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# Integration of Supply and Use Tables and Symmetrical Input-output Tables in the Danish National Accounts

***by***

***Peter Rørmose***

***Statistics Denmark***

***E-mail: prj@dst.dk***

## 1. Introduction

Supply and use tables (SUT) are a very important part of the Danish National Accounts. In fact, the Danish National Accounts are based on SUT. Large amounts of primary data are adapted to fit into the SUT framework and when the tables are balanced a number of the most important macroeconomic aggregates like e.g. GDP etc. can be derived directly from the SUT. This relates to all the aggregates in the "Goods and Services Account" and the "Production Account". This is in contrast to a procedure where SUT are compiled after the production of the national Accounts, which implies a number of restrictions on the SUT totals.

The input-output tables can be calculated easily on the basis of these SUT with only a few additional assumptions. Thus, the macroeconomic aggregates mentioned above become can be found in the input-output tables as well, and there is always full consistency between the National Accounts and the input-output tables. As the SUT are calculated annually as the basis of the National Accounts annual input-output tables are calculated quite easily annually as well.

The integration of the SUT and the input-output tables in the compilation of the National Accounts is found by Statistics Denmark to be the only way to secure a high quality series of input-output tables. When such emphasis is put on the compilation of SUT, as is the case in Denmark, the input-output tables that can be derived subsequently can gain a lot of confidence from the users. They can be sure that the principle of objectivity in the collection of data and in the compilation of tables has been adhered to. Thus if the National Accounts are compiled with professionalism in statistical approaches and practices and there is a high degree of transparency about it, then there should be confidence that the same qualities have been transmitted to the input-output tables because of the close integration of the two. The quality framework for official statistics that is being adopted worldwide these years should apply to input-output tables as well as they are becoming part of official statistics. The way National Accounts and input-output tables are integrated in Denmark through SUT secures the required quality of the input-output tables.

In the step between SUT and Symmetrical Input-Output Tables (SIOT) some assumptions are needed. The choice of assumption has been discussed in many papers but as pointed out recently by some authors e.g. Thage(2005) it is not a question of choosing between two different technology assumptions, but choosing between a technology assumption or a market share assumption. In the paper by Thage and also in this paper it is argued that the best (only) choice is the market share assumption if the aim is a SIOT that adheres to the quality framework of official statistics being adopted by various countries around the world and international institutions these years.

It is important to realize that the detailed content of the input-output tables is created in the process of balancing the commodity flows and the production accounts. Apart from a couple of minor weak assumptions, the subsequent compilation of the input-output tables is just a matter of presenting these data in a more accessible form with as little loss of information as possible. So since the SUT are such an important part of the National Accounts and the input-output tables the part about SUT has been allotted much space in this paper.

# 2. Supply and use tables in the Danish National Accounts

## 2.1. Concepts and advantages

The calculation of SUT's is a totally integrated part of the annual compilation of the National Accounts at Statistics Denmark. It has been the case since the current system of Supply and Use tables was established in the mid-seventies.

The supply and use tables are directly linked to the first three accounts in the accounts system:

- Goods and services
- Production account
- Generation of income account

The supply and use tables are a two-dimensional break-down of these accounts, the two dimensions being products on the one hand and industries and final demand components on the other hand. At Statistics Denmark it has been concluded that the best measurement of GDP and thus the best National Accounts is compiled when GDP is measured in at least two of the three different ways it can be measured (production method, the use method or the income method). The different methods are based upon different sources, so the main advantage is that these sources are cross-checked against each other. A systematic confrontation of the various primary statistical sources at a detailed level leads to a higher degree of confidentiality in the data. One example could be consumption of food in the households based on three different measures

- Consumer surveys adjusted for tourist expenditures in Denmark
- Retail sales of food adjusted for production for own use
- Total production of food, plus import of food, minus intermediate consumption of food, minus changes in stock minus exports.

