agricultural firms.**<br><br>(Data obtained from Statistics Sweden) |

We would like to emphasize that we are disaggregating the original system of Use and Make matrices at the coefficient level, i.e. we are interested on the components of the B and D matrices associated with a disaggregated agricultural sector. For the Use matrix this basically amounts to inferring the input use of different industries, with respect to commodities, in the form of coefficients. For the Make matrix the procedure amounts to determining the share of each industry in the production of a certain commodity. For instance we have used the FADN data together with national accounts and sector specific data from Statistics Sweden to determine how much of the milk is produced by specialized cattle farms as opposed to pig farms, cereal farms etc. Only one industry produces agricultural products of any important magnitude outside the agricultural complex, seed is produced by firms classified in the industry "trade". This flow was determined based on national account data and this sector was hence allowed some provision within partition 6 of Table 5.

# 6. Results and analysis

In this section the results of the analysis of the economic impacts of the Swedish agricultural sector are presented and discussed. In accordance with the aim, special focus is on livestock production and its different production lines. This section consists of three parts: one part based on descriptive statistics, one based on the disaggregated input-output coefficients and finally one part based on the multiplier analysis.

## *6.1 The importance of the Swedish agricultural sector*

In 2007, the total number of agricultural firms in Sweden was 72 609 (Statistics Sweden, 2008). This is a decrease (6%) compared to 2000, and compared to 2005 (4%). Although this figure may seem large, it includes many smallholdings, presumably hobby farms. In official Swedish statistics, a smallholding is defined as a farm with an estimated total labour need of less than 400 hours per year. In 2007, 34% of the total farm population in Sweden was smallholdings (Statistics Sweden, 2008). The smallholdings are assumed to play a minor role for the total family income (Statistic Sweden, 2008).

If the definition of a full-time farm is set to an estimated labour need of at least 1600 hours, the total number of farms in Sweden requiring a full-time farmer was about 18 800 in 2007 (Statistics Sweden, 2008). This is a decrease of 7% compared to 2006. Thus, about 50 000 of the Swedish farms can be considered as smallholdings or farms not in a need of a full-time farmer. Figure 2 shows the distribution of farms in Sweden according to their size. The figure shows that the majority of the farms can be considered as small, with an estimated labour need of less than 1600 hours per year.

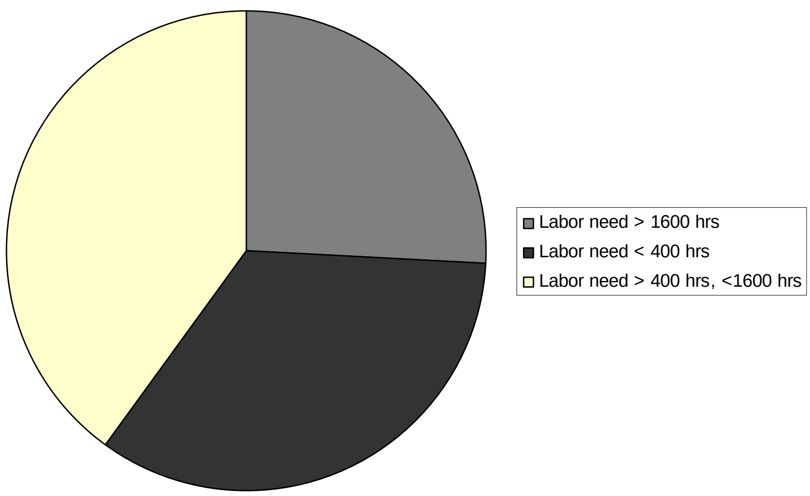


**Figure 2. Distribution of the number of farms according to farm size**
(Data source: Statistics Sweden 2008)

Figure 3 shows the distribution of the farms with an estimated labour need of more than 1600 hours per year, with respect to their specialization in livestock, crops or mixed farming. The figure shows that the majority of the larger farms are specialized in livestock production. This is not surprising as livestock production is more labour intensive than crop production and mixed farming.

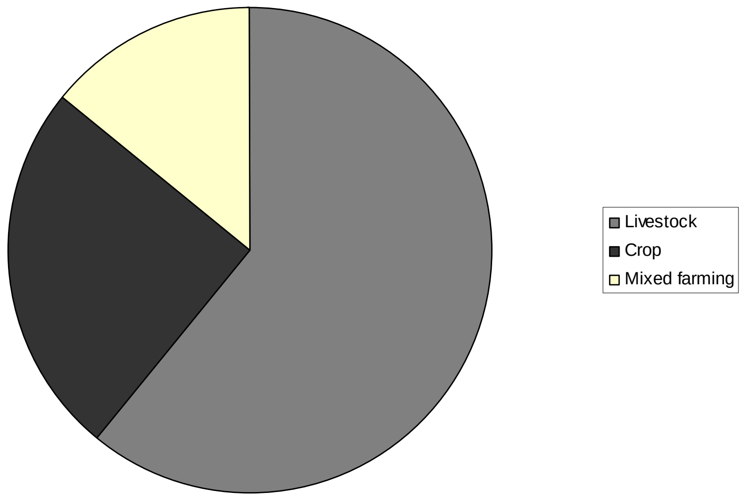


**Figure 3. Distribution of the larger farms, according to specialization**
(Data source: Statistics Sweden 2008)

Figure 4 shows the distribution of farms within different production lines, as well as the distribution of specialized farms in the production lines among Swedish farms in 2007. The figures are based on all farms, i.e. smallholdings are included. As can be seen from the figure, by far the most common production line is cereal production, in which more than 30 000 farms are engaged. Among the livestock producing farms, the most common production line is cattle, in which about 24 000 farms are engaged, followed by sheep production with 8000 farms.

