INPUT OUTPUT MEASUREMENT TABLES: METHODOLOGY AND RESULTS

Introduction

This document describes the construction of an Input-Output framework with a special focus on measurement goods and services.

The analysis serves two primary purposes:

- For the improved comprehension of the reader, it draws together key information from each chapter of the *Quantifying Measurement Activity in the UK* report, thus providing an overview, in tabular form, of where each source of measurement activity originates from.
- It expands upon the aggregated figures published in the *Quantifying Measurement Activity in the UK* report by showing the intermediate transactions that take place within the economy, thereby revealing the interdependency between measurement and other sectors.

The Input-Output Supply and Use Tables (SUTs) provide a picture of the flows of products and services in the economy for a single year and are used to set the level of annual Gross Domestic Product (GDP). Packaged within the Input-Output Analytical Tables (IOATs), there are three versions of the SUTs: a 'Domestic-Use' table, an 'Imports-Use' table, and a 'Combined-Use' table, showing separately the consumption of domestically produced and imported goods and services. This distinction is important because it provides the theoretical framework for further analysis of the structure of the economy, plus the composition and the effect of changes in final demand on the economy. Further derivations are made from the latter two tables to create the Matrix of Coefficients, Leontief Inverse, and Multipliers and Effects tables. Together, these tables form an essential tool for economic modelling.

The first IOATs in the UK were published in 1954 and have been reproduced roughly every five years since. The Office for National Statistics (ONS) published the most recent IOATs in 2016.

In this analysis, we have adapted the 'Domestic-Use' and 'Imports-Use' tables from the 2016 version of the IOATs using a method assisted by previous versions of the IOATs, in which a more granular classification of products and industries was used, as well as the estimates formulated within the *Quantifying Measurement Activity in the UK* report to highlight the influence of measurement goods and services on the economy.

Future iterations of this work may attempt to create, in the same manner, the remaining tables from the IOATs in order to draw further insights regarding the importance of measurement.

1. THE INPUT OUTPUT FRAMEWORK

The UK IOATs are a National Accounts product of the ONS. Key to understanding the Input-Output framework is making the distinction between the Input-Output SUTs and the derived IOATs.

1.1. SUPPLY AND USE TABLES

The SUTs consist of two product by industry matrices: the Supply Table and the Use Table. The Supply Table shows the output of each industry by type of product, where the diagonal elements can be interpreted as the principal product of an industry and the off-diagonal

elements are secondary production or by-products of the production process. We will not focus on these tables because they are not published by ONS.

The Use Table shows the demand for goods and services by product and by component of total demand. Total demand is the sum of intermediate demand and final demand, of which there are several sub-groups. These are defined in *Table 1.* The intermediate section of the Use Table also shows the components of value added (labour costs, gross operating surplus, taxes on production) for each industry.

Demand type			Definition
Total demand	Intermediate demand	Intermediate	Goods and services consumed as inputs by a process of production. They may be either transformed or used up by the production process.
	Final demand	Households	Goods and services consumed by households.
		Government	Goods and services consumed by government.
		Non-profit organisations serving households (NPISH)	Goods and services consumed by non-profit organisations which are not mainly financed and controlled by government and which provide goods and services to households for free.
		Gross fixed capital formation (GFCF)	Investment less disposals in fixed assets produced as outputs from production processes that are used repeatedly for more than one year.
		Acquisitions less disposals of valuables	Acquisitions less disposals of produced assets.
		Changes in inventories	Changes in stocks outputs, products, strategic stocks managed by government, and work in progress.
		Exports	Exports of goods and services.

Table 1: Definitions of types of demand

Products are listed down the rows and the industries are listed along the columns and are defined by the most recent versions of their respective classifications. For 2016, industries are defined using the 2007 version of the Standard Industrial Classification (SIC 07) and products are defined using the 2008 Classification of Products by Activity (CPA 08), both at the two-digit level.