The three different measurement methods will yield the same result only by coincidence. In the process of balancing it is very useful to have three different sources and the result will clearly be more solidly based than a result based on only one source. Naturally these arguments are based on a clear independency between the three sources. The initial difference between GDP from the production side and GDP from the use side is equivalent to the difference between the total supply and total demand. It is the conviction of Statistics Denmark that the most systematic way to do this balancing is to do it product by product at a rather detailed level. Once all the products are brought to balance through adjustments in the initial estimates of supply (domestic production and imports) and use (intermediate consumption and final demands) supply and use also balances at the aggregate level and thus $GDP_{production}$ and $GDP_{use}$ are equal. This is also called the commodity-flow method. It implies that detailed supply and use tables are compiled every year as an integrated part of the production of the national accounts. Moreover, it implies that symmetrical input-output tables can be compiled quite easily every year and not only in certain benchmark years.

The primary advantages of using the detailed commodity flow method have been summarized in the following 5 points

1. *Utilization of knowledge about differences between supply and use of products at a very detailed level can improve balancing of supply and use at the aggregated level.*

Thus, if an initial imbalance between $GDP_{production}$ and $GDP_{use}$ is found, it is hard to know where to look for the source of the imbalance and which initial estimate to modify, if the balancing takes place at an aggregated level.

2. *Utilization of knowledge about technical aspects of single products*
   Many products are used solely for specific purposes and by virtue of their specific technical characteristics. Knowledge about the domestic supply of such products can be used as a control of various ratios like input percentage (intermediate consumption in relation to production) or cost structures (technical coefficients) measured through business statistics. Thus, as an example a survey in the building industry might have contributed to a good knowledge about input of cement in the building industry in relation to the production value. Then, if in the balancing process it turns out that the supply of cement differ considerably from what is expected on the basis of the production value and the well known input percentage it might be necessary to adjust the initial estimates of supply of cement. Thus, knowledge about technical aspects of a certain product might help to reveal a statistical problem that might not have been discovered otherwise.

3. *Filling of holes due to lack of primary statistics*
   Most countries do have some smaller or bigger holes in their primary statistics. No matter at what level national accounts are balanced these holes must be taken into account. In a much aggregated system it is necessary to adjust the aggregated variables directly, whereas in a disaggregated system accounting identities combined with the some information on the products involved often enables sound calculations in the absence of primary statistics.

4. *Ideal basis for calculation of price and quantity indices*
   The detailed supply and use tables gives the appropriate weights to be used in the calculation of fixed price tables, and thus also the main aggregates of the national accounts.

5. *Strong basis for calculation of preliminary figures for the most recent years and quarterly accounts*
   The structural relationships inherent in the supply and use tables are valuable in the calculation of the preliminary and quarterly accounts. In the absence of supply and use tables these figures are often based on indicators instead of solid statistical information.

## 2.2. Basic design of a National Accounts system based on SUT

It is the experience of Statistics Denmark that a statistical system capable of producing sufficiently detailed supply and use tables should consist of the following elements

1. Definition of the list of products to be included in the system using the product nomenclature
2. Construction and annual maintenance of a key between on the one hand the nomenclature used for domestic production statistics and foreign trade statistics and on the other hand the products in the system.
3. Product statistics (production divided into products) for the main part of the industries
4. Foreign trade statistics for goods and preferably also services
5. For industries not covered by product statistics there should be a key between this industry and the products in the supply and use tables.

6. Business statistics or registers giving information about input shares (intermediate consumption in relation to production)
7. Surveys of cost structures or input structures that enables splitting intermediate consumption into actual products
8. Various sources that facilitates a splitting of final demand categories (consumption, exports etc.) into products

The first two points are crucial for the system in order to measure total supply of products as a sum of domestic production and imports. The question of data on products will be elaborated further below. The rest of the points are more or less necessary in the compilation of a benchmark year, but some of them are not totally necessary to have every year once the system is op and running. But the more frequent and the more detailed the surveys are the better. In years without these surveys the structures from the previous year are used and possibly slightly adapted in the balancing process.

