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# CONSTRUCTION OF THE ENERGY SOCIAL ACCOUNTING MATRIX FOR IRELAND, V2.0

Kelly de Bruin and Aykut Mert Yakut



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*This report has been accepted for publication by the Institute, which does not itself take institutional policy positions. The report has been peer-reviewed prior to publication. The authors are solely responsible for the content and the views expressed.*

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## EXECUTIVE SUMMARY

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A Social Accounting Matrix (SAM) represents the basis of a computable general equilibrium (CGE) model in terms of data. The matrix presents a snapshot of the economy for a given period of time, usually one year. This paper provides details concerning the data collection process to construct a SAM for the Ireland Environment, Energy and Economy (I3E) model. Due to the energy focus of the I3E model, the Social Accounting Matrix (SAM) is extended to construct an Energy SAM (ESAM). The ESAM includes several energy sectors and commodities and their concomitant carbon emissions. To this end, several data sources are used to disaggregate already available sectors and commodities into subsectors.

After each major development of the model and the SAM, an updated version of this report is published. The current report belongs to the second version of the SAM.

# 1 INTRODUCTION

A computable general equilibrium (CGE) model reproduces the structure of the economy in its entirety including productive sectors, goods, households, factor inputs, trade and the government, where the nature of all existing economic transactions among diverse economic agents is quantified. To calibrate the CGE model parameters, a Social Accounting Matrix (SAM) is needed. A SAM can be defined as an organised matrix representation of all transactions and transfers between different production activities (sectors), goods (commodities), factors of production (labour, capital, and land), and institutions (households, corporate sector, government, and enterprises) within an economy and with respect to the rest of the world. A SAM is thus a comprehensive accounting framework within which the full circular flow of an economy (where households use their disposable income for consumption, which creates income for production, which creates income for factors of production which are owned by households, which creates income for households who again devote their income to consumption) is captured.

This paper explains the data collection process and balancing procedure of the Energy SAM (ESAM) as used in the I3E model in detail. The next section explains the basic structure of a typical SAM. Section 3 summarises the data sources utilised to construct firstly the SAM and then the ESAM for the Irish economy. Section 4 is devoted to explaining both the construction steps of the aggregated version of the Irish SAM and the relationships across the economic agents, as defined in the I3E model. Sections 5 summarises the disaggregation of the energy sectors and commodities and the construction process of the ESAM, whereas Section 6 explains the disaggregation of the household sector into different household groups. Appendix I explains the relations between different prices and valuations used in the input–output tables. Appendix II provides the lists of activities and commodities defined in the I3E model and finally, the mapping of the Household Budget Survey (HBS) consumption items to the I3E commodities can be found in Appendix III.

## 2 Basic SAM Structure

A typical SAM depicts all the transactions in the economy in the form of a symmetric matrix. Each economic agent is represented as both a row and a column account. The number of agents represented depends on the nature of the analysis. If a researcher wishes to explore the distributive effects of a policy change, there would be more than one households group. Each row of the SAM gives receipts of an account while the column gives the expenditure. An entry in row  $i$  and column  $j$  represents the receipts of account  $i$  from account  $j$ . The total of each row has to be equal to the total of the corresponding column. The logic behind this rule is simple: an expenditure of one agent is the income of another agent, and an agent's income should be equal to its expenditure.

As a SAM is formed to calibrate the model parameters, the structure of a SAM is determined by the structure of the CGE model regarding the number of agents and commodities represented in the model. As summarised by Pyatt (1988), a SAM brings together data from many various sources to describe



the structural characteristics and is a very good way of displaying information concerning the structural interdependence in an economy at both the macro and meso levels. Round (2003) describes the SAM as a meso-level framework, noting that it operates as a functional bridge between a macro framework and markets and institutions that have a more detailed description.

### 3 Data Sources

Generally, Input–Output (IO) tables are used to construct SAMs and are constructed based on the Supply and Use Tables (SUTs). The SUTs provide the most detailed data on the sources of supply and demand of commodities, including exports and imports, the cost of production, the composition of gross value added and taxes and subsidies on products. Industries are on the rows of SUTs while products are on the columns. The supply table provides information on which sectors produce which commodities, imports by commodities, trade margins, taxes, and subsidies on products. The use table, by contrast, is formed by using four different tables: domestic use table (usage of domestically produced products), import use table (usage of imported products), net tax table (tax minus subsidies) on products, and lastly trade margins table. Trade and transportation services measured by trade and transportation margins which are necessary to deliver commodities from factories and docks to markets. They are one of the basic components of the valuation process.<sup>1</sup>

Each national statistical office produces an IO table by applying either the product technology or the industry technology assumption to the SUTs.<sup>2</sup> Regardless of the choice of conversion, the resulting IO will assume that each industry is associated with the production of a single product. In other words, IO tables restrict the information provided by SUTs, and do not allow industries to produce multiple products and do not allow commodities to be produced by multiple activities. However, secondary and tertiary products may play an essential role in some industries and should, therefore, be included. The latter restriction leads to ignorance concerning differentiated products produced by domestic industries.

In order to avoid the restrictions introduced by IO tables, a SAM can be constructed by directly using the SUTs. In this case, the domestic production can be represented more accurately, although several complexities emerge such that each industry has to determine the level of production of each product.

As a SAM records incomes and expenditures, which are flow variables, it provides a snapshot of the economy for a period of time. Choosing a year for which a SAM is constructed, the base-year, in other words, has important implications. By definition, a SAM depicts the economy in an *accounting equilibrium* where total expenditure is equal to total income for each agent. However, *economic equilibrium* requires that each agent does not tend to and has no incentive to change her/his behaviour. In other words, the decisions of agents are stable, which, in turn, requires stability of prices including commodity prices and factors of production prices since the latter determines income (cost of production) of house-

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<sup>1</sup> A brief explanation is provided on Appendix I. For further details, an interested reader is advised to see UN (1999); EURO-STAT (2008, 2013).

<sup>2</sup> Details of these assumptions are beyond the focus of this document. Details can be found in the manuals mentioned above.

holds (firms) and the former determines the consumption profiles of the agents. Therefore, selecting an appropriate base-year requires choosing a year in which prices are *relatively* stable.

Another essential restriction in choosing the base year is the availability of all required data, where the latest available data would be preferred. The latest SUTs for the Irish economy are available for the year 2015 in which there is a significant increase (of 26%) in the gross domestic product due to relocated balance sheets in the reporting procedure, which are mainly dominated by intellectual property products (CSO, 2017). Since this updated process has no impacts on prices, disposable income, consumption or energy demand, the year 2014 is chosen as the base year as the relation between all economic variables were more consistent to each other in 2014.

As the data provided by the SUTs is not sufficient to construct a SAM, additional data at a macro-economic level, including for example government transfers to households, government savings, and net factor income from the rest of the world are retrieved from government and national accounts.

To be able to analyse policy impacts via the energy system, several of the energy-related sectors in the SAM need to be further disaggregated to the desired level of detail creating a so-called Energy SAM (ESAM). An ESAM expands the SAM to include energy inputs explicitly and the concomitant emissions from energy use; in other words fuel combustion. Several energy-related sectors of the SAM are disaggregated into specific carbon commodities and industries. This process involves distributing the total value of the original sector over the newly created subsectors for the activity and commodity rows and columns in the SAM. The disaggregation process requires not only obtaining information on production activities intermediate input demand composition and the composition of value added by factors of production but also distribution of final consumption across private (household) consumption, public consumption, consumption by investment purposes (investment by origin) and exports.

Although the I3E model mainly focuses on the energy–economy interaction, the SUTs for the Irish economy are quite restrictive regarding the level of details for the energy-related sectors due to data confidentiality concerns. For instance, as there is only one refinery in the country, the Central Statistical Office (CSO) merges the petroleum sector with the furniture and other manufacturing sector, and provides highly aggregated data on the merged sector. The commodities produced by these quite distinct sectors are also provided in aggregate figures. The same aggregation is also a problem for the mining and quarrying sector, which produces peat and coal and extracts natural gas, which are commodities with different carbon contents affecting their emissions and the taxation policy applied to them. As explained in Section 5, extensive use is made of EUROSTAT and EXIOBASE datasets, as well as Energy Balance (EB) from the Sustainable Energy Authority of Ireland (SEAI) and the Business Energy Use Survey of CSO.