Table 2 depicts the structure of the Combined-Use Table. In this table, intermediate demand and final demand by product are valued at purchasers' prices (the prices that purchasers actually pay) and include both domestically produced and imported goods and services.

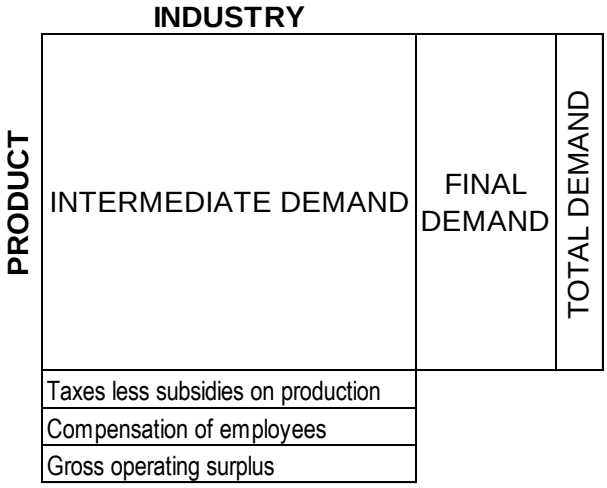

Table 2: Combined-Use Table (at purchasers' prices)

1.2. DOMESTIC-USE AND IMPORTS USE TABLES

The Domestic-Use Table removes imports of goods and services from the intermediate demand and final demand sections and is shown separately as a new row. In addition, this table is converted to basic prices (the price that producers receive less any tax payable, plus any subsidy receivable). Firstly, margins are redistributed from the estimates of goods in the intermediate demand and final demand sections and added to the distribution products (i.e. wholesale and retail). Secondly, ONS estimates taxes less subsidies on products using various data sources and shows their value separately as a new row. Table 3 depicts the structure of the Domestic-Use Table.

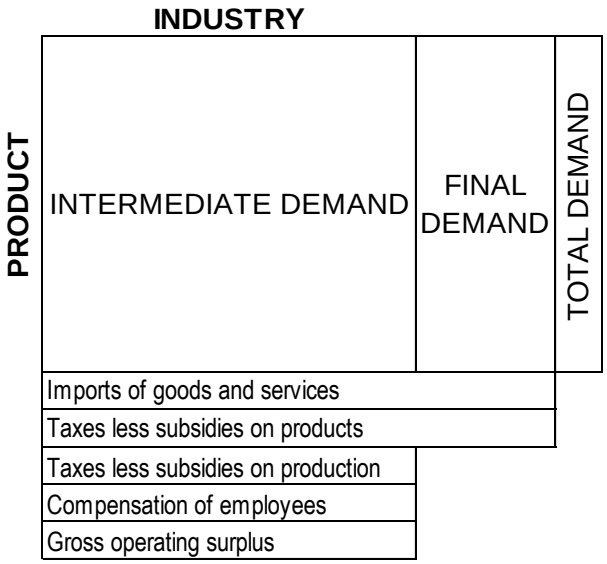

Table 3: Domestic-Use Table (at basic prices)

The Imports-Use Table shows the demand for imported goods and services and has the same structure as the Domestic-Use Table less the additional bottom five rows.

1.3. ANALYTICAL TABLES

The main difference between the IOATs and the SUTs is that the SUTs are asymmetric (product by industry) whereas the IOATs are symmetric (product by product or industry by industry).

The asymmetric Domestic-Use and Imports-Use tables are converted to symmetric tables using a methodology not entirely known.

These symmetric tables are required to derive tools such as the Matrix of Coefficients and Leontief Inverse.

Table 4 lists all the tables included in the detailed IOATs. For this iteration of the analysis, we only have the resources to work with the asymmetric tables and so goes no further to attempt to create alternate versions of other resources in the IOATs not described up till now.

The remainder of this document describes the methodology behind the construction of a measurement focused Domestic-Use and Imports-Use table.

