Supply-Use and Input-Output Tables

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1 Introduction

When input-output statistics are compiled in practice it is essential to take into account the desired properties and compilation methods of the symmetric input-output tables already while working on supply and use tables. By making appropriate choices of the groupings and structure of the supply and use tables it is possible to construct a data base which is relevant and useful in the current national accounts and at the same time can be transformed into a symmetric input-output table with a minimum of data manipulation.

It is recommended to implement a three step approach (Thage and Ten Raa, 2007)

1. Compilation of supply and use tables
2. Preparation of input-output data for analytical uses
3. Calculation of standard analytical results

The first step consists basically of defining the industries in the supply and use tables and in the activity tables of the national accounts in general. The second step of preparing input-output data for analytical uses provides options of compiling of symmetric product-by-product or industry-by-industry input-output tables based on different assumptions. The increased focus on supply and use tables has been an important trend during the decade. The direct application of supply and use tables in economic analysis has become more wide-spread. This development is based on both computational and analytical progress, down to econometric analysis of micro data directly in connection with the analysis. Insofar, a flexible approach is the best option. What matters is that the user is in a position to find his/her own aggregation of input-output data according to his/her specific needs (Eurostat, 2008).

2 Compilation of Supply and Use Tables

Supply-Use Tables (SUTs) consist of two interlinked tables: the supply table and the use table. The supply table shows the supply of goods and services by type of product and by type of industry, distinguishing between supply by domestic industries and imports of goods and services. In other words, the supply table provides information on the output (by product) generated by economic activities and the imports (by product) from abroad. The totals in the last column represent the total supply by products and the totals in the bottom row represent the total output by economic activity and total imports. A simplified supply table is presented in the figure 1 below.

<table>
<tr><td rowspan="2">Industries
Products</td><td colspan="4">Industries</td><td rowspan="2">Imports</td><td rowspan="2">Total</td></tr>
<tr><td>Agriculture, forestry, etc.</td><td>Mining and quarrying</td><td>...</td><td>Services</td></tr>
<tr><td>Agriculture, forestry, etc.
Ores and minerals, etc.
...
Services</td><td colspan="4">Output by product by industry</td><td>Imports by product</td><td>Total supply by product</td></tr>
<tr><td>Total</td><td colspan="4">Total output by industry</td><td>Total imports</td><td>Total supply</td></tr>
</table>

Figure 1: Simplified Structure of the Supply Table

The second table is the use table, which provides information on the uses of the different products. The use table shows the use of goods and services by type of product and by type of use, in other words, as intermediate consumption by industry, final consumption, gross capital formation or exports. Furthermore, the table shows the components of gross value added by industry – namely, compensation of employees, other taxes less subsidies on production, consumption of fixed capital and net operating surplus. While the totals by row represent the total uses by product, the total by column represent the total output by economic activity, total final consumption, total gross fixed capital formation and total exports. Figure 2 below shows the simplified structure of the use table.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="4">Products</td><td colspan="4">Industries</td><td colspan="3">Final uses</td><td rowspan="2">Total</td></tr>
<tr><td>Agriculture, forestry, etc.</td><td>Ores and minerals, etc.</td><td>...</td><td>Services</td><td>Agriculture, forestry, etc.</td><td>Mining and quarrying</td><td>...</td><td>Services</td><td>Final consumption</td><td>Gross capital formation</td><td>Exports</td></tr>
<tr><td>Products</td><td>Agriculture, forestry, etc.
Ores and minerals, etc.
...
Services</td><td colspan="4"></td><td colspan="4">Intermediate consumption by product and by industry</td><td colspan="3">Final uses by product and by category</td><td>Total use by product</td></tr>
<tr><td rowspan="4">Industries</td><td>Agriculture, forestry, etc.</td><td colspan="4" rowspan="4">Output by product by industry</td><td colspan="4" rowspan="4"></td><td colspan="3" rowspan="4"></td><td rowspan="4">Total output by industry</td></tr>
<tr><td>Mining and quarrying</td></tr>
<tr><td>...</td></tr>
<tr><td>Services</td></tr>
<tr><td colspan="2">Value added</td><td colspan="4"></td><td colspan="4">Value added by component and by industry</td><td colspan="3"></td><td>Value added</td></tr>
<tr><td colspan="2">Imports</td><td colspan="4">Total imports by product</td><td colspan="4"></td><td colspan="3"></td><td>Total imports</td></tr>
<tr><td colspan="2">Total</td><td colspan="4">Total supply by product</td><td colspan="4">Total output by industry</td><td colspan="3">Total final uses by category</td><td></td></tr>
</table>