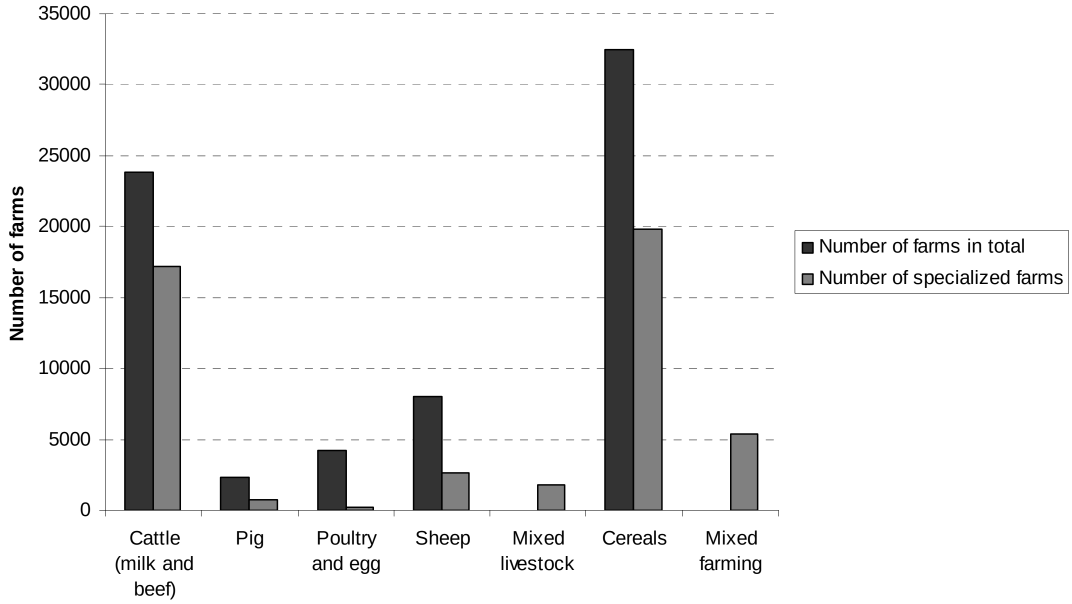


**Figure 4. The distribution of farms within different production lines in Sweden**
Smallholdings are included. (Data source: Statistics Sweden, 2008)

Figure 5 shows the distribution of production value, in 2006 (the latest figures) of the main products considered in this study. As shown in the figure, milk and beef production have the largest production value of the considered products, with a production value of 13 300 MSEK. Cereals has the second largest production value, of 9600 MSEK. Other agricultural products have a production value that is very similar to that of cereal production. Sheep production has the lowest production value, 160 MSEK.

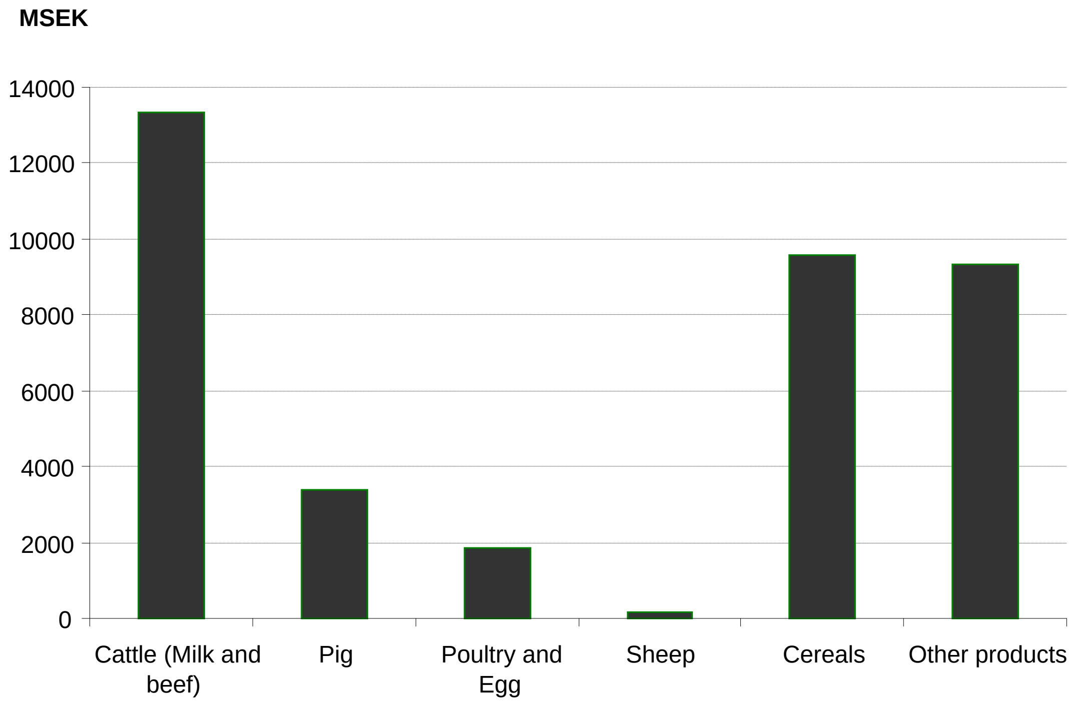


**Figure 5. Distribution of the production value**
Smallholdings are included. (Data source: Statistics Sweden, 2008)

Table 6 shows the change in production value between 2006 and 2005, as well as between 2006 and 2000, of the main agricultural products considered in this study. The main positive changes have been in poultry and egg, and in sheep, which shows that there is a potential of increased importance of these two production lines. The main negative effects have been in the production value of crop and cereals. The CAP reform, where farm support to a larger extent has been decoupled from production volumes, is likely to have caused some of the large decrease in production of crop and cereals.

**Table 6. Changes in production value 2000 – 2006, 2005 – 2006**
(Data source: Statistics Sweden, 2008). The calculations are based on real prices adjusted for inflation, base year 2006.

| | Milk and Beef | Pig | Poultry and Eggs | Sheep | Crop and cereals |
|---|---|---|---|---|---|
| Production value (2006, millions of SEK). | 13325 | 3386 | 1849 | 160 | 9598 |
| Change in production value since 2005. | -0.7% | +0% | +1% | +5% | -20% |
| Change in production value since 2000. | +2% | +2% | +20% | +13% | -27% |

## *6.2 Disaggregated input-output coefficients in the Swedish agricultural sector*

The agricultural sector in the Swedish Make and Use tables was disaggregated according to the framework outlined in Chapter 5. In this section we show extracts of the Make and Use tables, and comment briefly on the findings. The interested reader is referred to the tables in Appendix 1 and 2 for more information on the Use matrix. Note that the table in Appendix 1 is also an extract from the full table. Full Make and Use tables can be obtained from the authors upon request.

### *6.2.1 The disaggregated Make table*

Table 7 shows the Make coefficients of the commodities produced by the agricultural sector. The table shows for instance that the majority, 93.3% of all milk is produced by the specialized cattle farms. 5.1% of the milk is produced by the mixed livestock farms. Interestingly, only 31.3% of the pigs are produced by specialized pig farms. Farms engaged in mixed farming produce nearly as much as pigs as the specialized pig farms, 28.2%, and 22.2% are produced by the mixed livestock farms. Moreover the farms specialized in cereals produce some pigs. The great majority of all poultry and egg production takes place in the specialized poultry and egg farms. However, 9.4% of the production is done by the mixed farms.