Lastly, in order to analyse the distributional impacts of policy changes, the private household sector is disaggregated into 10 distinct representative household groups (RHGs, five in rural areas and five in urban areas) based on disposable income. The total labour force is also disaggregated into low-, medium-, and high-skilled labour based on attained level of education. In the disaggregation process of the households, the HBS, the Survey on Income and Living Conditions (SILC) and the Labour Force Survey (LFS) are used extensively. Details of the disaggregation procedure are discussed in Section 6.

## 4 Aggregated Social Accounting Matrix

This section is devoted to explaining the construction of the Irish ESAM; see Table 4.1 for an aggregated version. In the following subsections, the details of each account and the relationship between the agents are summarized.

The SUTs for Ireland consist of 58 industries and 58 products. These production sectors are firstly merged into 29 sectors based on their shares in total value added, employment and emissions. Subsequently, as explained in detail in Section 5, three sectors are further disaggregated, and the total number of sectors / activities in the I3E model reaching 32. The products are merged into 39 commodities based on their economic or environmental importance. Out of 39 commodities, 37 are domestically produced in Ireland while two of them (crude oil and coal) are imported in their entirety. The list of activities and commodities in the SAM can be found in Appendix II.

Notice that the columns of a SAM show the expenditures of the account whereas the rows consist of the incomes of the account. For the sake of simplicity, the notation  $(x,y)$  will be used where  $x$  stands for the row account and  $y$  stands for the column account.

### 4.1 Activities – ACT

The account Activities (ACT) produces commodities by using commodities as intermediate inputs and factors of production, and pays a production tax over the value of the production. Total domestic production, which is equal to the sum of the Supply Table is consumed by the Commodities (COM) account. In other words, the account COM buys all products from the ACT account, and this comprises the income of the ACT account. Thus, this value appears in the cell  $(ACT,COM)$ .

The column of the ACT account shows the cost structure of the production sectors. The total value of intermediate input demand, which is the income of the COM account, appears in the cell  $(COM,ACT)$ . The sectors make payments to the factors of production, which are capital  $(CAP,ACT)$ , low-skilled labour  $(LSL,ACT)$ , medium-skilled labour  $(MSL,ACT)$  and high-skilled labour  $(HSL,ACT)$ . The figure in the cell  $(CAP,ACT)$  directly comes from the Use Table's corresponding row sum. The sum of the payments to the labour types, which is also directly available in the Use Table, is disaggregated into payments to types of labour by using the Survey on Income and Living Conditions (SILC).<sup>3</sup>

The only information not available in the Use Table is the activities' payments to the rest of the world account (RoW), which corresponds to half of the cost of the European Union Emission Trading System (EU-ETS). In the current legislation, around half of the cost of the ETS is paid to the government and the remainder goes to the EU Commission. Half of the total cost of the ETS (around €80 million) is put in the cell  $(RoW,ACT)$  and this amount is deducted from the original 'Net taxes (taxes minus subsidies) on production' in the Use Table, and the remaining value, the cell  $(PT,ACT)$ , is the production tax payments of the activities.

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<sup>3</sup> See Section 4.4 for further details.

## 4.2 Commodities (COM) and Margins (MAR)

The row of the account of Commodities (COM) shows the components of total demand; the intermediate input demand (COM,ACT), trade and transportation margin demand (COM,MAR), government demand (COM,GOV), household (including Non-profit Institutions Serving Households-NPISH) demand (COM,HH), investment demand including changes in inventories (COM,S-I) and, finally, export demand (COM,RoW). All these values come from the corresponding columns of the Use Table. In the national accounts, in-kind transfers from the government to households are excluded from household consumption but included in public consumption. In the SAM, the value of in-kind transfers retrieved from the government accounts is added (subtracted) to (from) private (public) consumption.

Trade and transportation services are necessary to deliver commodities from factories and docks to markets. Producer prices do not comprise the cost of these margins since these are not part of the production process. These costs are paid by final users of commodities and are included in purchaser prices. On the Supply Table, the values in the column of margins are entered as negative for trade and transportation activities and they are positive for all other activities; the column sum is equal to zero. The reason for this is that trade and transportation activities are the producers of these intermediation services while the other sectors demand these services. The sum of margin demands – the sum of positive values on the margin column of the Supply table – appears in the cell (COM,MAR). The sum of negative values of the same column appears in the cell (MAR,COM) as these services are demanded by commodities, since a commodity is produced by several activities and the cost of margins is paid by consumers.

The column of the account of COM shows the sources of supply; the domestic production (ACT,COM), margin demand (MAR,COM), sales / value added tax on the total domestic demand (ST,COM), carbon tax collected on the domestic demand of the energy commodities (CT,COM) and, finally, import demand (RoW,COM).

## 4.3 Capital – CAP

The Capital account collects gross payments to capital, which equal the sum of net operating surplus and the consumption of fixed capital in the Use Table. Since this is the income of the Capital account, the value is in the cell (CAP,ACT). The account pays its entire income to the account of Enterprises (ENT,CAP), which is the owner of all production activities. The reason for introducing such an account is to simplify some details of the model; this solves the issue of a lack of sector-specific data such as corporate tax payments.

## 4.4 Labour Types – LSL, MSL and HSL

The accounts of different labour types collect gross wage income from the activities (L,ACT) and pay the wage income tax to the account of Direct Tax (DT,L), where  $L$  stands for each labour account, LSL, MSL and HSL. The net-of-tax amount goes to households as net wage income (HH,L). The total value of direct tax income of labour types is equal to the income tax revenue of the government.

These labour types are created by using the SILC data based on attained level of education. For instance, individuals with no formal/ primary or lower secondary education are assumed to be low-skilled, individuals who have an upper secondary, post Leaving Certificate or third level without a degree are assumed to be medium-skilled, and lastly, individuals with a third-level degree or above are assumed to be high-skilled. Then, for each type of household defined in the model, the composition of wage income by skills is retrieved: the share of labour income of each type of labour in total wage income of each RHG. In this analysis, individuals under age 16 or without information concerning attained education are excluded.

The SILC also provides the economic sector of employment by NACE codes for each working individual, but the sectoral classification of the survey is quite restrictive, especially for manufacturing and transportation sectors. To have more accurate results on the sectoral wage costs, the Labour Force Survey (LFS) is utilised by using the same mapping of the attained level of education and the skill types defined in the model. Then, the share of each type of labour in the total sectoral employment can be estimated.

#### **4.5 Enterprises – ENT**

As mentioned before, the account is the owner of all production activities. It collects the net capital income from the capital account (CAP,ENT).

Total income is split between corporate tax payments (DT,ENT), payments to households as net-of-tax capital income (HH,ENT) in the form of dividends, and corporate savings (S-I,ENT). The corporate savings are collected from the Quarterly Accounts of Institutional Sectors (QAIS). Payments to households are calculated as a residual.

#### **4.6 Government – GOV**

All tax accounts pay their revenues to the government account (GOV,T), where *T* stands for each tax account, PT, ST, CT, and DT. Government expenditure consists of public demand of commodities (COM,GOV), welfare and pension transfers to households (HH,GOV), and interest payments over the outstanding foreign debt stock to the rest of the world (RoW,GOV).

It should be noted that the total revenue of the government in the SAM is less than its realised value in 2014 by around €11 billion. The reasons for this difference can be explained as follows. First, the total amount of indirect taxes (taxes on production and consumption) is €18.27 billion in the SUTs while it is €21.21 billion in the government accounts. The difference of €2.94 billion can be attributed to subsidies on production and commodities. The remaining difference, €8.5 billion, is equal to the sum of the following items in the government account: sales of goods and services, investment income, current transfer revenue, and capital transfer revenue. The recipient of sales of goods and services is the activity of public services, which is defined as a separate production activity (sector) in the I3E model. The remaining items are ignored as the I3E model does not have specific agents that are payers or recipients of these income items.