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Figure 2: Simplified Structure of the Use Table

The classification of products, in practice, is often more detailed than the classification of industries, thus generating rectangular SUTs. For example, the output of the dairy industry is separately shown in the SUTs for the products of processed milk, butter, yoghurt, cheese and so forth, and not as only one aggregate product for all dairy products.

There are three basic identities that hold between the supply table and the use table.These identities are fundamental in the balancing process that is carried out when compiling SUTs. The first identity corresponds to the fundamental identity in national accounts, whereby for each economic activity the following holds:

Identity (1): Output = Intermediate consumption + GVA

The second identity is that the total supply by product is equal to the total use by product. This means that the amount of products available for use in an economy must have been supplied either by domestic production or by imports, and the same amount of products entering an economy in an accounting period must be used for intermediate consumption, final consumption, capital formation or exports. This means that, for each product (or group of products):

Identity (2): Output + Imports = Intermediate consumption + Final consumption + Capital formation + Exports

Another important identity which is also key when linking the production and income approaches to calculating GDP and the industry and institutional sector dimension through the SUTs is the following:

Identity (3): For each industry, the GVA using the production approach equals the GVA estimate using the income approach.

Once balanced, the supply table and the use table can be integrated into a single matrix, often referred to as the SUTs framework, which is shown in the figure 3 below. This table clearly shows the two basic identities linking the SUTs. The total supply by product (left part of the bottom row) equals the total use by product (top part of the last column) and the total outputs by industry are identical in both SUTs (the middle part of the bottom row equals the middle part of the last column).

		Products				Industries				Final uses			Total
		Agriculture, forestry, etc.	Ores and minerals, etc.	...	Services	Agriculture, forestry, etc.	Mining and quarrying	...	Services	Final consumption	Gross capital formation	Exports	
Products	Agriculture, forestry, etc. Ores and minerals, etc. ... Services					Intermediate consumption by product and by industry				Final uses by product and by category			Total use by product
Industries	Agriculture, forestry, etc. Mining and quarrying ... Services	Output by product by industry											Total output by industry
Value added						Value added by component and by industry							Value added
Imports		Total imports by product											Total imports
Total		Total supply by product				Total output by industry				Total final uses by category			

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Figure 3: Supply and Use Tables Framework

SUTs thus bring together the components of each of the three approaches to measuring GDP– namely, the production, income and expenditure approaches. The following figure 4 provides a graphical overview of the SUTs, explicitly identifying the main identities that are ensured in balanced SUTs.

Production approach: GDP = Output (at basic prices) - Intermediate consumption + Taxes less subsidies on products

Income approach: GDP = Compensation of employees + Gross operating surplus + Other taxes less subsidies on production + Taxes less subsidies on products

Expenditure approach: GDP = Final consumption + Gross capital formation + Exports - Imports