Category	Title
Product by industry tables	Combined-Use (at purchasers' prices)
	Transition matrix (from purchasers' prices to basic prices)
	Domestic-Use Table (at basic prices)
	Imports-Use Table
Product by product tables	Domestic-Use Table (at basic prices)
	Imports-Use Table (at basic prices)
	Matrix of Coefficients
	Leontief Inverse
Further analyses	Multipliers and effects (output, employment cost and GVA)
	Composition of final demand in terms of direct and indirect GVA
	Industrial analysis of primary inputs
	Classification key
	Imports EU and non-EU

Table 4: Full list of resources included in the detailed IOATs

2. CONSTRUCTION OF THE INPUT OUTPUT MEASUREMENT TABLES

This section describes the methodology for creating Domestic-Use and Imports-Use tables that highlight the flows of measurement related goods and services within the economy; these are referred to as the Input-Output Measurement Tables (IOMTs) from herein.

We begin by modifying the existing Use tables from the 2016 IOATs to create simplified versions which focus on industries with the highest dependency on measurement. Then, we implement the relevant aggregated estimates generated within the *Quantifying Measurement Activity in the UK* report, in conjunction with some further analysis to draw the necessary detail from them, to fill the newly created blank spaces in the simplified table.

2.1. SIMPLIFIED USE TABLES

On the left-hand side of *Table 5* is a replica of *Table 3* – the Domestic-Use Table. The table on the right-hand side of *Table 5* is identical but with each corresponding section numbered for ease of reference. Each numbered section of the Domestic-Use Table undergoes modification to create the Domestic-Use IOMT.

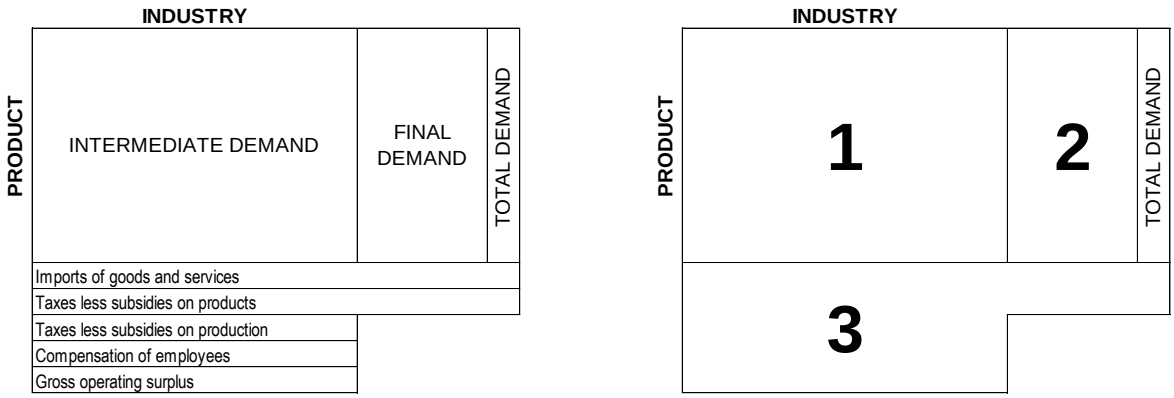

Table 5: Numbering the sections of the Domestic-Use Table (at basic prices) for modification

Section 1: This part of the table is a square matrix, where products and corresponding industries are represented at the two-digit level in the CPA 2008 and SIC 2007 classifications, respectively. For example, CPA_02 and SIC_02 are both described as 'Forestry and logging'. These codes range from 01 to 97.

We condense the grouping of both products and industries (to maintain a square matrix) into broader sectors to draw attention to areas of the economy that are particularly measurement intensive. Furthermore, aggregating CPA and SIC codes will make for more accurate estimation further down the line. *Table 6* lists the new grouping of products and industries for the IOMTs.