**Table 4.1: Aggregated SAM of Ireland  
for the year 2014, €billion**

	ACT	COM	MAR	CAP	LSL	MSL	HSL	PT	ST	CT	DT	ENT	GOV	HH	S-I	RoW	Total
ACT		417.95															417.95
COM	240.95		25.22										26.24	87.08	45.16	216.90	641.56
MAR		25.22															25.22
CAP	102.99																102.99
LSL	8.07																8.07
MSL	28.75																28.75
HSL	36.42																36.42
PT	0.74																0.74
ST		17.14															17.14
CT		0.39															0.39
DT					0.72	10.40	17.02					15.52					43.66
ENT				102.99													102.99
GOV								0.74	17.14	0.39	43.66						61.92
HH					7.35	18.35	19.40					48.94	28.08			-28.41	93.71
S-I												38.53		6.62			45.16
RoW	0.04	180.85											7.60				188.49
Total	417.95	641.56	25.22	102.99	8.07	28.75	36.42	0.74	17.14	0.39	43.66	102.99	61.92	93.71	45.16	188.49	

**ACT:** Activities; **COM:** Commodities, **CAP:** Capital; **LSL:** Low-skilled labour; **MSL:** Medium-skilled labour; **HSL:** High-skilled labour; **MAR:** Trade and transportation margins; **PT:** Production tax; **ST:** Sales tax; **CT:** Carbon tax; **DT:** Direct tax; **GOV:** Government; **HH:** Households; **ENT:** Enterprises; **S-I:** Saving–Investment; **RoW:** Rest of the world.

#### **4.7 Households – HH**

Households have net-of-tax wage income from the labour accounts (HH,L) where *L* stands for the labour types, dividend income from the enterprises (HH,ENT), transfer (including pension income) from the government (HH,GOV), and income from foreign asset holdings paid by the rest of the world account (HH,RoW). The value of the last item is readily available in the national accounts. The sum of these items yields household disposable income as all items are in net-of-tax terms. Households devote their disposable income to private consumption (COM,HH) or to saving (S-I,HH), which is calculated as residual to hold the balance of the account of HH. The HBS and SILC are used extensively in the calibration process of household-level parameters. For further information, see Section 6.

#### **4.8 Rest of the World – RoW**

As in the case of all single-country CGE models, all countries except Ireland are assumed to be a single unit referred to as the ‘rest of the world’. All monetary flows between the rest of the world and Ireland are traced within the rest of the world (RoW) account. Since all transactions related to this account are assumed to be denominated in a foreign currency, an exchange rate adjustment takes place. In the case of Ireland, although there is no exchange rate discrepancy for the transactions within the EU, almost two-thirds of the value of foreign trade consists of trade flows between Ireland and the United States and Ireland and the United Kingdom. As there is no distinction between these trade partners within the I3E model, the exchange rate movements also play an important role.

The account receives half of the cost of ETS permits paid to the European Commission (RoW,ACT), imports of commodities (RoW,COM), and the government interest payments over the outstanding foreign debt stock (RoW,GOV). The account’s expenditures consist of exports of commodities (COM,RoW) and net factor income of households (HH,RoW). The last item is calculated residual to balance the account. The calculated value is very close to that of the net factor income data available in the national accounts; -€29.7bn, a negative value indicates that the country runs a current account surplus.

#### **4.9 Savings-Investment – S-I**

The receipts of the account of Savings–Investment are corporate savings (S-I,ENT) and private savings (S-I,HH). Since the total amount of savings is used to finance the investment expenditures in the economy, the only expenditure item of the account is commodity demand for investment purposes (COM,S-I).

### **5 Energy Sector Disaggregation Process**

To be able to analyse impacts via the energy system, several of the energy-related sectors (activities and commodities) in the CSO SUTs need to be further disaggregated to the desired level of detail. The disaggregation entails creating multiple sectors from a single sector including: Mining, Quarrying, and

Extraction (MQE – NACE 5-9), Petroleum, Furniture and Other Manufacturing (PFOM – NACE 19, 31, 32) and Electricity and Gas Supply (EGS – NACE 35).

In the case of MQE, a distinction needs to be made between crude oil, peat, coal, natural gas and other mining sectors. Other mining includes metal ore, stone, sand, and clay. PFOM has been aggregated to avoid data confidentiality issues. This sector needs to be disentangled from furniture and other manufacturing and further disaggregated into diesel, gasoline, kerosene, fuel oil, LPG and other petroleum products. EGS needs to be disaggregated into electricity services and gas services.

The disaggregation process involves distributing the total value of the original sector over the newly created subsectors for the activity and commodity rows and columns in the SUTs. The disaggregation process requires not only obtaining information on production activities, including, intermediate input demand composition and the composition of value added by factors of production, but also distribution of final consumption across private (household) consumption, public consumption, consumption by investment purposes (investment by origin), and exports.

The disaggregation relies heavily on two data sources: the 2014 Irish Energy Balance (EB) published by the SEAI and the 2014 Business Energy Use Survey (BEUS) published by the CSO. The EB presents national energy statistics on energy production and consumption in Ireland. The flow of energy from production, transformation and the energy sectors' own use through to final consumption in different sectors of the economy is given in energy units (ktoe). These energy units are converted into tonnes and monetary units using different fuel prices derived from the SEAI domestic and commercial fuel costs archives and the IEA fuel costs data for Ireland. The BEUS is an annual survey conducted by the CSO that collects information about energy use by businesses in Ireland. This survey presents both the energy use of different fuels and sectors in energy units as well as in monetary costs. The BEU provides the latest data concerning business energy use and will be used in the future to update the EB.

Once the energy sector is disaggregated, the I3E will be able to explicitly include carbon commodities (peat, coal, natural gas, gasoline, gas oil, fuel oil, kerosene, and other petroleum products), which are used by the various production sectors or consumed directly by final users. In this way, carbon and carbon emissions can be tracked through the various production and consumption channels.

In what follows, we discuss the disaggregation process of each energy-related sector in turn.

## **5.1 Petroleum and Furniture**

In the SUTs for Ireland, the petroleum sector (NACE 19) is combined with the furniture and other manufacturing sector (NACE 31 and 32) to create the PFOM sector. This has been done to avoid data confidentiality issues, where the petroleum sector is dominated by a single firm. CSO data from 2011 concerning output and value added are used as well as EUROSTAT data, to disaggregate these sectors.



### 5.1.1 Supply Table disaggregation

The CSO does provide data for 2011 for the petroleum and chemicals sectors (NACE 19, 20) and the furniture and other manufacturing sector (NACE 31 and 32) separately concerning market output, intermediate consumption, gross value-added and taxes on product less subsidies. Using the 2011 supply table data for the chemical sector (NACE 20), the level of these variables for the petroleum sector can be estimated. Where output for the petroleum sector is given as:

$$X_{pet} = X_{pch} - X_{ch} \quad (5.1)$$

where  $X_{pch}$  represents the output for the combined petroleum and chemicals sector (as given in the 2011 CSO output data),  $X_{ch}$  is the output for the chemicals sector (obtained from the 2011 SUTs) and  $X_{pet}$  is the estimated output for the petroleum sector.

For gross value added, intermediate consumption and taxes on product less subsidies, the same approach is used:

For gross values added:

$$VA_{pet} = VA_{pch} - VA_{ch} \quad (5.2)$$

For intermediate consumption:

$$IC_{pet} = IC_{pch} - IC_{ch} \quad (5.3)$$

$$IC_{pet} = \sum_c Z_{cpet} \quad (5.4)$$

and for taxes on product less subsidies (net tax on production):

$$TAX_{pet} = TAX_{pch} - TAX_{ch} \quad (5.5)$$

We later use these estimated variables to capture the relative sizes of the petroleum and furniture and other manufacturing sectors in Ireland compared to other EU countries.

EUROSTAT provides supply tables for various EU countries and the EU27 and EA19, the monetary union.<sup>4</sup> Comparing the energy balances of the various EU countries, the EU27 and EA19 with that of Ireland, we believe that the EA19 best represents the energy structure of Ireland. For the disaggregation process, it is assumed that the EA19 flows can approximate the Irish relative flows within the economy from and to the petroleum and furniture and other manufacturing. In other words, for example 50% of PFOM commodities in the EA19 are used (for example, manufacturing chemicals), it is assumed that 50% of the Irish petroleum commodities are also used in the manufacturing of chemicals. Moreover, if in the EA19, 20% of total commodities produced by the petroleum sector are chemicals, 20% of commodities produced by the petroleum sector in Ireland are assumed to be chemical products.

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<sup>4</sup> Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovakia, Slovenia, and Spain.