**Necessary primary statistics**

The statistical unit used in the compilation of supply and use tables is the "local kind-of-activity unit". Ideally production statistics and surveys of cost structures should be made for every industry defined as an aggregation of local kind-of-activity units. In practice the statistical unit will often be the firm which is a larger and more heterogeneous unit than the local kind-of-activity unit. A commodity-flow system does not require statistics for all local kind-of-activity units, but it is a fact that the more homogeneous the industries are the better supply and use tables can be compiled both as a framework for balancing the national accounts and for input-output analyses. Therefore emphasis should be put on the effort to segregate trade and building activities carried out as secondary activities in other industries and then to put together all trade activities and building activities in "clean" separate industries. The reason is that that these secondary activities are quite considerable in size and that their input structure differs quite substantially from the input structure in the primary activities in those industries where they originate from. There is trade activity as secondary activity in many industries even when the statistical unit is the local kind-of-activity unit.

This paper will not go through all the major sources of data for the Danish national Accounts. However, it should be mentioned that there is a lot of work being done to transfer data from the many different sources of business statistics, general government statistics, and financial institutions etc. to comply with the definitions and the categorisations of the National Accounts. After processing all the accounting statistics they are transferred to the common accounting plan used in the so-called "Intermediate System" to comply with the ESA 95 definition of statistical units in the National Accounts. However, this is not enough transformation.

In "Intermediate System 2" a number of further corrections are being made to the first version of the system. On the supply side it includes among other things corrections for hidden economy, revenues from licenses and royalties and software produced on own-account. On the use side it comprises among other things FISIM, purchased software, public fees, corrections for insurance premiums etc.

**Benchmark years and current years**

When building a commodity-flow system from the bottom one of the biggest challenges is the determination of the first input structure and the first structure of trade and transport margins. It

requires a mobilisation of all available surveys of structures and consumption and investment surveys. If there is nothing available for some areas it will be possible to use structures from similar industries, structures from the same industry in other countries or just common sense.

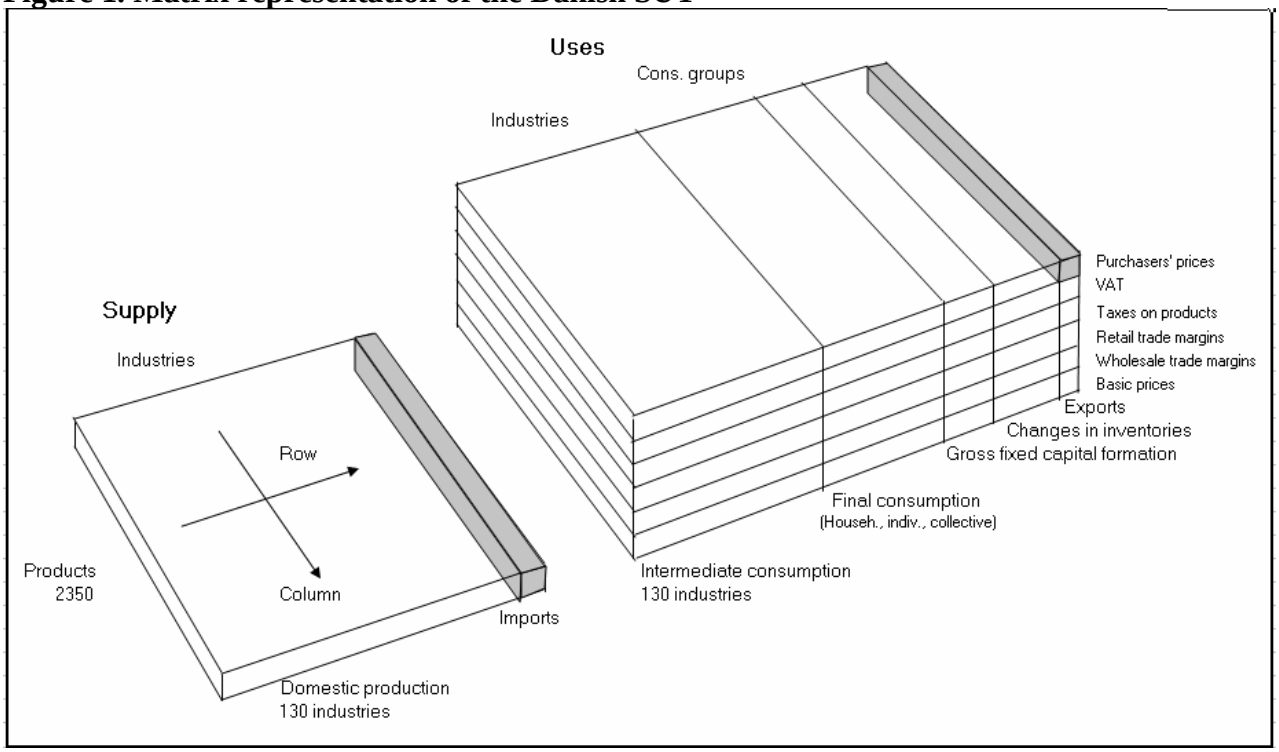
For the current year the best strategy normally is to use as a starting point the input structure and the distribution by product of final demand categories in fixed prices from the previous year. Then the known structure can be modified with new findings from new surveys etc. This will be described in more detail later.