**Table 7. Make coefficients of the agricultural sector**

| **Farm type/ Commodity** | Milk | Beef | Pig | Poultry and egg | Sheep | Cereals | Forage | Other crop (e.g. potatoes and sugar beets) | Other animals | Service AG |
|---|---|---|---|---|---|---|---|---|---|---|
| Cattle | 0.933 | 0.758 | 0.018 | 0.000 | 0.005 | 0.080 | 0.277 | 0.222 | 0.736 | 0.254 |
| Pig | 0.000 | 0.002 | 0.313 | 0.000 | 0.000 | 0.013 | 0.003 | 0.016 | 0.000 | 0.013 |
| Poultry and Egg | 0.000 | 0.000 | 0.000 | 0.896 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Sheep | 0.000 | 0.000 | 0.000 | 0.000 | 0.718 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Mixed livestock | 0.051 | 0.079 | 0.222 | 0.000 | 0.109 | 0.010 | 0.025 | 0.024 | 0.000 | 0.026 |
| Cereals | 0.000 | 0.001 | 0.165 | 0.000 | 0.006 | 0.784 | 0.600 | 0.466 | 0.014 | 0.563 |
| Mixed farming | 0.016 | 0.160 | 0.282 | 0.094 | 0.160 | 0.113 | 0.094 | 0.271 | 0.250 | 0.144 |

### *6.2.2 The disaggregated Use table*

Table 8 shows an aggregated excerpt of the disaggregated Use table. In the appendix we present a more detailed breakdown of the various intermediate inputs used by the different production lines.

**Table 8. Excerpt of the disaggregated Use matrix**

| Commodity/Farm type | Cattle | Pig | Poultry and Egg | Sheep | Mixed livestock | Cereals | Mixed farming |
|---|---|---|---|---|---|---|---|
| Agricultural | 0.099 | 0.107 | 0.194 | 0.098 | 0.163 | 0.085 | 0.108 |
| Feedstuff | 0.119 | 0.217 | 0.227 | 0.081 | 0.148 | 0.006 | 0.051 |
| Other manufactured products | 0.077 | 0.056 | 0.061 | 0.07 | 0.083 | 0.135 | 0.092 |
| Energy, water | 0.033 | 0.038 | 0.017 | 0.028 | 0.034 | 0.037 | 0.032 |
| Construction | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 |
| Trade, transport | 0.091 | 0.089 | 0.093 | 0.093 | 0.089 | 0.096 | 0.093 |
| Financial, real estate, business services | 0.048 | 0.039 | 0.050 | 0.050 | 0.045 | 0.058 | 0.050 |
| R&D, education | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 |
| Public administration | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |
| Health/veterinary services | 0.014 | 0.014 | 0.000 | 0.010 | 0.010 | 0.000 | 0.004 |
| Personal and cultural | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| Total intermediate use | 0.529 | 0.608 | 0.690 | 0.478 | 0.620 | 0.465 | 0.478 |

The disaggregated Use matrix shows the use of products, or commodities, in the production of each one of the different production lines. It should be emphasized that the *value added* of the production lines are not shown in the Use matrix. The value added covers payments to labour and capital, two categories which of course are large parts of farm production inputs. It should also be stressed that intermediate production of production inputs at the farm, e.g. forage and other feed stuffs are considered in terms of the inputs they require to be produced. This means that e.g. forage is accounted for by considering the farmers purchases of fertilizers and seed. Forage and all other agricultural products in the table refer to products that are bought from other farms.

Table 8 shows that much of the intermediate inputs of the agricultural production lines are purchased processed feed stuffs such as feed concentrates. Evidently poultry and egg as well as pig farms purchase much of their feeds from the food and beverages sector. Cattle and mixed livestock farms produce more feeds on the farms, resulting in lower coefficients for purchased feedstuffs. This might also be explained by differences in the input structures of the production lines. Other large coefficients refer to other manufactured products, agricultural products (which include input of live animals as well as agricultural services), trade and transports, and financial and business services. The entire use matrix is too large to be presented here but it should be noted that this matrix for example shows the various deliveries from the agricultural production lines to the food and beverages complex.

### 6.3 Multiplier and impact analysis

Based on the input-output tools discussed in the methodological section of this report we will now proceed by analyzing the agricultural production lines of the disaggregated input-output table for Sweden. We will focus on three main areas, i.e. output, employment and household income.

#### 6.3.1 Output multipliers, aggregated analysis

The open and closed output multipliers of the traditional IO system are depicted in Table 9. These multipliers indicate what impact a one unit (i.e. SEK) increase in final demand of the sector would have on the output of the entire economy. That is, if the closed multiplier of a certain sector is 2, this would indicate that a final demand increase of one SEK in this sector would result in a total output stimulation throughout the economy of two SEK.

An inspection of the output multipliers indicates that agriculture on an aggregate level have strong potential to stimulate economic growth relative to other sectors. The open multiplier of 1.83 is the largest of the aggregated system, but it cannot compete with some multipliers within the other sectors. Large multipliers also accrue to *food products and beverages*, *wood and products of wood* and *recreation, sporting and cultural services*. The high open multiplier for agriculture would indicate that the sector, at an aggregate level, tends to use a high proportion of intermediate inputs and that these inputs in turn are produced using a high proportion of other intermediate inputs. That is, agriculture uses for example fodder, fertilizers, machinery and equipment which are complex products that in turn require a high amount of intermediate inputs to produce. When agriculture stimulates these sectors they in turn will have to purchase intermediate inputs and this chain of events stimulates the economy. The purchases from service sectors such as financial or consultancy services will not, in the same way, create a “demand-pull” effect in the indirect analysis. Such sectors rest more on capital and labour for their production, and labour earnings will affect only the closed multiplier. At the same time the open multiplier indicates that agriculture probably utilizes a lower proportion of high paid labour, capital and imports.

Turning to the closed multiplier, this analysis can be strengthened as the value of 2.61 for agriculture is no longer the highest one among the aggregated sectors, although it is still a large multiplier. The closed multiplier indicates the potential to stimulate output given the assumption that wages increase as a sector grows and wages in turn are used for household final consumption. The somewhat lower multiplier (closed) for agriculture compared to for example *hotels and restaurants* and *public administration, defense, education and health* indicates primarily two things. First, an increase in final demand for agricultural products will have a small stimulation on induced effects through wages in the own sector. This is due to the fact that agriculture has a wage/output ratio around 25%, which is low compared to tertiary sectors in the economy. Secondly, at the same time, agriculture stimulates indirectly sectors in the secondary segment of the economy, sectors like *food and beverage* and *machinery and equipment*, which are mechanized in their production processes and also utilize less labour input than many of the tertiary sectors. Thus, induced effects from increased final demand in agriculture have a somewhat lower potential compared to some non-primary sectors of the economy. However, as agriculture stimulates a wide range of sectors the total effect is rather significant and agriculture should be recognized as having a large potential based on also the closed multiplier.