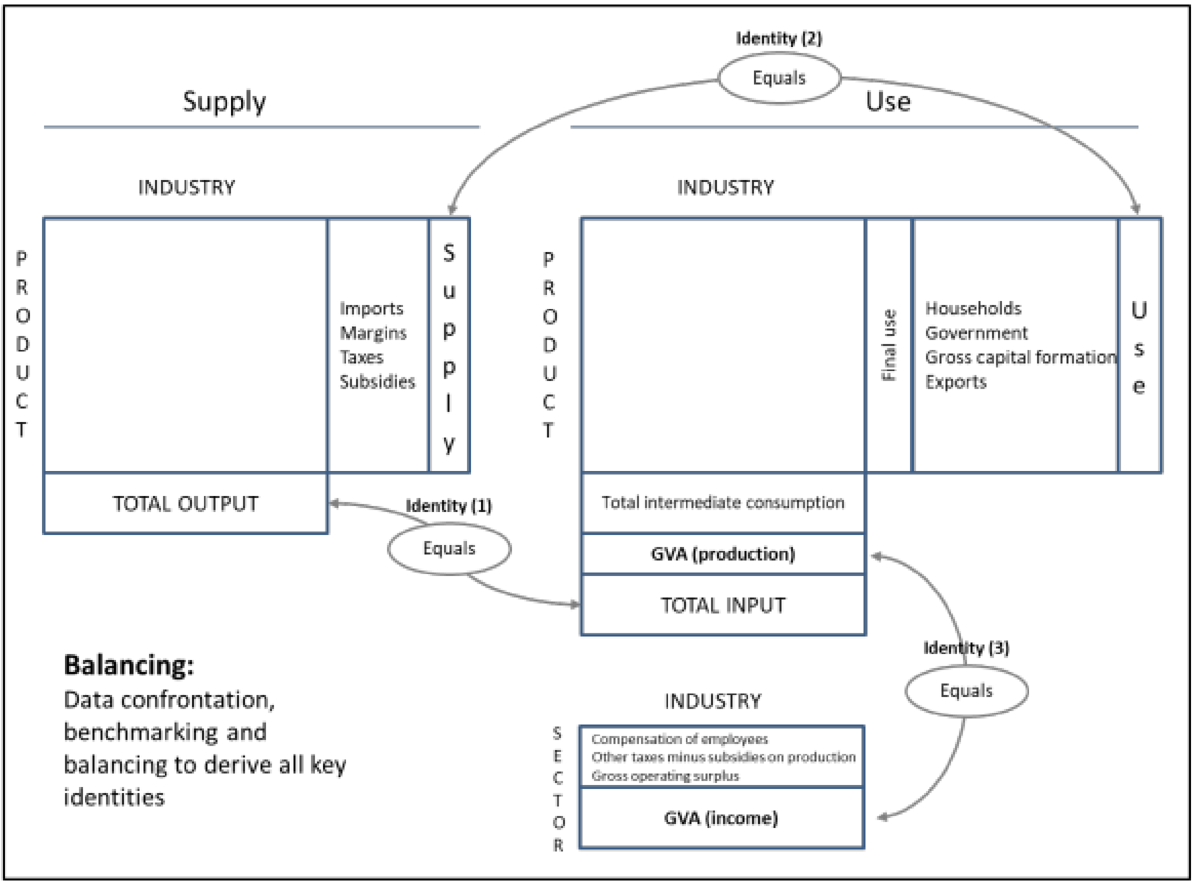

Figure 4: Supply and Use Tables Framework

The use table records the intermediate consumption and final uses by type of product but it does not distinguish between the consumption of domestically produced goods and services and that of imported goods and services. Although such a split is not a necessary condition for the creation of balanced SUTs in current prices, it is a key step linking SUTs and Input-Output Tables (IOTs). Once the imports use table is constructed, the domestic use table can be estimated by subtracting the imports use table from the use table. The imports use table and the domestic use table form the basis for the construction of input imports tables and domestic IOTs, respectively (Mahajan et al., 2018).

3 Preparation of Input-Output Data for Analytical Uses

For many analytical purposes, a transformation from a pair of SUTs into a single Input-Output Table (IOT) where total input (row totals) and total output (column totals) are equal brings considerable advantages. IOTs have algebraic properties that make them particularly suitable for analyses that enable estimates of the effects of changing relative prices, labour and capital requirements in the face of changing output levels, the consequences of changing patterns of demand and so on. They may also be used as the basis for an expanded version that may be used to estimate the demands made by the economy on the environment.

The IOTs derived from the SUTs further describe the interrelationships between industries and products, along with the sale and purchase relationships between producers and consumers within an economy. They can be produced to illustrate flows between the sales and purchases (final and intermediate) of industry outputs (referred to as industry-by-industry tables) or to illustrate the sales and purchases (final and intermediate) of product outputs (referred to as product-by-product tables). In the IOTs, two identities of the SUTs system are reduced to a single type of identity. It is typical for IOTs that, for each product or industry, the input equals output and total input equal total output.