CPA/SIC code	Product/Industry description	Further notes
10 – 33	Manufacturing	All manufacturing activities. Corresponds directly to SIC sector C.
05 – 09, 35 – 43	Other production	All mining, quarrying, utilities (water, gas, electric, waste) and construction. Corresponds directly to SIC sectors B, D, E and F.
45 – 53	Wholesale, retail and transport	Includes wholesale and retail trade, transportation and postal and courier activities. Corresponds directly to SIC sectors G and H.
61 – 63	ICT	Telecommunications, computer programming and information service activities.
71	Technical testing and analysis	A combination of technical testing and analysis and architectural and engineering activities.
72	Research and development	Research and development activities.

84	Central government activities	Includes public administration, compulsory social security and, crucially, defence activities.
86	Health	All human health activities, not including residential care or social work activities.
All else	Other	An accumulation of low measurement intensive activities.

Table 6: IOMT Product/Industry Grouping

Finally, an additional product/industry group is added, called Instrumentation. This group represents products of instrumentation and the industry that manufactures those products. This product/industry is a subset of the Manufacturing product/industry which subsequently becomes Manufacturing less instrumentation. There is no two-digit CPA/SIC code that corresponds directly to Instrumentation which is why we make this distinction after the regrouping of products and industries. In total there are 10 products/industries in the IOMTs.

Section 2: *Table 7* represents all the components of final demand included in the 2016 Use Tables, where columns:

- A + B + C = D
- F + G = H and E + H = I
- J + K = L
- D + I + L = M

A	B	C	D	E	F	G	H	I	J	K	L	M
Consumption by households	Consumption by NPISHs	Consumption by government	Final consumption	GFCF	Acquisitions less disposals of valuables	Changes in inventories	Changes in inventories and acquisition less disposals of valuables	Gross capital formation	EU Member States (evolving composition) including EU institutions	Extra-EU (evolving composition)	Total exports	Total final use

Table 7: Components of final demand included in the 2016 Use Tables

For simplification, in the IOMTs we remove columns:

- D
- F, G, H and I. Changes in inventories and acquisitions less disposals of valuables account for a relatively trivial amount of final demand and so, for simplification, we neglect these columns in the IOMTs. Their value is still accounted for in the total demand column.
- J and K
- M

Finally, we combine columns B and C, as these both represent non-market consumption, to create ‘consumption by government and NPISHs’.

Section 3: Like section 2, simplifications and modifications were made to the rows in section 3 of the 2016 Use Tables. *Table 8* represents all the additional inputs of consumption/output included in the 2016 Use Tables, where rows:

- N + O + P = Q (this is intermediate consumption at purchasers’ prices)
- U + V = W
- R + T + W = Y
- Q + Y = Z

N	Total
O	Use of imported products, cif
P	Taxes less subsidies on products
Q	Total intermediate consumption/final use
R	Compensation of employees
S	Wages and salaries
T	Other taxes on production minus other subsidies on production
U	Consumption of fixed capital
V	Operating surplus and mixed income, net
W	Operating surplus and mixed income, gross
X	Mixed income, gross
Y	Value added, gross
Z	Output

Table 8: Inputs of consumption/output included in the 2016 Use Tables

For simplification, in the IOMTs we remove rows:

- Q
- S (row R includes S plus additional employee benefits)
- U, V and X.

Finally, we split row R into three separate rows: Compensation of employees (Calibration); Compensation of employees (Testing); and Compensation of employees (Non-measurement). The former two rows indicate the cost of labour for solely measurement related activities. The distinction between calibration and testing activities is made in the *Quantifying Measurement Activity in the UK* report.

Combining the modifications from all three sections of the Use Table we construct the full Domestic-Use IOMT, depicted in *Table 9*, and the Imports-Use IOMT, depicted in *Table 10*.