Trying to deepen the analysis somewhat we have simulated a shock to consider the impact of an increase in final demand corresponding to 10% of the output value of each sector or production line. In the methodology section we discussed the problem of double counting when multiplying multipliers to the corresponding output level. Trying to show the economic importance of a sector by claiming the amount of output or labour the sector gives rise to will overstate the total size of the economy because the sectors output in itself is greatly stimulated by other sectors from the outset. Dietzenbacher (2005) proposed to simply simulate a final demand shock based on a percentage of each sector's output value. This will allow the multipliers to operate in the demand- driven way for which they were constructed, while we are able to capture some of the size effects of the sectors. Hence, we multiplied each output multiplier (closed) with 10% of the sectors output value. This should be interpreted as the potential to stimulate further growth in the economy if the sector was to grow. What this shows us is that although agriculture has high potential to stimulate the economy, based on both open and closed multipliers, the size of the sector makes it unsuitable for any large scale labour market, or economic, stimulation packages. Many sectors with much lower multipliers are larger in economic terms and will boost the economy (in absolute terms) more if they were to grow. Having said this we should recognise the importance of agriculture in some regions and municipalities. In regions where agriculture employs more than 10% of the labour force, or has a major part in the total production value, stimulation of the sector could have large absolute effects as opposed to just multiplier induced potential.

**Table 9. Aggregated output multiplier analysis based on the aggregated IO for Sweden 2005**

(Product-product table)

| **Sector** | **Output Multipliers** | | **Impact of 10% increase in output (mil. SEK)[a]** |
|---|---|---|---|
| | **Open** | **Closed** | |
| Agriculture | 1.83 | 2.61 | 9 429 |
| Forestry; hunting; fisheries | 1.45 | 2.00 | 4 650 |
| Manufacture; construction work; mineral extr. | 1.65 | 2.32 | 400 464 |
| *Food products and beverages* | *1.89* | *2.69* | *31 660* |
| *Wood and products of wood* | *1.99* | *2.69* | *20 390* |
| *Machinery and equipment* | *1.67* | *2.40* | *41 360* |
| Energy and water supply; recycling | 1.54 | 2.03 | 21 102 |
| Trade; transports | 1.69 | 2.40 | 223 517 |
| Hotels and restaurants | 1.79 | 2.63 | 22 176 |
| Fin. services; real estate; business services | 1.56 | 2.29 | *310 485* |
| *Services to financial intermediation* | *1.66* | *2.87* | *3 589* |
| Public adm; defense; education; health | 1.60 | 2.71 | 242 317 |
| *Recreational, sporting and cultural services* | *1.83* | *2.63* | *22 8301* |

[a] Impact of an increase in final demand corresponding to 10% of the output value of each sector or production line.

### *6.3.2 Output multipliers, disaggregated analysis*

The major purpose of this study was to disaggregate the analysis of the agricultural sector into the most important livestock production lines and commodities. As has already been described we have proceeded with seven production lines and ten commodities. Table 10 indicates the multipliers and induced impact of a shock for our production lines and in a sense “breaks down” the analysis of Table 9. Multipliers give a different picture compared to the descriptive statistics of the agricultural sector. They offer a way to analyze the potential of different production lines based on more than merely production values and the number of firms. At the same time we should realize that the size of a certain production line limits the possibility to utilize a high multiplier; the size of the production line can for example show the prevailing demand for a product or the availability of resources to produce the product. At the same time a larger production line can also be subject to bottlenecks for capital, labour or other resources. Hence a potential possibility of growing as a result of final demand stimulation might be limited by the situation in and outside the production line.

Leaving this *caveat lector* behind we focus on the multipliers. Not surprisingly the *poultry and egg* production line displays the largest multiplier. This indicates that this production line is highly industrialized and uses a large proportion of compound intermediates in its production. Inspection of the disaggregated Use matrix indicates that this is true. The production line uses live animals, a high proportion of feed, fuels and energy of different kinds and construction work. Compared to other production lines in agriculture *poultry and egg* utilizes a larger proportion of purchased intermediate inputs in their production. Other high multipliers accrue to *mixed livestock, pig* and *cattle.* These livestock production lines also use more intermediate inputs in their production and hence would stimulate deliveries from e.g. feed producers if they were to grow. Relatively “low” multipliers are found for the *sheep*, *mixed farming* and *cereals* producers. This is explainable by the fact that these producers rely more on the “soil and sun” for output of their products. Notwithstanding the fact that this also holds for the other agricultural production processes, these production lines use less intermediate inputs and more free resources (sun) and capital resources (such as land). Cereal production uses mainly seed, machinery and equipment, construction, fertilizers and pesticides. A larger fraction of their inputs, notably chemicals, are also imported compared to some other production lines. Comparing sheep to some of the other livestock production lines it is noticeable how these use less feed (sheep are fed grass to a larger extent than e.g. milk cows and pigs), less veterinary services and less machinery and constructions.

Observing the closed multipliers we realize that these multipliers are somewhat skewed towards production lines that are more labour intensive. Based on figures from Statistics Sweden sheep production is a production line which uses up a very large fraction of their production value as labour input. Unless these labour inputs are unpaid this production line is able to stimulate the economy more than other agricultural production lines. That is, employees in this production line receive a wage which they can use for commodity consumption. Focusing on the more traditional production lines we see that mixed livestock have a high potential based on the closed multipliers. Together with the high multipliers of some of the other livestock production lines this presents a picture where labour intensive agricultural production is better at stimulating output in the rest of the economy, compared to cereals and arable based production lines. Lower values of the cattle production might be explained by the higher level of technical efficiency in this production line as compared to other livestock production. Whereas cattle is ranked fourth based on open multipliers it is only ranked sixth based on the closed model. Note also that *poultry and egg* has a lower relative closed multiplier compared to other production lines of the agricultural complex. This is due to the fact that poultry and egg has a low labour intensity compared to many of the other production lines. Increasing output (due to a final demand pull) in this production line will create large intermediate input increase but only a moderate induced effect due to low consumption stimuli.

**Table 10. Production line output multipliers from the disaggregated IO**

| Production line | Output Multipliers[a] | | Impact of 10% increase in output (mil. SEK)[b] |
|---|---|---|---|
| | Open | Closed | |
| Cattle | 1.88 (4) | 2.65 (6) | 3577 |
| Pig | 2.04 (3) | 2.92 (5) | 370 |
| Poultry and Egg | 2.26 (1) | 2.94 (4) | 480 |
| Sheep | 1.80 (5) | 3.55 (1) | 39 |
| Mixed livestock | 2.05 (2) | 3.31 (2) | 455 |
| Cereals | 1.72 (7) | 2.38 (7) | 3070 |
| Mixed farming | 1.78 (6) | 2.94 (3) | 1531 |

[a] Numbers in parenthesis indicate the internal ranking of multipliers.
[b] Impact of an increase in final demand corresponding to 10% of the output value of each sector or production line.