Concerning the estimation of product sales in the supply table, to distinguish the share of each commodity produced by the activity PFOM that is designated as being produced by petroleum, both the estimated output of the petroleum and furniture and other manufacturing sectors and the share of each commodity's production in total production (output) in each sector in the EA19 are used. The share of each commodity in total production by the petroleum activity is referred to here as the supply table commodity share and is calculated as follows:

$$scs_{EU\text{pet}c} = \frac{X_{EU\text{pet}c}}{\sum_c X_{EU\text{pet}c}} \quad (5.6)$$

where  $X_{EU\text{pet}c}$  represents the value of commodity  $c$  produced by the activity petroleum, given in the EUROSTAT EA19 supply table for 2014. The share for furniture and other manufacturing is calculated in the same way.

The share of each commodity produced by the activity PFOM that is designated as being produced by petroleum is then given by:

$$ss_{\text{pet}c} = \frac{X_{\text{pet}} scs_{\text{pet}c}}{X_{\text{pet}c} scs_{EU\text{pet}c} + X_{\text{fm}} scs_{EU\text{fm}c}} \quad (5.7)$$

where  $X_{\text{fm}}$  and  $X_{\text{pet}}$  represent the output for the furniture and other manufacturing and petroleum sectors respectively in 2011, as calculated above.  $scs_{EU\text{fm}c}$  represents the supply table commodity share for the furniture and other manufacturing sector. In this way, we weight the EA19 shares by the relative magnitudes of the furniture and other manufacturing and petroleum sectors in Ireland.

The remainder is designated as furniture and other manufacturing:

$$ss_{\text{fm}c} = 1 - ss_{\text{pet}c} \quad (5.8)$$

The share of the PFOM commodities produced by the different activities that is designated as petroleum commodities (in the supply table rows) is calculated similarly by first calculating the EA19 supply table activity share:

$$sas_{EU\text{apet}} = \frac{X_{EU\text{apet}}}{\sum_a X_{EU\text{apet}}} \quad (5.9)$$

The share of the PFOM commodities produced by the different activities that is designated as petroleum commodities is then calculated as follows:

$$ss_{\text{apet}} = \frac{X_{\text{pet}} sas_{EU\text{apet}}}{X_{\text{pet}} sas_{EU\text{apet}} + X_{\text{fm}} sas_{EU\text{afm}}} \quad (5.10)$$

The remainder is designated as furniture and other manufacturing:

$$ss_{\text{afm}} = 1 - ss_{\text{apet}} \quad (5.11)$$

For the case of flows from petroleum and furniture and other manufacturing to themselves and each other, the share is calculated differently as follows, where for example the share of the PFOM produced by the petroleum activity is estimated by first estimating the EA19 share:

$$s_{ASEU\ pet\ pet} = \frac{X_{EU\ pet\ pet}}{X_{EU\ pet\ pet} + X_{EU\ pet\ fm} + X_{EU\ fm\ fm} + X_{EU\ fm\ pet}} \quad (5.12)$$

$$s_{SEU\ pet\ pet} = \frac{X_{pet} s_{ASEU\ pet\ pet}}{X_{pet} (s_{ASEU\ pet\ pet} + s_{ASEU\ pet\ fm}) + X_{fm} (s_{ASEU\ fm\ fm} + s_{ASEU\ fm\ pet})} \quad (5.13)$$

Note that the bulk of production in each activity falls in the corresponding commodity: almost all of the production of activity petroleum concerns the commodity petroleum.

The trade margins for the commodities are not given for the EA19. In this case, we have used data for the EA19 countries for which data are available.<sup>5</sup> First the shares of trade margins in total supply for each sector is calculated:

$$sm_{EU\ pet} = \frac{M_{EU\ pet}}{Z_{EU\ pet}} \quad (5.14)$$

$$sm_{EU\ fm} = \frac{M_{EU\ fm}}{Z_{EU\ fm}} \quad (5.15)$$

where  $M_{EU\ pet}$  is the sum of the payments of EA19 countries by the petroleum commodity to margins, and  $Z_{EU\ pet}$  represents the sum of the EA19 countries' total supply.

The share of total trade margins for PFOM that is designated to the petroleum commodity is then:

$$sm_{pet} = \frac{X_{pet} sm_{EU\ pet}}{X_{pet} sm_{EU\ pet} + X_{fm} sm_{EU\ fm}} \quad (5.16)$$

The imports of and sales taxes on petroleum products are directly calculated based on the 2014 EB and CSO trade data, where the remainder of the PFOM totals are designated as pertaining to the furniture and other manufacturing sector. This is described in more detail in the next section.

### 5.1.2 Use Table disaggregation

For disaggregating the use table, we use the same approach as in the case of the supply table. EUROSTAT, however, does not provide the use table at purchaser prices but at basic prices: purchaser prices are the sum of basic prices, net taxes on products, trade and transport margins and non-deductible VAT. This use table needs to be converted from basic to purchaser prices. To do this, the data concerning the use table in both basic and purchaser prices for the EA19 countries for which these data are available are collected.<sup>6</sup> A basic-to-purchaser multiplier is calculated for each of these countries (given by N) for each commodity

<sup>5</sup> Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Italy, Luxembourg, Netherlands, Portugal, Slovakia, Slovenia, and Spain.

<sup>6</sup> Estonia, France, Italy, Netherlands, Portugal, Slovenia.

and activity combination for the petroleum sector and furniture and manufacturing sectors. The example of the petroleum sector is shown here, where the basic-to-purchaser price multiplier is given as:

For the activity petroleum:

$$bpm_{ncpet} = \frac{ZPP_{ncpet}}{ZBP_{ncpet}} \quad (5.17)$$

where  $ZPP_{ncpet}$  are the values in the use table for country  $n$  commodity  $c$  for activity petroleum at purchaser prices and  $ZBP_{ncpet}$  at basic prices.

We then take the average multiplier by dividing the sum of these by the number of countries for which there is data ( $N$ ):

$$bpm_{EU\ pet} = \frac{\sum_n bpm_{ncpet}}{N} \quad (5.18)$$

For the commodity petroleum:

$$bpm_{npeta} = \frac{ZPP_{npeta}}{ZBP_{npeta}} \quad (5.19)$$

We then take the average multiplier by dividing the sum of these by the number of countries:

$$bpm_{EU\ peta} = \frac{\sum_n bpm_{npeta}}{N} \quad (5.20)$$

Using these multipliers, the EUROSTAT EA19 use table at basic prices is converted to purchaser prices. Finally, these multipliers are adjusted such that the relative shares of intermediate consumption for the petroleum and furniture and other manufacturing sectors hold (as calculated using 2011 CSO data):

$$ics_{pet} = \frac{IC_{pet}}{IC_{pet} + IC_{fm}} \quad (5.21)$$

This is done by multiplying each multiplier for each sector by the same factor; in other words all petroleum multipliers are multiplied by the same factor. Following this, this converted EUROSTAT use table in purchaser prices is applied to disaggregate the CSO use table for the PFOM sector.

Concerning the estimation of intermediate demand, the share of each commodity used by the activity PFOM that is designated as being used by the activity petroleum is calculated by first calculating the EA19 use table (in purchaser prices) activity share of intermediate consumption, which represents the share of commodity  $c$  in total intermediate demand by activity petroleum, and given by:

$$uc_{SEU\ cpet} = \frac{Z_{EU\ cpet}}{\sum_c Z_{EU\ cpet}} \quad (5.22)$$

where  $Z_{EU\ cpet}$  represents the value of commodities used by the activity petroleum in the converted EUROSTAT EA19 use table for 2014.