### 2.3. The Danish SUT

The Danish SUT are built up and stored in plain ASCII text files. Historically software for handling these data have been written in third generation languages like Cobol, Fortran and Pascal. These days, applications for handling the preparation of data have been rewritten in SAS®. But still a lot of home made applications mostly in Pascal are being used for taking "intelligent" decisions in various parts of the compilation and for the automatic part of the balancing process.

As a tool in the manual balancing process and as a general tool for viewing and extracting data for the basic SUT text file, a large system of Visual Basic macros have been written for Microsoft Excel. It works together with the Pascal programmes to import, export and sort data and also to do calculations. As a typical Danish SUT text file has about 50,000 records it is important to have fast software for dealing with it, because in certain periods the programmes are executed hundreds of times each day. The principles of the Danish SUT are illustrated in the following figure

**Figure 1. Matrix representation of the Danish SUT**




The figure shows how all the 2350 products in the Danish SUT at the moment are supplied to the economy partly as domestic production and partly as import. On the right hand side it shows how

these products are being used for various purposes like intermediate consumption and final demand. Products are shown as rows and categories of use are shown as columns. When something is referred to in the remaining of this paper as a row or column it comprises all the layers in the stack of matrices.

Notice that the bottom layer of the figure is the supply as well as the use in basic prices. On the use side of the figure the different value layers are built upon the basic prices ending with the purchasers prices as the top level. In between are layers for trade and transport margins as well as net taxes on products and VAT. This is made to "visualize" the transformation from basic prices to purchaser's prices for each single cell on the use side. In the balanced SUT supply and use must balance at the basic price level. Here is a special case, however, with the trade and transport margins. At the supply side they are shown as output of trade and transport industries, but at the use side they are left out at the basic price level and "lifted" up into the margin matrices where they are distributed in accordance with the basic values to which they are related. In the figure the wholesale trade margin layer also comprises the transport margins.

The rows and the columns of the SUT can be further elaborated on the following points

- About 1950 goods and about 400 services makes the 2350 products that is the current level in the Danish SUT. All the 4 digit Harmonised System (HS) goods are represented and some are subdivided into 6 digit HS groups. Important work is done every year to keep the list of products updated with the changes in the HS. There is a key linking each of the National Accounts products to CPA. The services are categorized according to the CPA nomenclature. When the HS is changed it may be possible to aggregate some of the products in the system in order to maintain the time series intact all the way back to 1966.
- The number of columns of industries for domestic production is 130. Those 130 activity groups are based on the official Danish nomenclature for activities which is linked directly to NACE and ISIC. It is based on establishment units or "local-kind-of activity units". But in a few cases it has been found to be important to have more homogenous industries defined by its activity. This applies to agricultural production, construction, trade and motor vehicle repair. Thus all trading activity is combined into trade industries regardless of the industry in which the activity is classified in the primary statistics.
- Import is just one column. In the transformation of SUT to Symmetrical Input-Output Tables (SIOT) it is expanded as described later.
- The 72 columns of private consumption are classified according to COICOP. NPISH forms a separate group.
- Government consumption, gross fixed capital formation and inventory changes are divided into a number of subgroups.
- Export is for reasons of deflation divided into two groups. Ordinary export and re-export.