Trying to capture the size of the different production lines within agriculture we propose a decomposition of the Mattas-Shrestha output elasticity for the food and beverage sector. As explained earlier this elasticity measures the percentage output increase throughout the economy from a percentage increase in final demand of one sector. As many of the outputs from primary production are absorbed within the intermediate use matrix it is difficult to measure the impact of a change in final demand (i.e. household consumption, government consumption and exports). Therefore we have decomposed the elasticity of 0.044 for food and beverages into our seven production lines. It should be noted that other sectors in addition to our seven production lines also make up this total elasticity of 0.044, thus the elasticities in Table 11 only sum to 0.00297. These results are presented in Table 11 and they indicate that *cattle* is the most important production line taking size into consideration. The production value of the cattle production line (notably milk) is large in comparison to other agricultural outputs. Crop and cereal production follow in second place and mixed farming with a mix of milk, meat and cereal outputs follow third. This ranking shows that even though some of the smaller production lines show great potential in creating output, they are not as important in comparing impacts of production lines today. Notably sheep production shows almost no impact in creating output values based on a 1% increase in demand for food products. It might be interesting to compare these numbers with some other sectors. Within the food and beverages complex it can be noticed that the fish sector has an elasticity of 0.0004 which is similar to that of mixed farming. The elasticity of 0.044 for the food and beverages complex can be compared to for example 0.038 for pulp, paper and paper products, 0.033 for chemical products and 0.072 for motor vehicles.

**Table 11. Decomposed elasticity of a one percent final demand increase in the food and beverages sector**

| Production line | Decomposed elasticity of "food and beverages" sector (total 0.044)[a] |
|---|---|
| Cattle | 0.00166 (1) |
| Pig | 0.00015 (5) |
| Poultry and Egg | 0.00013 (6) |
| Sheep | 0.00002 (7) |
| Mixed livestock | 0.00022 (4) |
| Cereals | 0.00041 (2) |
| Mixed farming | 0.00038 (3) |

[a] Numbers in parenthesis indicate the internal ranking of values.

The final part of our output analysis focuses on the output effects of an increase in demand for certain commodities rather than production line, or farm type. Since agricultural firms produce a mix of outputs it is interesting to frame the IO analysis in terms of commodities rather than industries. Looking at the open multipliers in Table 12 we see that once again poultry and egg are the products with the largest potential. Other products with high multipliers are pigs, cattle, other animals and milk. Pig has a higher rank when analyzing products compared to farm types. This probably indicates that specialized pig farms still produce an output mix containing cereals, something that affects the output multiplier negatively for the farm type. Looking at only the commodity pig the ranking improve to second place, from third. Once again the closed multipliers confirm the picture that labour intensive commodities have a greater potential to stimulate output. Notably the service commodity as well as sheep shows low indirect potential but a large induced effect. Taking services as an example, this commodity is labour intensive since it includes farmers hiring out machinery with drivers etc. The scale effect can once again be seen to work in favor of milk. This commodity is, based on its production value and multiplier, best suited to stimulate the economy. Cereals, other crops, beef and pigs are other commodities that based on size and multipliers show potential.

**Table 12. Commodity output multipliers from the disaggregated IO**

| Commodity | Output Multipliers[a] Open | Closed | Impact of 10% increase in output (mil. SEK)[b] |
|---|---|---|---|
| Milk | 1.88 (3) | 2.77 (5) | 2647 |
| Beef | 1.87 (4) | 2.84 (4) | 1068 |
| Pig | 1.91 (2) | 2.54 (6) | 862 |
| Poultry and Egg | 2.20 (1) | 2.90 (2) | 530 |
| Sheep | 1.82 (6) | 3.10 (1) | 48 |
| Cereals | 1.52 (10) | 2.43 (8) | 1037 |
| Forage | 1.78 (7) | 2.26 (10) | 333 |
| Other crops (e.g. potato, sugar beets) | 1.78 (7) | 2.42 (9) | 1551 |
| Other animals | 1.85 (5) | 2.52 (7) | 560 |
| Services to agriculture | 1.78 (7) | 2.88 (3) | 870 |

[a] Numbers in parenthesis indicate the internal ranking of multipliers.
[b] Impact of an increase in final demand corresponding to 10% of the output value of each sector or production line.

### *6.3.3 Employment multipliers, aggregated analysis*

Often employment is a priority of national or regional development programs; therefore it might be necessary to interpret the potential of sectors or commodities in their ability to create jobs. Once again we begin by analyzing the agricultural sector in relation to the rest of the economy. To recapitulate the type 1 and 2 employment multipliers capture the number of jobs that will be created throughout the economy given a one person increase in the sector under study. Hence the type 2 multiplier is the direct, indirect and induced effect divided by the direct effect. Compared to the large multiplier for output for the agricultural sector we can see from Table 13 that agriculture has a much more moderate potential to create employment. This is partly due to the fact that agriculture has a rather high "physical labour coefficient", as measured as employees per output generated. This implies that each person employed within the sector creates a small output (value) compared to other sectors and hence the increase of one person will not stimulate the economy as much.

Investigating the non-agricultural sectors of the economy we see that public administration, which is labour intensive, seems to interact with sectors with low indirect and induced effects and hence show lower multipliers. Other sectors which can be assumed to be labour intensive e.g. trade, hotels, financial services seem to perform better and this might be explained by their ability to stimulate other sectors in society in consecutive indirect and induced rounds. Extremely high multipliers are found in energy and water supply, and this is certainly due to the low labour to output ratio which creates a large effect when studying weighted multipliers.

**Table 13. Employment multipliers from the Swedish IO from 2005**
(product-product table)

| Sector | Employment Multipliers | |
|---|---|---|
| | Type 1 | Type 2 |
| Agriculture | 1.47 | 1.89 |
| Forestry; hunting; fisheries | 1.29 | 1.65 |
| Manufacturing; construction work; mineral extraction | 1.86 | 2.74 |
| Energy and water supply; recycling | 2.31 | 3.69 |
| Trade; transports; hotel; restaurants | 2.16 | 3.34 |
| Financial services; real estate; business services; insurance | 1.94 | 2.90 |
| Public administration; defense; education; health; recreation | 1.40 | 2.01 |

### *6.3.4 Employment multipliers, disaggregated analysis*

Analyzing the employment multipliers of the disaggregated agricultural system we must remember that these measure the potential of a production line to stimulate employment throughout the entire economy based on an increase in labour in the production line we study. This means that we use the creation of one employment position in the production line as a basis for our analysis. Production lines which have a low ratio of employment per output will hence stimulate considerable output based on this person. For example, *poultry and egg* has a relatively low "physical labour coefficient", as measured as employees per output generated, and the production line has the highest type 1 and 2 employment multipliers. Hence this production line has high multipliers for two reasons. First, the type 1 and 2 multipliers are measured as employment in the rest of the economy originating from one more person employed in the production line under study. One more person in *poultry and egg* will stimulate output (due to the low physical labour coefficient) and hence this increase will stimulate other sectors in the economy. Secondly, as evident from the output multipliers, the production line uses a large fraction of intermediate inputs from other firms.