These shares are then weighted by the relative shares of the petroleum and furniture and other manufacturing sectors in intermediate consumption in 2011 given by the CSO. The share of commodities used

by the PFOM sector that is designated as being used by petroleum is hence calculated as follows:

$$us_{cpet} = \frac{IC_{pet} ucSEU_{cpet}}{IC_{pet} ucSEU_{cpet} + IC_{fm} ucSEU_{cfm}} \quad (5.23)$$

The remainder is designated as furniture and other manufacturing:

$$us_{cfm} = 1 - us_{cpet} \quad (5.24)$$

The share of the PFOM commodities used by the different activities that is designated as petroleum commodities is similarly estimated by first estimating the EA19 use table activity share of intermediate consumption, which represents the share of activity  $a$  in total intermediate demand of the petroleum commodity:

$$uas_{EU_{peta}} = \frac{Z_{EU_{peta}}}{\sum_a Z_{EU_{peta}}} \quad (5.25)$$

$$us_{peta} = \frac{IC_{pet} uas_{EU_{peta}}}{IC_{pet} uas_{EU_{peta}} + IC_{fm} uas_{EU_{fma}}} \quad (5.26)$$

The remainder is designated as furniture and other manufacturing:

$$us_{fma} = 1 - us_{peta} \quad (5.27)$$

For the case of flows from petroleum and furniture and other manufacturing to themselves and each other, the share is calculated differently as follows, where for example the share of the PFOM used by the petroleum activity is given by:

$$us_{petpet} = \frac{IC_{pet} uas_{EU_{petpet}}}{IC_{pet} (uas_{EU_{petpet}} + uas_{EU_{petfm}}) + IC_{fm} (uas_{EU_{fmpet}} + uas_{EU_{fmfm}})} \quad (5.28)$$

Concerning the shares of value-added, total gross value added (GVA) of PFOM is directly divided across the petroleum and furniture and other manufacturing sectors based on their gross value added provided for 2011. The share of the petroleum sector is then given as:

$$vas_{pet} = \frac{VA_{pet}}{VA_{pet} + VA_{fm}} \quad (5.29)$$

The operating surplus, net taxes, and consumption of fixed capital – the elements of GVA are also divided based on the levels of GVA for each sector.

Total final uses are calculated as the total uses (which is total supply in the supply table) minus total inter-industry demand (which is the sum of intermediate consumption over products). Total final uses ( $fu$ ) are then divided among the final uses (consumption of households, NPISH, government consumption, gross fixed capital formation, change in inventories, and exports) based on their shares in total final uses

for the EA19.

$$FU_{fupet} = \frac{TFU_{pet} FU_{EUfupet}}{TFU_{EUpet}} \quad (5.30)$$

Some of the final use elements are later adjusted when disaggregating petroleum products if more reliable data are available. This is discussed in the next section.

## 5.2 Petroleum products

The petroleum sector represents a single activity or industry. The petroleum commodities, however, need to be further disaggregated into gasoline, kerosene, fuel oil, LPG, diesel and other petroleum products. This is done based on the Irish EB published by the SEAI and the CSO's BEUS.

We convert the EB into tonnes and monetary units using different fuel prices derived from the SEAI domestic and commercial fuel costs archives and the IEA fuel costs data for Ireland. In Table 5.1, the prices for each fuel type used and the source are given, as well as the conversion factors used to calculate the fuel-specific CO<sub>2</sub> emissions.

**Table 5.1: IEA fuel costs data for Ireland**

Fuel type	Price (€/toe, excl. taxes)	Source	Emissions coefficient (tCO <sub>2</sub> /TJ)	Source
Gasoline	783.3	IEA	70.0	SEAI
Kerosene	741.1	IEA & SEAI	71.4	SEAI
Fuel Oil	771.4	IEA	73.3	SEAI
LPG	657.8	IEA & SEAI	63.7	SEAI
Diesel	1,048.0	IEA	73.3	SEAI

Disaggregating the supply table, we first disaggregate the supply of petroleum products produced by the petroleum sector. The above-calculated share of petroleum commodity produced by petroleum ( $ss_{petpet}$ ) is divided among the different petroleum products (given by  $pp$ ). This is based on the estimated monetary values of the EB of transformation output of refineries, calculated by:

$$TS_{pp} = p_{pp} SOR_{pp} \quad (5.31)$$

where  $p_{pp}$  is the price of the petroleum product  $pp$  in €/ktoe and  $SOR_{pp}$  is the quantity of supply by oil refineries in ktoe of  $pp$ . The supply share for each petroleum product is given as:

$$ss_{petpp} = \frac{SOR_{pp}}{\sum_{pp} SOR_{pp}} \quad (5.32)$$

For disaggregating the supply of petroleum commodities by other activities (which is extremely small), we apply the EXIOBASE dataset (Version 2.2.2). EXIOBASE is a global, detailed Multi-regional Environmentally Extended Supply and Use / Input-Output database. It was developed by harmonising and detailing SUTs for a large number of countries. This dataset focus on resources and includes a detailed disaggregation of the petroleum sector for Ireland. We calculate the share of each petroleum product in

supply by:

$$ss_{app} = \frac{S_{app}}{\sum_a S_{app}} \quad (5.33)$$

where  $S_{app}$  is the supply of the petroleum product by activity  $a$  in EXIOBASE.

To disaggregate the use table, we use the same approach but apply the BEUS data to determine which activities use which petroleum products. We divide the total use of petroleum products across the various products assuming the same shares as in the BEUS monetary data. Where our estimates of total petroleum product use differ significantly from those of the BEUS, our petroleum/furniture and other manufacturing shares are adjusted to replicate the BEUS estimates.

Total intermediate uses are used to divide the total share:

$$us_{app} = \frac{I_{app}}{\sum_{pp} IU_{app}} \quad (5.34)$$

where  $IU_{app}$  represents intermediate uses in monetary terms for each activity by petroleum product.

Imports are estimated based on both the EB and CSO import data, which give the value of imports for different product types defined using the Standard International Trade Classification (SITC, Rev 4). The aggregated CSO import data concerning petroleum, petroleum products and related material (SITC 33) are shared among the various petroleum products based on the monetary EB estimates.<sup>7</sup> Taxes on petroleum products are taken from the Revenue Commissioners' tax receipt data, which give carbon and other taxes on the different petroleum products.

### 5.3 Mining and quarrying

The MQE sector composes of various mining activities. It needs to be disaggregated into other mining, peat, coal, natural gas and crude oil. To disaggregate the different mining sectors, the EXIOBASE dataset (Version 2.2.2) and the 2007 CSO SUTs are utilised. In earlier CSO SUTs (up to 2007), a distinction was made 'mining' (coal, peat, crude oil, natural gas and metal ore extraction) and 'ther mining' (any other mining). EXIOBASE data display the same relative split between mining and other mining as the CSO data. These data are adjusted based on the EB to account for the relative decrease in natural gas production between 2007 and 2014. As will be discussed in the description of the EGS further on, it is assumed that natural gas used by activities is directly supplied by the natural gas extraction sector here. Furthermore, natural gas imports are also accounted for in the MQE sector.

#### 5.3.1 Supply Table disaggregation

Coal and crude oil are not extracted in Ireland; hence these sectors do not have a share in MQE domestic supply. All supply is imported. Coal and crude oil do not represent an activity and are only disaggregated as commodities. We define the different mining activities and commodities are defined as

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<sup>7</sup> Note that this category also includes crude oil, which falls under the mining sector and hence is excluded here.

*min*; these are coal, crude oil, peat, natural gas and other mining (though coal and crude oil are omitted in the supply case).

The supply table is disaggregated by assuming the same relative shares as EXIOBASE and the EB. The share of each commodity produced by MQE activity that is designated as being produced by each activity *min* is given by:

$$SS_{minc} = \frac{X_{Exiominc}}{\sum_{min} X_{Exiominc}} \quad (5.35)$$

where  $X_{Exiominc}$  represents the value of commodity *c* produced by activity *min* given by EXIOBASE.

The share of MQE commodities produced by the different activities that is designated as being each *min* commodity (in the supply table) is similarly given by:

$$SS_{amin} = \frac{X_{Exioamin}}{\sum_{min} X_{Exioamin}} \quad (5.36)$$

Regarding the case of flows from the mining sectors to themselves (hence the supply of mining commodities by mining activities), the CSO 2007 split between energy mining (natural gas and peat) and other mining is applied first to determine their relative sizes. Here, EXIOBASE is used to subtract metal ore mining from the CSO-defined mining to obtain energy mining and then add it to other mining. Energy mining is then split between natural gas and peat by applying the EB data, which give the most accurate estimate of the domestic supply of peat and natural gas for 2014.

The estimated monetary values of domestic production of peat and natural gas as given by the EB are calculated. The total supply in monetary terms ( $TS_{min}$ ) is calculated based on the 2014 EB as follows:

$$TS_{min} = p_{min} QI_{min} \quad (5.37)$$

where  $p_{min}$  is the price of the commodity *min* given by the SEAI in €/ktoe and  $QI_{min}$  is the quantity of intermediate use in ktoe of *min*.