The following figure 5 provides a simplified IOT where the columns of the original use table referring to industry-based structures are transformed into product-based structures. The relations between output and input are now relations between products and primary inputs necessary to produce outputs in similar production units. Primary inputs are inputs that are not outputs of other industries. They include the imports of goods and services and the components of GVA, such as compensation of employees, and others. They are necessary to the production process but are not produced anywhere in the domestic economy.

Products \ Products	Products				Final uses			Total
	Agriculture, forestry, etc.	Ores and minerals; etc.	...	Services	Final consumption	Gross capital formation	Exports	
Agriculture, forestry, etc. Ores and minerals; etc. ... Services	Intermediate consumption by product				Final uses by product and by category			Total use by product
Imports	Intermediate consumption of imported products				Final use of imported products			
Value added	Value added by component							Value added
Total	Total supply				Total final uses by category			

Empty cells by definition

Figure 5: Simplified IOT (product by product)

For the transformation of SUTs into IOTs, various assumptions have to be made or adjustments are required based on industry-by-industry or product-by-product assumptions:

1. Product-by-product IOTs: these may be compiled using either the product technology assumption (whereby each product is produced in its own specific way, irrespective of the industry where it is produced) or the industry technology assumption (whereby each industry has its own specific means of production, irrespective of its product mix).

2. Industry-by-industry IOTs: these may be compiled using either the fixed industry sales structure assumption (whereby each industry has its own specific sales structure, irrespective of its product mix) or the fixed product sales structure assumption (whereby each product has its own specific sales structure, irrespective of the industry where it is produced).

A mixture of both assumptions can also be applied by implementing a hybrid technology assumption. However, the selection of the appropriate type of IOT – product-by-product or industry-by-industry – depends on a number of statistical and practical considerations.

The International Standard Industrial Classification of All Economic Activities (ISIC) is the international reference classification of economic activities (also referred to as “industries”). The fourth revision, ISIC Rev. 4, was issued by the United Nations in 2008 (UN, 2008).Its main purpose is to provide a set of activity categories that can be used for collecting and presenting internationally comparable statistics by economic activity. The classification is used to classify statistical units such as establishments or enterprises, according to the economic activity in which they mainly engage. All categories at each level of the classification are mutually exclusive.

The international reference classification of products is the Central Product Classification (CPC). The latest revision, CPC Version 2.1, was issued by the United Nations in 2015 (UN, 2015). The primary purpose of CPC is to classify all goods and services that are the result of production in the economy. CPC presents categories for all products that can be the object of domestic or international transactions or that can be entered into stocks. It includes products that are the output of economic activity, including transportable goods, non-transportable goods and services. CPC in general follows the definition of products within the SNA.

CPC and ISIC are both general purpose classifications, with ISIC representing the activity side. Each subclass of CPC consists of goods or services that are predominantly produced in a specific class of ISIC. The relationship between industries and their products is complex, however, and changes over time, and it should be noted that there has been no intention of establishing a one-to-one correspondence between CPC and ISIC. Such an effort is considered neither practical nor desirable as it might lead to an inadequate description of CPC categories, in particular at the higher levels.

An economic unit may engage in a variety of production activities. The classification of the economic unit is made in accordance with the importance of the production activities. In this regard, the activities of an economic unit are subdivided into principal activity, secondary activity and ancillary activities. The principal activity of an economic entity is the activity that contributes most to the value added of the entity, as determined by what is known as the “top-down method”. This method follows a hierarchical order, starting with the identification of the relevant category at the highest level (section) and progressing down through the levels of the classification to the lowest level (classes). The effect of this top-down method is such that the principal activity need not account for 50 per cent or more of the total value added of an entity or even that its generated value added exceed that of all other activities carried out by the unit, although, in the majority of cases, it will do so.