### 2.4. The balancing process

The balancing includes at lot of work at various stages, but the process can summarized as the following six points

1. Compilation of the current years SUT product nomenclature, which determines the number of products in the system in the current year
2. The Intermediate Systems 1 + 2 must be worked up and target totals compiled

3. Compilation of predetermined values
4. Initial automatic balancing
5. Manual balancing
6. Final balancing

2) When SUT is to be compiled for a new year the best of all situations would be if new data could fill all cells. However, as mentioned before it will be necessary to exploit the structures of the previous year's tables to fill some of the cells not covered with new data. But the first step should always be to collect new target totals and as much of the other values as possible.

The so-called "Target Total Module" draws on the Intermediate System 2 and a number of other systems and comes up with the following list of target totals, where ANVID corresponds to transaction codes

| ANVID | |
|---|---|
| 1010 | Domestic turnover (= P.1 Output) |
| 1020 | Imports of goods and services (=P.7) |
| 1021<br>1022<br>1023 | Customs and duties on imports (=D.212) |
| 2010 | Intermediate consumption (=P.2) |
| 2030 | Household final consumption expenditure (P.31) |
| 2041 | Government individual consumption expenditure, market (P.31) |
| 2042 | Government individual consumption expend., non-market (P.31) |
| 2043 | Government collective consumption expenditure (P.32) |
| 2051 | Gross fixed capital formation, machinery and transp. equipment (P.511) |
| 2053 | Gross fixed capital formation, buildings and structures (P.511) |
| 2054 | Gross fixed capital formation, breeding stock (P.511) |
| 2055 | Gross fixed capital formation, valuables (P.53) |
| 2056 | Gross fixed capital formation, software (P.512) |
| 2057 | Gross fixed capital formation, artistic originals (P.512) |
| 2058 | Gross fixed capital formation, exploratory drillings (P.512) |
| 206x | Changes in inventories (P.52) |
| 2081 | Exports of goods and services, Danish production (P.6) |
| 2082 | Exports of goods and services, re-exports (P.6) |

Total supply is defined as: 1010+1020+1021+1022+1023
Total use is defined as: 2010+2030+204x+205x+206x+208x

Rearranging the variables gives GDP:
1010-2010 = GDP from the production side
2030+204x+205x+206x+208x = GDP from the expenditure side

After the balancing, which takes place at the product level (2350 products), the two expressions for GDP equal. It must be noted, that 1010 and 2010 are compiled at the 130 industry level and 2030 at the level of 72 consumption groups and 204x is subdivided into 31 groups according to purpose.

3) On the supply-side (cf. fig. 1) the available data allows us to fill out the complete supply matrix annually. Data from the agricultural accounts, accounting statistics (from the Structural Business

Statistics) and the General government accounts makes it possible to calculate total output in basic values (column totals for industries in fig.1) for almost all industries. Only for a few branches (financial intermediation) separate calculations have to be made.

On the use side there is less abundant information available, usually only for column totals. There is only scattered and often irregular information available. So a variety of other sources are used to distribute the products all over the use table.

4) Then follows sort of an automatic modified RAS procedure balancing of the preliminary SUT. Even though it is called automatic at this point a lot of data preparation and modifications by hand is involved before the procedure is run. Every run results in a new list of unsolved problems that have to be taken care of. The procedure could in principle be run as an iterative process but it is not. The reason is that it is considered possible to something sensible in a manual way to the more structural problems that are revealed at this stage. So after this stage the SUT is still unbalanced

5) That leads to the manual balancing. Every spring 4-6 people spend about a month on a manual balancing of the SUT. Each person gets his own area of responsibility. Such areas typically consist of a complex of industries and categories of final use with a high degree of interaction and their common products on either the uses- or production side. On the other hand all products and categories of use must belong to a complex to ensure, that they all are looked after by a responsible person.

The tasks of each balancer are the following:

- Eliminate still existing differences between supply and use of products at basic prices. These differences can have various explanations. As mentioned earlier, serious problems may reveal a need to correct data from primary statistics. However, many remaining differences may be explained by differences in the coding of the same kind of products between production- and foreign trade- statistics, and the problem can then be solved by moving output, im- or exports from one product to another.