Where the total supply of energy mining are used to divide the total share of energy mining supply:

$$SS_{minmin} = \frac{T_{min}}{\sum_{min} TS_{min}} \quad (5.38)$$

### 5.3.2 Use Table disaggregation

The use table disaggregation follows a similar methodology as the supply table, where the share of each commodity used by MQE activity that is designated as being used by *min* is given by:

$$SU_{cmin} = \frac{Z_{Exiocmin}}{\sum_{min} Z_{Exiocmin}} \quad (5.39)$$



where  $Z_{Exiocmin}$  represents the value of commodities  $c$  used by the mining sector  $min$  given in EXIOBASE or BEUS. For the sectors/commodities for which they are available, we have used BEUS 2014 data as they are more up-to-date and reliable.

The share of MQE commodities used by the different activities that is designated as  $min$  commodities is similarly given by:

$$su_{min} = \frac{Z_{Exiomina}}{\sum_{min} Z_{Exiomina}} \quad (5.40)$$

or the case of flows from mining activities to themselves and each other the share is calculated as follows, where the share of mining and quarrying commodities produced by mining that is designated as energy mining is similarly given by:

$$su_{minmin} = \frac{Z_{Exiominmin}}{\sum_{min} Z_{Exiominmin}} \quad (5.41)$$

Finally, the total value-added of the MQE needs to be distributed between peat, natural gas, and other mining activities. Value-added consists of four components: compensation of employees; net operating surplus; consumption of fixed capital; and net taxes on production (the term  $vac$  refers to these components). The total of these are shared between the activities based on their relative shares in the EXIOBASE data (adjusted for a decrease in natural gas production using the EB) and using CSO 2007 value-added data:

$$va_{vaca} = \frac{VA_{Exiovaca}}{\sum_{vac} Z_{Exiovaca}} \quad (5.42)$$

where  $VA_{Exiovaca}$  represents the value of the value-added component  $vac$  for the sector  $a$  given in EXIOBASE. The same approach is used to disaggregate the final demand.

## 5.4 Electricity and Gas

The EGS (NACE 35) is disaggregated into separate gas and electricity sectors. In the SUTs, natural gas is represented both in the MQE and EGS sectors. Examining the data, it is assumed that activities are supplied with natural gas directly from the natural gas extraction sector (within MQE). Furthermore, natural gas is imported in the MQE sector. The gas supply service sector provides gas supply services, such as the transmission and distribution of gas. This sector also supplies natural gas to households and the government.

### 5.4.1 Supply Table disaggregation

The EGS sector is separated into gas and electricity using the EXIOBASE data, the BEUS data and the EB data of 2014 and price data from the SEAI.

The supply of EGS commodities by EGS is disaggregated using the same relative shares as in the EB data. Total supply in monetary terms for natural gas and electricity ( $TS_{gas}$  and  $TS_{el}$ ) are calculated based on the 2014 EB. We show the calculations for gas, where the same approach is used for electricity, as

follows:

$$TS_{gas} = p_{gas} QS_{gas} \quad (5.43)$$

where  $p_{gas}$  is the price of the natural gas in €/ktoe and  $QS_{gas}$  the quantity of supply in ktoe.

The gas supply commodity that is produced by the gas supply is a share of the EGS supply:

$$ss_{gas} = \frac{T_{gas}}{TS_{gas} + TS_{el}} \quad (5.44)$$

The small amounts of supply from other sectors is shared among gas supply and electricity supply using the EXIOBASE shares. Imports are split using the CSO import data.

### 5.4.2 Use Table disaggregation

EGS use is split into gas supply and electricity use. To disaggregate the column – use by the EGS sector – EXIOBASE data are used, where the same shares as in the EXIOBASE data are used. The EGS row – the use by other activities of EGS – is split using the BEUS data using the monetary values. Value added is split using the EXIOBASE value-added shares. Final demand is split using the EB.

### 5.4.3 Further disaggregation of Electricity

The electricity production sector is further disaggregated into three sectors: electricity production by conventional inputs and technology ( $A\_ELC$ ), by wind ( $A\_WND$ ), and by other renewable resources ( $A\_ORE$ ). EXIOBASE is applied to disaggregate electricity production, which contains data on electricity production by different resources/inputs. Among all renewable resources, wind has the highest share in the electricity production in 2021 and is expected to remain the largest renewable energy source in the future in Ireland.

## 5.5 Carbon Tax

Carbon taxes are estimated using the Revenue Commissioners' data on tax receipts. These data give both carbon tax and other excises on solid fuels, electricity and the various oils and fuels such as gasoline, diesel, LPG. The volumes of petroleum products taxed are also compared with estimations to ensure consistency.

## 6 Household Disaggregation

As stated by CSO (2015), the main focus of the HBS is consumption expenditure, and the main focus of SILC is the measurement of income, poverty, social exclusion and living conditions. Therefore, in the calibration of the required household-level parameters concerning the composition of income, the SILC is used. The consumption side, on the other hand, is calibrated by using the HBS.

In the current version of the model, ten different household groups are defined based on their disposable income. In the HBS, the CSO provides disposable income quantiles (20 groups) separately for urban and rural areas. These households are merged into five groups in rural areas and five groups in urban areas. In the SILC data set, since there is no directly available quintile variable, households are assigned into a group uniquely by using two available variables: `urb_rur` states the area of residence and `ann_dispinc`, which is total net disposable household income after social transfers using the national definition of income. For each area of residence, the income variable is disaggregated into five groups, each of which includes the same number of households. Following this, the SILC income items are aggregated into four groups as follows.

**Table 6.1: Aggregation Key of the SILC Income Items to the I3E Income Items**

SILC Code	Definition	Income Item
<code>ann_emp_inc</code>	Employee income	Wage
<code>ann_self_emp</code>	Cash benefits or losses from self-employment	Wage
<code>ann_inv_inc</code>	Amount received in investment income	Capital/Asset
<code>ann_othinc</code>	Other direct income	Capital/Asset
<code>ann_prop_inc</code>	Amount received in income from rental of property or land	Capital/Asset
<code>ann_child_all</code>	Family/children related allowances	Transfer
<code>ann_disab_ben</code>	Amount received in disability benefits	Transfer
<code>ann_ed_ben</code>	Amount received in education-related allowances	Transfer
<code>ann_house_all</code>	Housing allowances	Transfer
<code>ann_othst</code>	Other social transfers	Transfer
<code>ann_sick_ben</code>	Amount received in sickness benefits	Transfer
<code>ann_socexcl_all</code>	Amount received in other social transfers	Transfer
<code>ann_unemp</code>	Unemployment benefits	Transfer
<code>ann_oldage_ben</code>	Old-age benefits	Pension
<code>ann_priv_pen</code>	Amount received in private pensions	Pension
<code>ann_sur_ben</code>	Amount received in survivors benefits	Pension

*Note:* All items are total household annual income.

Following this, the share of each household group in each income item (wage, asset, welfare transfer, and pension) is calculated, and these parameters are used to disaggregate the figures across households on the HH row in Table 4.1. The sum of income items for each household yields the disposable income of the household group – the row sum of the respective HH columns.

In the disaggregation of the column items on the HH column in Table 4.1, the only required information is the distribution of commodity  $c$ 's consumption across household groups. To obtain the parameters to perform this disaggregation, each consumption item in the HBS is mapped to a commodity defined in the I3E model, as shown in Appendix III. In this way, total household consumption demand of each commodity can be allocated across the household types. Ensuring an accounting balance of the household accounts requires that the sum of consumption demand of each household be subtracted from the disposable income of the respective household group to get the household level private savings (S-I,HH).