4 Calculation of Standard Analytical Results

The benefit of the input-output framework is that all information of the SUTs and IOTs can be integrated into one matrix. The first two rows of the integrated input-output framework (figure 8) refer to products. In particular, the first row shows the use of domestic products as intermediate output by industries (the matrix U_d) and final uses (the matrix Y_d). The matrix U_d has products in the rows and industries in the columns. Similarly, the second row of the integrated input-output framework shows the use of imported products as intermediate output by industries (U_m) and final uses (Y_m). The matrix U_m has products in the rows and industries in the columns.

	Industries	Output	Imports	Supply
Products	V^T	x	m	q
Output	g^T			

Figure 6: Supply Table

The typical element of the matrix U_d, say, in rows i and column j, represents the amount of

	Industries	Final use	Use
Domestic products	U_d	Y_d	x
Imported products	U_m	Y_m	m
GVA	W		w
Output	g^T	y	

Figure 7: Domestic Use Table

	Domestic products	Industries	Final use	Total
Domestic products		U_d	Y_d	x
Imported products		U_m	Y_m	m
Industries	V			g
GVA		W		w
Total	x^T	g^T	y	

Figure 8: Integrated Supply and Use Framework

product i used up in the production of industry j. The row sums of this matrix represent the total intermediate use of the various products in production. The column sums represent the intermediate use of all products by the various industries. The matrix Y_d has again products in the rows and final uses categories in the columns. Each element of the corresponding summation vector represents the net final use of a particular domestic product for consumption, capital formation and net exports. The column sums of V give the domestic output of the various products, the row sums of V give the domestic output of the various industries. These row totals are the elements of the vector of industry outputs (g). The column totals are the elements of the transposed vector of industry output (g^T).

The third column of the integrated input-output framework shows the total costs required to produce the industry outputs. The column sums of U_d and U_m, which represent the cost of intermediate inputs, and the elements of the row vector W, which represent the cost of primary input (value added), determine the value of industry output. The fifth row and column of the "Integrated input-output framework" relate to total input and total output of products and industries, but also to total value added and net final expenditures. The system is balanced if total input of products (x^T and m^T) equals total output of products (x and m) and total input of industries (g^T) equals total output of industries (g). If this is the case, total value added (w) equals total net final expenditure (y).

When the input table for imports (ITI) has been derived, it can be presented in different ways. But here we consider that the full ITI is added, element by element, to the domestic output part of the IOT (the first subtable) to obtain an IOT where no distinction is made between domestically produced products and imported products. This type of IOT can also be obtained directly from the SUTs, with no distinction made between domestic output and imports. This distinction is therefore not a precondition for compiling an IOT. Here we also consider the industry technology assumption. It means that each industry has its own specific way of production, irrespective of its product mix. This assumption applies best to cases of by-products or joint products, since in these cases several products are produced in a single production process.

The formula for industry technology can be derived through the following transformation matrix (Mahajan et al., 2018)

- $T = C^T$, where $C = V^T(\hat{g})^{-1}$ is the product-mix matrix (share of each product in output of an industry)
- Input coefficients intermediates: $A = UT(\hat{x})^{-1}$
- Input coefficients value added: $R = WT(\hat{x})^{-1}$

Capital letters denote matrices and the small letters vectors. Transpose matrices are written as matrices with the attachment of a superscript (T). Vectors are written as column vectors and row vectors are written as transposed column vectors with the attachment of a superscript (T). Use of superscript ˆ indicates diagonalization of a vector.

5 Conclusion

Over the past 60 years, there have been many descriptions generalizing the matrix multiplication for the IOTs. Using the method proposed by Rueda-Cantuche and Raa (2009), the starting point for the construction of the product-by-product IOTs is the amount of product i used by industry j (to produce product k): intermediate use u_{ij}. Schematically, the transformation underlying product-by-product IOTs is: product $i \rightarrow$ industry $j \rightarrow$ product k. For the industry-by-industry IOTs, this will be viewed as a product i contribution to the delivery from industry j to industry k. This is: industry $j \rightarrow$ product $i \rightarrow$ industry k. This common framework for IOTs is made precise by indexing the so-called input-output coefficients by three subscripts. The first subscript indexes the input, the second the observation unit, and the third the output.

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