- To check the credibility of the results from the automatic balancing.

- To redistribute products between uses until the sum of values in a column are inside an acceptable distance from their targets.

- To evaluate whether the results indicates needs for adjustment of the target column totals. The target-values will usually not be equally well founded on statistical sources. The less well-founded target column totals might be reconsidered in the light of the additional information obtained from the SUT-framework.

To keep the system manageable certain rules are to be followed. One of these is that all products are kept balanced with total uses = supply during the balancing process. This also applies to net taxes on products other than VAT. Another rule is that even though balancers are allowed to make corrections outside their "own" area they must ensure that major changes outside one’s own complex are always negotiated with the “owners” of the other complexes involved, and that information is passed between the relevant persons.

Yet another important aspect of the manual balancing procedures is the need for documentation. Many corrections entered by the “balancers” will be independently motivated with references to statistical and other available sources or with common-sense considerations. It is important that the considerations behind the solutions are visible to other “balancers” and that the solutions can be reproduced, when the same problems are encountered in following years. These comments are entered directly in the spreadsheets where the adjustments are made.

The "balancers" use spreadsheets as an interface to a master file containing the SUT-tables. The master file is placed on a network server and is shared by all “balancers”. Procedures for extracting data from master-file to spreadsheet and transferring corrections from spreadsheet to the updated master-file are available as macros called from toolbars in the spreadsheet environment.

When updating the shared master-file it is important, that no invalid data are allowed as corrections. All corrections are tested for errors before they are accepted. Corrections to the cells need not necessarily be specified for all levels from basic- to purchasers’ prices by the “balancers”. The software used to update the master-file will carry out the calculation of the missing values from default assumptions such as preservation of the trade margin percentages and recalculation of VAT using the same rules as in the original master file.

In the process the “balancers” need access to updated information on the state of the system like remaining differences between supply and uses at basic prices by product and the actual distances between column-totals and their targets. This information is obtained via the macros in the spreadsheet environment. It is also possible to extract information from the master-files of previous years for comparison purposes and to merge data covering several years into spreadsheets as time series.

6) Finally the remaining imbalances are removed with more or less automatic procedures. An example could be to distribute remaining differences between the total of columns and the target totals over all the cells in the column linearly. And then the SUT is done.

## 3. Compilation of symmetrical input-output tables

The SUT’s can be used directly for economic analyses and as a part or econometric and other types of models. So for many analytical purposes there is no need to construct a symmetrical input-output table (SIOT). But to ensure the accessibility to these data for some of the users it is still important to make the SIOT’s available. Otherwise many users would not be able to use the these data and others might spend a lot of time trying to construct SIOT’s on their own choosing more or less inferior compilation methods due to a lack of insight into the basic data. So it is still an important task for the statistical agencies (or others) to compile and to disseminate it to the public.

“A basic principle in the compilation of statistics is that whenever results of the same or higher utility to the user can be obtained in a less complicated (i.e. more transparent) and or less resource demanding way it should be done”. Thage (2005).

In practice it is necessary to rely to a certain extent on assumptions in order to be able to transform the observed data in the SUT to SIOT. At Statistics Denmark a number of principles for methodological sound statistical methods are applied in this process

- Assumptions are made with as much respect to the type of data actually available as possible in order to obtain the SIOT with a minimum of data manipulation, keeping the requirements for economic analyses in mind. The idea of starting from abstract economic theory defining ideal requirements for the SIOT is not seen as a possible solution since the requirements have to be relaxed or abandoned in the practical compilation process anyway.
- Existing micro-macro links should be retained as far as possible
- As little of the original information as possible should be lost
- Comparability with other statistics and the rest of the National Accounts is very important and should be maintained
- Applied methods should be transparent and based on observed data

The compilation of the SIOT implies a further departure from observed data, so assumption should be as weak as possible to obtain the desired tables.

It has been pointed out in recent years (see Thage(2005)) that in the construction of SIOT there is not a choice between industry technology and product technology. The distinction is now between the technology assumption and sales structure assumption. If the stronger assumption of technology is chosen, only product-by-product tables can be compiled, whereas if the weaker market share assumption is chosen, only industry-by-industry SIOT can be compiled.