## References

- CSO. (2015). *A Consistency Check between Five EU-SILC Indicators Compiled from EU-SILC 2010 and HBS 2010*. [https://www.cso.ie/en/media/csoie/methods/surveyonincomeandlivingconditions/A\\_Consistency\\_Check\\_between\\_SILC\\_2010\\_and\\_HBS\\_2010.pdf](https://www.cso.ie/en/media/csoie/methods/surveyonincomeandlivingconditions/A_Consistency_Check_between_SILC_2010_and_HBS_2010.pdf).
- CSO. (2017). *National Income and Expenditure 2017 Frequently Asked Questions (Information Note)*. Central Statistical Office (CSO). <https://www.cso.ie/en/methods/nationalaccounts/din/nie2017faq/>.
- EUROSTAT. (1995). *European System of Accounts (ESA 1995)*.
- EUROSTAT. (2008). *Eurostat Manual of Supply, Use and Input-Output Tables*.
- EUROSTAT. (2013). *European System of Accounts (ESA 2010)*.
- Pyatt, G. (1988). A sam approach to modeling. *Journal of Policy Modeling*, 10(3), 327-352.
- Round, J. (2003). Social Accounting Matrices and SAM-based Multiplier Analysis. In F. Bourguignon & L. A. Pereira da Silva (Eds.), *The Impact of Economic Policies on Poverty and Income Distribution: Evaluation Techniques and Tools* (chap. 14). The World Bank, Washington, DC.
- UN. (1999). *Handbook of Input-Output Table Compilation and Analysis*.

## Appendix I Valuation

Trade and transportation margins and net taxes on products (taxes minus subsidies) comprise one of the basic components of the valuation process. EUROSTAT (1995) distinguishes between two main valuation concepts of the flows of goods and services: purchaser prices and basic prices.

- **Purchaser prices** is the price the purchaser actually pays for the products. It includes any taxes less subsidies on the products (but excluding deductible taxes like a value-added tax (VAT) on the products); and any transport charges paid separately by the purchaser to take delivery at the required time and place. Since final consumers confront that price in the market, it also corresponds to the commodity's retail price.
- **Basic prices** is the price receivable by the producer from the purchaser for a unit of a good or service produced. It is output minus any tax payable on that unit as a consequence of its production or sale (taxes on products), plus any subsidy receivable on that unit as a consequence of its production or sale (subsidies on products). It excludes any transport charges invoiced separately by the producer. It includes any transport margins charged by the producer on the same invoice, even when they are included as a separate item on the invoice.

The difference between these two basic valuation concepts relates therefore to 'trade and transport margins' on the one hand, and to 'taxes less subsidies' on products on the other. Producer prices were the main valuation concept in the former system of national accounts. When we also introduce the concept of producer prices, the difference between these two valuation concepts can be attributed to the two factors.

- **Producer prices** is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any value added tax invoiced to the purchaser. It excludes any transport charges invoiced separately by the producer.

Thus, the relationship between the different types of prices can be shown as follows:

Purchaser price (excluding any deductible VAT)

- Non-deductible VAT
- Trade and transport margins

= Producer price

- Taxes on products (excl. VAT)
- + Subsidies on products

= Basic price

Producer prices do not include the cost of margins, since these are not part of the production process. These costs are paid by final users of commodities and are included in purchaser prices. Since a commodity is produced by several activities and the cost of margins is paid by consumers, margins are demanded by commodities, and they are reported as a part of the use table.

## Appendix II Lists of Activities and Commodities

**Table II.1: Activities**

Abbreviation	Name	NACE Codes
A.ACC	Accommodation and Hotel Services	55-56
A.AGR	Agriculture	1-3
A.ATS	Air Transportation	51
A.BFM	Basic Metal Manufacturing	24-25
A.BPP	Basic Pharmaceutical Products	21
A.CHE	Chemical Products	20
A.CON	Construction	41-43
A.EDU	Education Sector	85
A.FBT	Food, Beverage and Tobacco	10-12
A.FSR	Financial Services	64-66
A.HHS	Health Sector	86-88
A.HTP	High-Tech Products	26-28
A.LTS	Land Transportation	49
A.NGS	Natural Gas Supply	
A.OIN	Other Industrial Products	17,18,33
A.OMN	Other Mining Products	
A.ONM	Other Non-metallic Products	23
A.OTM	Other Manufacturing	31-32
A.PEA	Peat	
A.PET	Petroleum	
A.PUB	Public Sector	84
A.RES	Real Estate Services	68
A.RUP	Rubber and Plastic Products	22
A.TEL	Telecommunication Services	61
A.TEX	Textile	13-15
A.TRD	Trade	45-47
A.TRE	Transportation Equipment	29-30
A.WAT	Water and Sewerage	36,37-39
A.WTS	Water Transportation	50
A.WWP	Wood and Wood Products	16
A.OTR	Other Transport (Storage and Postal)	52-53
A.PSE	Professional Services	69-75
A.ADS	Admin and Support Services	77-82
A.OSE	Other Services	remaining*
A.ELC	Electricity	
A.WND	Wind	
A.ORE	Other Renewables	

\*: It excludes NACE codes 5-9 (Mining, Quarrying and Extraction), 19 (Petroleum Products), and 35 (Electricity and Gas Supply).

**Note:** The activities without NACE codes are further disaggregated sectors.

**Table II.2: Commodities**

C_AGR	Agriculture	C_HTP	High-tech products
C_PEA	Peat	C_TRE	Transportation equipment
C_COA	Coal	C_ELC	Electricity
C_CRO*	Crude oil	C_NGS	Natural gas
C_OMN*	Other mining	C_WAT	Water and sewerage
C_FBT	Food, beverage, and tobacco	C_CON	Construction
C_TEX	Textile	C_TRD	Trade
C_WWP	Wood and wood products	C_LTS	Land transportation
C_OIN	Other industrial products	C_WTS	Water transportation
C_GAL	Gasoline	C_ATS	Air transportation
C_KRS	Kerosene	C_OTR	Other transportation
C_FUO*	Fuel-oil	C_ACC	Accom. and hotel serv.
C_LPG	Liquid petroleum gas	C_TEL	Telecommunication services
C_DIE	Diesel	C_FSR	Financial services
C_OPP	Other petroleum products	C_RES	Real estate services
C_OTM	Other manufacturing	C_PSE	Professional services
C_CHE	Chemical products	C_ADS	Admin and support services
C_BPP	Basic pharmaceuticals	C_PUB	Public services
C_RUP	Rubber and plastic	C_EDU	Education
C_ONM	Other non-metallic minerals	C_HHS	Health
C_BFM	Basic fabricated metals	C_OSE	Other services

\*: Not subject to private consumption.

### Appendix III Mapping of HBS Consumption to the I3E Model

HBS	Definition	I3E
H01_01_16	Takeaway food brought/delivered to home	C_ACC
H01_02	Meals away from home (incl. takeout tea/coffee)	C_ACC
H02_02	Drink consumed out	C_ACC
H09_09	Holiday expenditure	C_ACC
H09_19_02	Catering services (e.g. for wedding)	C_ACC
H05_12	Other services relating to dwelling	C_ADS
H05_16	Central heating maintenance	C_ADS
H05_18	Central heating installation	C_ADS
H07_15	Repairs and insurance for household appliances	C_ADS
H09_04	Admission and subscription charges - sports and leisure	C_ADS

H09_12_04	Conveyancing, estate agents and surveyors	C_ADS
H09_19_04	Room hire (e.g. function room)	C_ADS
H01_01_10	Total fish	C_AGR
H01_01_11	Fruit and nuts	C_AGR
H01_01_12	Vegetables	C_AGR
H08_06_02	Air travel within ROI	C_ATS
H08_06_03	International air travel	C_ATS
H07_17	Cutlery	C_BFM
H07_18	Kitchen utensils	C_BFM
H07_20	Small tools (e.g. hammer, spanner, saw)	C_BFM
H06_08	Hair products	C_BPP
H06_09	Cosmetics and related accessories	C_BPP
H06_10	Baby toiletries/accessories (e.g. nappies)	C_BPP
H09_01_01	Prescription medication	C_BPP
H09_01_02	Over the counter (OTC) medicines	C_BPP
H09_01_03	Other medical products (plasters, bandages, etc.)	C_BPP
H09_01_10	Spectacles and lenses (including accessories and repairs)	C_BPP
H09_13	Plants, flowers, seeds, fertilisers and insecticides	C_BPP
H06_01	Detergents, washing up liquid and washing powder	C_CHE
H06_02	Disinfectants, polishes and other cleaning materials	C_CHE
H06_03	Non-durable small household articles	C_CHE
H06_04	Toilet paper	C_CHE
H06_05	Toiletries - disposable (e.g. toothpaste)	C_CHE
H06_06	Toilet soap, liquid soap, shower gel, etc.	C_CHE
H06_07	Toilet requisites (e.g. toothbrush and comb)	C_CHE
H05_15	Other materials for the maintenance and repair of the dwelling	C_CON
H05_17	Services for maintenance & repair of the dwelling (e.g. electrician, painter)	C_CON
H05_19	Capital improvements contractor (e.g. extension and room conversion)	C_CON
H08_02_02	Diesel	C_DIE
H09_07	Education and training	C_EDU
H04_01	Electricity	C_ELC
H01_01_01	Bread	C_FBT
H01_01_02	Flour	C_FBT
H01_01_03	Pastries and biscuits	C_FBT
H01_01_04	Breakfast cereals	C_FBT
H01_01_05	Milk, cream yoghurts and cheese	C_FBT
H01_01_06	Butter, fats and cooking oil	C_FBT