Other production lines with high multipliers include pig, cattle and cereals. These are production lines that produce a high output based on number of persons employed and that interact with other sectors of the economy in such a way that they stimulate indirect and induced effects. The fact that pig production has higher potential compared to cattle and cereals is related to the fact that the production line stimulates more intermediate demand if it were to grow (see Table 10) and this production within the economy will stimulate employment in those sectors. Turning to the demand-driven employment multipliers, the employment created throughout the economy from a one million increase in final demand in one sector, we see that the ranking in this case depends on both the labour intensity in the sectors, the output multipliers and the labour intensity of the sectors with which the individual sectors interact. Hence sheep has a high multiplier due to its own labour intensity whereas mixed livestock, mixed farming, pig and cattle rather have high multipliers due to a mix of the above-mentioned drivers. The fact that poultry and egg has a low impact in generating employment due to increases in output is explained by the limited direct effect (low employment generated in the own production) and the limited induced effect. We saw from the output analysis that poultry and egg does have high type 1 multipliers whereas the type 2 multipliers were somewhat less prominent. Hence the limited direct employment effect is transmitted through a large indirect effect and a lower induced effect, to create a value of 1.88 persons per million SEK.

**Table 14. Employment multipliers for the production lines of the disaggregated model**

| Production line | Employment Multipliers[a] Type 1 | Type 2 | Employment generated throughout the economy per million SEK increase in final demand (closed model)[a] |
|---|---|---|---|
| Cattle | 1.59 (3) | 2.07 (3) | 2.32 (5) |
| Pig | 1.65 (2) | 2.15 (2) | 2.63 (4) |
| Poultry and Egg | 2.55 (1) | 3.41 (1) | 1.88 (7) |
| Sheep | 1.15 (7) | 1.37 (7) | 7.60 (1) |
| Mixed livestock | 1.37 (5) | 1.75 (5) | 4.04 (2) |
| Cereals | 1.49 (4) | 1.94 (4) | 1.98 (6) |
| Mixed farming | 1.25 (6) | 1.59 (6) | 3.79 (3) |

[a] Numbers in parenthesis indicate the internal ranking of multipliers and employment generated.

As for the output effects we can disaggregate the employment effect based on commodities rather than farm types. This allows us to analyze the specific characteristics of products rather than farm types which even though they are specialized produce a mix of products. We see that once again the results are affected by the fact that forage in this case has a low employment per output ratio, indicating that one more person producing would produce a large output and hence stimulate employment in the rest of the economy. Focusing on more traditional commodities we conclude that one more person producing poultry and egg, pigs, other animals, and other plants would generate more total economy employment compared to if these persons were employed in producing agricultural services, sheep or cereals. This picture does not change if induced effects are taken into consideration. Noticeably the output multiplier for services increased in ranking when induced effects were taken into consideration whereas the employment multiplier does not. First of all the low ranking of the commodity is explained by the fact that the output is employment intensive; it will create much employment on an output basis but not on an employment basis. Including induced effects we realized that this production line grows in importance when we analyzed output potential since it uses sectors which considerably stimulated output, e.g. machinery and equipment. These production lines do not seem to have a high employment-creating potential and hence services have a low type 2 multiplier.

Once again we refer to the employment per output multipliers, i.e. multipliers that show how much employment one unit of new final demand in a sector creates throughout the economy. These figures shows a somewhat different picture since commodities with a larger employment share might be able to create a larger, primarily direct and induced, effect. That is, if we assume size does not matter the sectors with a large fraction of employment to output will benefit from a large direct employment effect. The indirect and induced effects might have less of an impact on sector ranking in that case.

**Table 15. Employment multipliers for commodities of the disaggregated model**

| Commodity | Employment Multipliers[a] Type 1 | Type 2 | Employment generated throughout the economy per million SEK increase in final demand (closed)[a] |
|---|---|---|---|
| Milk | 1.48 (6) | 1.90 (6) | 2.87 (6) |
| Beef | 1.41 (7) | 1.78 (7) | 3.17 (3) |
| Pig | 1.92 (3) | 2.50 (3) | 1.90 (9) |
| Poultry and Egg | 2.12 (2) | 2.78 (2) | 2.06 (7) |
| Sheep | 1.15 (9) | 1.30 (10) | 7.50 (1) |
| Cereals | 1.14 (10) | 1.43 (9) | 3.14 (4) |
| Forage | 2.18 (1) | 2.88 (1) | 1.38 (10) |
| Other crops (e.g. potato, sugar beats) | 1.61 (5) | 2.07 (5) | 2.97 (5) |
| Other animals | 1.78 (4) | 2.31 (4) | 2.06 (7) |
| Services to agriculture | 1.24 (8) | 1.56 (8) | 3.75 (2) |

[a] Numbers in parenthesis indicate the internal ranking of multipliers and employment generated.

### *6.3.5 Income multipliers, aggregated analysis*

Finally we turn to the income generating potential of the production lines. The interpretation of the income multipliers is similar to that of the employment multipliers. The income multipliers show the indirect effect, and for type 2 also the induced effect, throughout the economy of a one unit income increase in the sector. As the income multipliers are, overall, similarly ranked in the same way as the employment multipliers, we do not see any surprising results in Table 16. Agriculture performs relatively poorly in generating overall income compared to other sectors.

**Table 16. Income multipliers from the aggregated national IO table**

| Sector | Income Multipliers Type 1 | Type 2 |
|---|---|---|
| Agriculture | 1.73 | 2.45 |
| Forestry; hunting; fisheries | 1.58 | 2.23 |
| Manufacturing; construction work; mineral extraction | 1.79 | 2.55 |
| Energy and water supply; recycling | 1.91 | 2.71 |
| Trade; transports; hotel; restaurants | 1.79 | 2.54 |
| Financial services; real estate; business services; insurance | 1.94 | 2.74 |
| Public administration; defense; education; health; recreation | 1.46 | 2.07 |

### 6.3.6 Income multipliers, disaggregated analysis

As for employment, investigating multipliers based on final demand stimulation presents a somewhat different picture compared to type 1 and 2 multipliers. Once again, the production lines with higher direct wages per output effects perform better together with production lines with larger type 2 output multipliers. The fact that some of the income multipliers are below one only indicates that much of the stimulation is caught in the intermediate transactions of production lines and does not, to the same extent as for production lines with higher values, transmit into income. It is interesting to note that the model predicts stimulation above one for three of the industries.

**Table 17. Income multipliers for the production lines of the disaggregated model**

| Production line | Income Multipliers[a] | | Income generated throughout the economy per SEK increase in final demand (closed)[a] |
|---|---|---|---|
| | Type 1 | Type 2 | |
| Cattle | 1.98 (3) | 2.80 (3) | 0.64 (5) |
| Pig | 2.05 (2) | 2.91 (2) | 0.73 (4) |
| Poultry and Egg | 3.52 (1) | 4.98 (1) | 0.56 (6) |
| Sheep | 1.30 (7) | 1.84 (7) | 1.46 (1) |
| Mixed livestock | 1.57 (5) | 2.22 (5) | 1.05 (2) |
| Cereals | 1.85 (4) | 2.61 (4) | 0.55 (7) |
| Mixed farming | 1.41 (6) | 2.00 (6) | 0.97 (3) |

[a] Numbers in parenthesis indicate the internal ranking of multipliers and income generated.