On the basis of these considerations Statistics Denmark are very strongly in favour of compiling industry-by-industry SIOT's on the basis of the market share assumption, which is to be the *fixed product sales structure*. The definition of this is

Fixed product sales structure:

*it is assumed that the relative shares in which a product is supplied from domestic production industries and import is the same no matter to which industry or final demand component it is delivered*

This is actually the only additional assumption necessary to make the industry-by-industry SIOT on the basis of the Danish SUT.

When information from the SUT is complemented with information about the use of primary inputs (incl. the gross operating surplus and mixed income by kind of activity) it can all be set up in a matrix like the following

| | Product | Industry | Final use | Total |
|---|---|---|---|---|
| Product | | U | F | q + b |
| Industry | V | | | g |
| Imports | b' | | | i * b' |
| Primary input | | Y | $Y_f$ | y |
| Total | q' + b' | g' | f' | |

Here **U** shows the intermediate input of the approximately 2350 products in the domestic production by 130 industries. These products are domestically produced as well as imported. The **F** matrix shows the final use of the same 2350 products. Finally the column vector **q** + **b** shows the total supply of products in the economy domestically produced as well as imported. The **V** matrix shows the domestic production by 130 industries of approximately 2350 different products and

consequently the column vector **g** is the domestic production by industry. The totals in the *product row* equal the totals of the *product column*. The matrix **Y** describes the primary inputs necessary for production and the matrix $\mathbf{Y_f}$ is a corresponding matrix for the final use. Naturally, it has no entries for wages and gross operating surplus. Final demand by category is contained in the vector **f**. Vectors **q**, **g** and **b** are measured in basic prices and **f** is measured in purchaser's prices.

Together with the fixed product sales structure assumption mentioned above it is assumed that the same import share applies to all categories of use of a particular product.

It means that for a given product it is assumed that the imported share is the same whether it is used for intermediate consumption in any given industry or delivered to any given final demand category.

The calculation of the vector of import shares for all products is the following

$$m = \frac{b}{\hat{q} + b}$$

where the ^ means that the vector has been diagonalized.

This information is utilized to split the **U** and **F** matrices into a domestically produced part and an imported part named $\mathbf{U}_D$ , $\mathbf{U}_M$ and $\mathbf{F}_D$ , $\mathbf{F}_M$ in the following way

$$U_D = (I - \hat{m}) \cdot U \quad , \quad F_D = (I - \hat{m}) \cdot F$$
$$U_M = \hat{m} \cdot U \quad , \quad F_M = \hat{m} \cdot F$$

Here **I** is the unity matrix, and the ^ over the import share vector indicates that it has been diagonalized, i.e. it has been made the diagonal in a square matrix.

If we assume there is domestic supply corresponding to all imported products the market share matrix can be calculated in the following way

$$D = V(\hat{q})^{-1}$$

Now using the fixed product sales structure assumption allows us to compile a SIOT industry-by-industry and an industry by final demand table

Domestic produced and imported intermediate consumption = $D(I - \hat{m})U$ and $D\hat{m}U$

Domestic produced and imported final demand = $D(I - \hat{m})F$ and $D\hat{m}F$

**Specific practical problems (regarding the Danish case)**

- Foreign trade not classified by product. There are types of foreign transactions that cannot be specified by an actual product. This concerns items like consumption by non-residents on the Danish economic territory and by residents in the ROW, the expenditures by Danish ships and planes abroad, and some imports concerning oil drilling activities in the North Sea.

- The share of import in exports. The assumption that exports has the same import content as the regards other uses of the same product is not very likely to be true. Normally exports will have a lower import share than domestic uses, so this is taken care of in a special calculation.

- The D-matrix. For some imported goods there is no equivalent domestic production (like bananas) so the D-matrix is in principle not defined in all columns. Therefore a so-called characteristic industry is connected with all products, so if there is no domestic production of a certain imported good, the entire import is attributed to the row corresponding to its characteristic industry.

**References:**

Thage, B (2005) “Symmetric Input-Output Tables: Compilation Issues”. Paper presented for the fifteenth International Input-Output Conference in Beijing China.