H01.01.07	Eggs	C_FBT
H01.01.08	Pasta, pizza, quiche and grains	C_FBT
H01.01.09	Meat	C_FBT
H01.01.13	Sugars, confectionary and snacks	C_FBT
H01.01.14	Other food items	C_FBT
H01.01.15	Non-alcoholic beverages	C_FBT
H02.01	Drink consumed at home	C_FBT
H02.03	Tobacco	C_FBT
H05.06	Second dwelling - mortgage and home insurance	C_FSR
H05.08	Primary dwelling insurance	C_FSR
H08.03.01	Vehicle insurance	C_FSR
H08.03.02	Travel insurance	C_FSR
H09.10	Insurance/pension premiums	C_FSR
H09.12.07	Bank service charges	C_FSR
H09.12.08	Bank and Post Office counter charges	C_FSR
H09.12.09	Fees and service charges of brokers/investment consultants	C_FSR
H08.02.01	Petrol	C_GAL
H09.01.04	Doctor (not consultant)	C_HHS
H09.01.05	Dentist	C_HHS
H09.01.06	Specialist practice (including consultant, orthodontist)	C_HHS
H09.01.07	Physiotherapy and other paramedical services/fees	C_HHS
H09.01.08	Services of medical analysis labs	C_HHS
H09.01.09	Hospital services	C_HHS
H07.05	Fridges and freezers	C_HTP
H07.06	Washing machines, spin and tumble dryers	C_HTP
H07.07	Dishwasher	C_HTP
H07.08	Gas cooker	C_HTP
H07.09	Electric cooker and combined electric/gas (including microwave)	C_HTP
H07.10	Other major household appliances (including rental)	C_HTP
H07.11	Heaters/air conditioners/shower units etc.	C_HTP
H07.12	Cleaning equipment (e.g. vacuum)	C_HTP
H07.13	Small electric household appliances	C_HTP
H07.14	Gas/electric appliances spare parts	C_HTP
H07.19	Electrical tools for house and garden	C_HTP
H07.21	Electrical consumables (e.g. batteries, bulbs)	C_HTP
H07.22	Lighting equipment	C_HTP
H07.23	Audio equipment	C_HTP
H07.24	Accessories for audio equipment	C_HTP

H07_25	Television sets	C_HTP
H07_26	DVD and digital media players	C_HTP
H07_27	Satellite dish purchase	C_HTP
H07_28	TV/video/audio/computer - spare parts	C_HTP
H07_29	Cameras, camcorders and accessories	C_HTP
H07_30	Optical instruments (e.g. binoculars)	C_HTP
H07_31	Computers (including media tablets, laptops)	C_HTP
H07_32	Printers, ink cartridges, calculators and computer accessories	C_HTP
H07_33	Consoles for computer games	C_HTP
H07_36	DVD and CD (pre recorded and blank)	C_HTP
H07_37	Film/memory card, hard drives and memory sticks	C_HTP
H07_44	Lawn mowers	C_HTP
H07_45	Electrical items for personal care (e.g. hair dryer)	C_HTP
H09_02_01	Telephone, answering and fax machine - purchase and repair	C_HTP
H09_02_02	Mobile phone/car phone purchase	C_HTP
H04_03	Liquid Fuels (e.g. heating oil)	C_KRS
H08_05	Bus, Luas, rail and taxi	C_LTS
H08_06_04	Other purchased transport services	C_LTS
H04_02	Gas	C_NGS
H07_43	Garden accessories	C_OIN
H07_16	Glassware, china and pottery	C_ONM
H07_46	Fancy and decorative goods (e.g. mirrors)	C_ONM
H08_02_03	Other fuels and lubricants for personal transport	C_OPP
H07_02	Furniture recovering and repairs	C_OSE
H07_38	Repairs and/or insurance of TV, video, audio, DVD and computer	C_OSE
H07_41	Repair and maintenance of other major durables for recreation	C_OSE
H09_05	Betting and lotteries	C_OSE
H09_12_03	Trade union and professional organisation contributions	C_OSE
H09_14	Hairdressing and personal grooming	C_OSE
H09_15_03	Repair to personal goods	C_OSE
H09_15_04	Personal goods not otherwise specified	C_OSE
H09_18_05	Charitable donations and subscriptions	C_OSE
H09_19_01	Present - not specified	C_OSE
H09_19_03	Funeral expenses	C_OSE
H09_19_07	Cleaning of clothing	C_OSE
H09_19_08	Cleaning of clothing	C_OSE
H09_19_09	Footwear repair and hire	C_OSE

H09_19_10	Other services (e.g. photocopying and newspaper advert)	C_OSE
H09_19_11	Celebration articles	C_OSE
H05_23	Carpets and rugs	C_OTM
H07_01	Household furniture	C_OTM
H07_39	Musical instruments (purchase and hire)	C_OTM
H07_40	Major durables for indoor recreation	C_OTM
H07_42	Garden furniture	C_OTM
H09_01_11	Therapeutic equipment - non optical items (e.g. wheelchair)	C_OTM
H09_08	Games and items for sports and open-air recreation	C_OTM
H09_15_01	Jewellery, clocks and watches	C_OTM
H09_16_02	Baby utensils and articles	C_OTM
H09_19_05	Postage (e.g. stamps and registered mail)	C_OTR
H04_04	Solid Fuels	C_PEA
H09_11	Pet costs	C_PSE
H09_12_01	Legal fees paid to solicitors	C_PSE
H09_12_12	Other licences	C_PSE
H09_17	Care, domestic and household services	C_PSE
H09_19_06	Photographic services	C_PSE
H09_12_10	Passport fees	C_PUB
H09_12_11	Birth/death/marriage certificate fees	C_PUB
H05_01	Rent paid for primary dwelling	C_RES
H05_02	Ground rent and other rentals paid by tenants	C_RES
H05_03	Second dwelling rent	C_RES
H05_04	Mortgage payment (primary dwelling)	C_RES
H05_05	Purchase (including deposit) on primary dwelling	C_RES
H05_07	Purchase (including deposit) on second dwelling	C_RES
H05_14	Equipment hire and small material purchase (e.g. sandpaper)	C_RUP
H05_20	Double glazing, kitchen units, sheds, etc.	C_RUP
H05_21	Purchase of materials for capital improvements	C_RUP
H05_22	Bathroom fittings	C_RUP
H05_24	Hard floor coverings	C_RUP
H07_34	Computer games/software	C_TEL
H07_35	Downloads, streaming, apps and other internet services n.e.c	C_TEL
H09_02_03	Telephone account payment	C_TEL
H09_02_04	Mobile phone account payments	C_TEL
H09_02_05	Mobile phone top-up and other payments	C_TEL
H09_03	Internet, telephone and television subscriptions	C_TEL

H09_06	Reading materials	C_TEL
H03	Total clothing and footwear	C_TEX
H07_03	Bedroom textiles	C_TEX
H07_04	Other household textiles	C_TEX
H09_15_02	Leather and travel goods	C_TEX
H08_04	Vehicle maintenance and other costs	C_TRD
H08_06_01	Delivery charges (e.g. for takeaways) and other transport services	C_TRD
H08_01	Vehicles (net of trade in)	C_TRE
H09_16_01	Prams, pushchairs and car seats	C_TRE
H05_10	Water charges	C_WAT
H05_11	Refuse/sewage collection and skip hire	C_WAT
H05_13	Paint, wallpaper, timber and plaster	C_WWP

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