The commodity-based analysis shows that cereals have a small potential in creating income throughout the economy. It is interesting to notice both in the employment analysis and in the income analysis that cereal *farms* tend to be labour and income extensive whereas the actual *commodity* cereals are defined as labour and income intensive. The fact that it is income intensive, together with the fact that it does have a low output multiplier, indicates that it has a low potential in creating income if we measure income in terms of income generated per unit of extra income in the sector. This means that cereals as a product does not need to create as much output, which stimulates the rest of the economy, to be able to generate one more SEK of income to the labour of the commodity. This is captured by looking at the income generated throughout the economy from an increase in final demand; cereals will due to their income generating abilities have strong direct effects. These direct effects are transmitted through a somewhat lower multiplier into a value of 0.75 which is in fourth place. With stronger indirect effects the commodity would have performed even better. As it is, commodities with strong type 2 output multipliers perform well due to strong direct and induced effects.

**Table 18. Income multipliers for the commodities of the disaggregated model**

| Commodity | Income Multipliers[a] Type 1 | Type 2 | Income generated throughout the economy per SEK increase in final demand[a] |
|---|---|---|---|
| Milk | 1.82 (6) | 2.58 (6) | 0.74 (5) |
| Beef | 1.69 (7) | 2.38 (7) | 0.80 (3) |
| Pig | 2.58 (3) | 3.64 (3) | 0.53 (8) |
| Poultry and Egg | 2.93 (2) | 4.14 (2) | 0.58 (6) |
| Sheep | 1.43 (9) | 2.02 (8) | 1.07 (1) |
| Cereals | 1.28 (10) | 1.82 (10) | 0.75 (4) |
| Forage | 3.11 (1) | 4.39 (1) | 0.40 (10) |
| Other crops (e.g. potato, sugar beets) | 2.08 (5) | 2.95 (5) | 0.53 (8) |
| Other animals | 2.32 (4) | 3.29 (4) | 0.56 (7) |
| Services to agriculture | 1.42 (8) | 2.01 (9) | 0.92 (2) |

[a] Numbers in parenthesis indicate the internal ranking of multipliers and income generated.

# 7. Conclusion

The aim of this study has been twofold. First we wanted to investigate the role of agriculture in the Swedish economy by taking multiplier effects into consideration. Second we wanted to investigate the direct, indirect and induced effects of separate livestock production lines on the Swedish economy in relation to cereals and other agricultural production lines. In particular, we were interested in the roles of the production lines cattle (milk and beef), swine, poultry, sheep, mixed livestock, cereal production and mixed farm production.

To attain this goal we have used the input-output model to analyze the interlinkages between sectors, as well as the potentials, of the various sectors in the economy. Another approach which can be used to model interlikages between sectors is the computable general equilibrium (CGE) approach (e.g. Ahmmad, 2002).

The IO model, like other models of reality, suffers from some theoretical shortcomings. First of all it is based on the Leontief production function which assumes linearity in the use of all input factors. The production process is also assumed to exhibit constant returns to scale and no lack of capacity. However, in the longer run, we argue that these two assumptions hold because over time the economy will adjust to the optimal scale. More serious is the assumption of no substitutability implied by the model; this must be taken into consideration when analyzing larger shocks to the system. Finally, we should emphasize that the analysis does not take externalities into consideration, but that the use of damaging inputs can be explicitly analyzed and other emissions attached to the analysis.

A further assumption of the IO model is the homogeneity of the products produced by different production lines. Working with the Use and Make structure of the system however, we have been able to explicitly take into consideration the way in which different farm types diversify in their production. That is, we have been able to model how a certain farm type produces a mix of animals, cereals and other outputs. Based on this specification of the system we have also been able to consider both farm types and commodities in the consecutive analysis.

Assessing agriculture in Sweden based on aggregated input-output data and disaggregated descriptive statistics a picture emerges of a sector with large potential to stimulate output throughout the economy, but where each person employed has limited impacts in creating employment and income elsewhere in the economy. That is, compared to other sectors, agriculture has high output multipliers, whereas type 1 and 2 employment and income multipliers are more moderate. The disaggregated descriptive data present a picture of a dominant cattle and cereal production. Cattle, both milk and meat, show strong product values and together create more production value than cereals. Pig production, poultry and egg, and sheep are all marginalized compared to these two larger production lines.

Disaggregating the Swedish input-output table with respect to agricultural farm types and commodities allow us to refine this analysis in at least two ways. First of all, it allows us to analyze the intermediate input use and the production of agricultural commodities of the different production lines in the disaggregated table. We can use the table to study what inputs different farm types use and we can observe the contributions of mixed livestock farms, mixed farms and the more specialized farm types in producing milk, cattle, pig, cereals etc. From this analysis it is evident, for example, that poultry and egg production utilizes more resources within the transactions table whereas other farm types are more balanced in their use of intermediate and final inputs. Naturally livestock producers are more intensive in their input use of feed, labour and construction whereas cereal producers are more intensive using seed, machinery, equipment, chemicals and agricultural services. We can also, without using the tables as a "model", say something about the various deliveries from the agricultural sector to down-stream producers and consumers. All farm types and commodity groups supply the majority of their output to the food and beverages complex (except agricultural services and seed) whereas cereal producers to a larger extent interact with restaurants, hotels, recreational activities and final consumers. Moreover poultry and egg (with egg being dominant) show these linkages to hotels, restaurants and final consumption.

Secondly, using the input-output table as a model we can analyze the various interlinkages in the economy in forms of multipliers and elasticities. Some of the more marginalized production lines and commodities show strong potentials to create output throughout the economy if they were to expand production. This is interesting in relation to the change in production values taking place between 2000 and 2006, where this is in fact the only production line growing. Investigating the linkages between the agricultural production lines and the food and beverages sector it is easy to conclude that the production lines contributing the most to any growth in economic activity due to general consumption increase are milk, beef and cereals. This is due to the dominant size of these production lines in relation to their output multipliers. Hence smaller production lines might have potential to create output, employment and income but the size effect is still in favor of the larger production lines.

Trying to capture the relative importance of the production lines today we have developed a method to disaggregate the farm production lines linkages with food and beverages. Based on the method developed by Mattas and Shrestha (1991) we have realized that it is inappropriate to analyze the agricultural complex based on final demand. The reason for this is the limited information available in the final demand component of the table regarding agriculture. Because almost all production developed in agriculture is delivered to food and beverage producers, tracing the links between final demand for food and beverages back to agriculture would be more appropriate. Therefore we have suggested using the approach of disaggregating the elasticities making up the elasticity for food and beverages, assigning the relative indicators to agricultural production lines. This analysis showed the relative importance of milk, beef and cereals.

Examining the employment and income potential of agriculture we conclude that poultry and egg, which had high output multipliers, shows less of a potential to stimulate employment if output were to grow. This is due to the organization of production. Turning this argument around, one more person employed in this production line could create much output and hence considerably stimulate employment. The effect of the "shock" is hence in the framing of sector expansion. This is true for all of the agricultural production lines as evident from the analysis of the previous section.

Finally we would like to stress possible applications for future research within the disaggregated IO analysis of agriculture. First of all it would be interesting to disaggregate the analysis to appropriate geographical units of Sweden. Such an analysis can be used to assess agricultural policy reforms, rural development strategies or the economic importance of regional production systems. Secondly, a combined efficiency (e.g. Coelli et al., 2005) and input-output analysis would increase our understanding of agriculture's potential if all production units were as efficient as the best ones. In relation to efficiency and IO it would be interesting to study the impacts of structural change, diversification and new output mixes. Third, it would also be interesting to extend the analysis by decomposing not only the agricultural sector, but also the food-and-beverage complex into its different parts. Finally, using IO as a tool together with exogenous information about positive and negative externalities (that is amenities, nitrogen or carbon emissions) we could assess the environmental sustainability of agricultural production lines. By applying the gross table, rather than the net table used in this study, emissions arising from internal production of intermediate production inputs could be accounted for. Using employment data on gender and age we could extend the concept of sustainability to include social sustainability. All components of sustainability (economic, environmental and social) would then be covered.

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## Appendix 1: Excerpt of the Use matrix

| **Commodity/Farm type** | Cattle | Pig | Poultry and Egg | Sheep | Mixed livestock | Cereals | Mixed farming |
|---|---|---|---|---|---|---|---|
| Milk | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Beef | 0.008 | 0.000 | 0.000 | 0.000 | 0.004 | 0.000 | 0.006 |
| Pig | 0.000 | 0.045 | 0.000 | 0.000 | 0.074 | 0.007 | 0.023 |
| Poultry and Egg | 0.000 | 0.000 | 0.182 | 0.000 | 0.001 | 0.001 | 0.001 |
| Sheep | 0.000 | 0.000 | 0.000 | 0.067 | 0.000 | 0.000 | 0.001 |
| Seed | 0.011 | 0.009 | 0.008 | 0.008 | 0.015 | 0.051 | 0.028 |
| Cereals | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Forage | 0.006 | 0.000 | 0.000 | 0.000 | 0.003 | 0.000 | 0.003 |
| Other (potato/sugar) | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Other animals | 0.001 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 |
| service AG | 0.073 | 0.052 | 0.004 | 0.023 | 0.066 | 0.026 | 0.045 |
| C02 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C05 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C10 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 |
| C13 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |
| C15 | 0.119 | 0.217 | 0.227 | 0.081 | 0.148 | 0.006 | 0.051 |
| C17 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C18 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C19 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C20 | 0.004 | 0.003 | 0.000 | 0.019 | 0.002 | 0.000 | 0.001 |
| C21 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C22 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| C23 | 0.023 | 0.014 | 0.023 | 0.013 | 0.028 | 0.058 | 0.031 |
| C24 | 0.007 | 0.004 | 0.004 | 0.004 | 0.009 | 0.027 | 0.014 |
| C25 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C26 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 |
| C27 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| C28 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| C29 | 0.016 | 0.008 | 0.007 | 0.007 | 0.017 | 0.023 | 0.019 |
| C30 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C31 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C33 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C34 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| C35 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C36 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C37 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C40 | 0.033 | 0.038 | 0.017 | 0.028 | 0.034 | 0.037 | 0.032 |
| C41 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C45 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 | 0.030 |
| C50 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 | 0.072 |
| C55 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| C60 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |
| C61 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C62 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C63 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 | 0.006 |
| C64 | 0.008 | 0.006 | 0.010 | 0.010 | 0.006 | 0.013 | 0.010 |
| C65 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 |
| C66 | 0.028 | 0.019 | 0.030 | 0.030 | 0.025 | 0.038 | 0.030 |
| C67 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |

| | Cattle | Pig | Poultry and Egg | Sheep | Mixed livestock | Cereals | Mixed farming |
|---|---|---|---|---|---|---|---|
| C70 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C71 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 | 0.003 |
| C72 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C73 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 | 0.013 |
| C75 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 | 0.004 |
| C80 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C85 | 0.014 | 0.014 | 0.000 | 0.010 | 0.010 | 0.000 | 0.004 |
| C90 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C91 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 | 0.001 |
| C92 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| C93 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## Appendix 2: Key to sector codes

| SNI code | name |
|---|---|
| **01** | Products of agriculture, hunting and related services |
| **02** | Products of forestry, logging and related services |
| **05** | Fish and other fishing products; services incidental of fishing |
| **10** | Coal and lignite; peat |
| **13-14** | Metal ores and other mining and quarrying products |
| **15-16** | Food products, beverages and tobacco products |
| **17** | Textiles |
| **18** | Wearing apparel; furs |
| **19** | Leather and leather products |
| **20** | Wood and products of wood and cork (except furniture); articles of straw and plaiting materials |
| **21** | Pulp, paper and paper products |
| **22** | Printed matter and recorded media |
| **23** | Coke, refined petroleum products and nuclear fuels |
| **24** | Chemicals, chemical products and man-made fibers |
| **25** | Rubber and plastic products |
| **26** | Other non-metallic mineral products |
| **27** | Basic metals |
| **28** | Fabricated metal products, except machinery and equipment |
| **29** | Machinery and equipment |
| **30** | Office machinery and computers |
| **31** | Electrical machinery and apparatus / Radio, television and communication equipment and apparatus |
| **33** | Medical, precision and optical instruments, watches and clocks |
| **34** | Motor vehicles, trailers and semi-trailers |
| **35** | Other transport equipment |
| **36** | Furniture; other manufactured goods n.e.c. |
| **37** | Secondary raw materials |
| **40** | Electrical energy, gas, steam and hot water |
| **41** | Collected and purified water, distribution services of water |
| **45** | Construction work |
| **50-52** | Trade |
| **55** | Hotel and restaurant services |
| **60** | Land transport; transport via pipeline services |
| **61** | Water transport services |
| **62** | Air transport services |
| **63** | Supporting and auxiliary transport services; travel agency services |
| **64** | Post and telecommunication services |
| **65** | Financial intermediation services, except insurance and pension funding services |
| **66** | Insurance and pension funding services, except compulsory social security services |
| **67** | Services auxiliary to financial intermediation |
| **70** | Real estate services |
| **71** | Renting services of machinery and equipment without operator and of personal and household goods |
| **72** | Computer and related services |
| **73** | Research and development services / Other business services |
| **75** | Public administration and defense services; compulsory social security services |
| **80** | Education services |
| **85** | Health and social work services |
| **90** | Sewage and refuse disposal services, sanitation and similar services |
| **91** | Membership organization services. |
| **92** | Recreational, cultural and sporting services |
| **93** | Other services |

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