	Instrumentation	Manufacturing	Other production	Wholesale, retail and transport	ICT	Technical testing and analysis	R&D	Central gov. activities	Health	Other	Total intermediate demand	Households	Gov. and NPISHs	GFCF	Exports	Total demand
Instrumentation																
Manufacturing																
Other production																
Wholesale, retail and transport																
ICT																
Technical testing and analysis																
R&D																
Central gov. activities																
Health																
Other																
Total consumption																
Imports of goods and services																
Taxes less subsidies on products																
Taxes less subsidies on production																
Compensation of employees (Calibration)																
Compensation of employees (Testing)																
Compensation of employees (Non-measurement)																
Gross operating surplus																
Gross value added																
Total output																

Table 9: Structure of the Domestic-Use IOMT

	Instrumentation	Manufacturing	Other production	Wholesale, retail and transport	ICT	Technical testing and analysis	R&D	Central gov. activities	Health	Other	Total intermediate demand	Households	Gov. and NPISHs	GFCF	Exports	Total demand
Instrumentation																
Manufacturing																
Other production																
Wholesale, retail and transport																
ICT																
Technical testing and analysis																
R&D																
Central gov. activities																
Health																
Other																
Total imports																

Table 10: Structure of the Imports-Use IOMT

3. POPULATING THE INPUT-OUTPUT MEASUREMENT TABLES

The IOMTs are largely just reduced versions of the original Use Tables. However, the inclusion of the product/industry Instrumentation, plus the distinction between measurement and non-measurement labour costs, creates cells within the IOMTs that cannot be derived directly from the original Use Tables. *Table 11* illustrates how each cell within the Measurement Domestic-Use Table is calculated.

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		Instrumentation	Manufacturing	Other production	Wholesale, retail and transport	ICT	Technical testing and analysis	R&D	Central gov. activities	Health	Other	Total intermediate demand	Households	Gov. and NPISHs	GFCF	Exports	Total demand
1	Instrumentation																
2	Manufacturing																
3	Other production																
4	Wholesale, retail and transport																
5	ICT																
6	Technical testing and analysis																
7	R&D																
8	Central gov. activities																
9	Health																
10	Other																
11	**Total consumption**																
12	Imports of goods and services																
13	Taxes less subsidies on products																
14	Taxes less subsidies on production																
15	Compensation of employees (Calibration)																
16	Compensation of employees (Testing)																
17	Compensation of employees (Non-measurement)																
18	Gross operating surplus																
19	Gross value added																
20	**Total output**																

Key: Derived directly from original Domestic-Use Table

Estimated using a variety of data sources

Derived directly from original Domestic-Use Table, less any corresponding estimated cells

Table 11: Calculation of cells within the Domestic-Use IOMT

Referring to *Table 11*, cells that are BLACK are the addition of the relevant cells (as explained in the *Construction of the Input-Output Measurement Tables chapter*) from the original Domestic-Use Table. Cells that are RED would be BLACK but for the subtraction of the relevant WHITE cells. For example, because products of Instrumentation are a subset of products of Manufacturing, B1:P1 is subtracted from BLACK B2:P2 to create RED B2:P2. This ensures that the total consumption and output of the economy in the IOMTs is the same as in the original Use Tables.

Also, note that in the final Measurement Domestic-Use Table the array L14:O19 is blank because the inputs of the production process do not apply to the components of final demand.

This chapter explains how we have derived all WHITE and RED cells from *Table 11*.

3.1. DATA SOURCES

The resulting IOMTs are partially derived from estimates formulated within the *Quantifying Measurement Activity in the UK* report – use of these estimates are clearly stated throughout. Otherwise, all data in these analyses are taken from ONS publications.

The analysis relies heavily on the **2005 IOATs**. These are the last tables published using 123 Input-Output groups which are consistent with the 1992 Standard Industrial Classification (SIC 1992). Within the 123 Input-Output (IO 123) groups is a unique code that groups together all products of Instrumentation and the industry that manufactures those products: 76 (Medical and precision instruments).

The *Quantifying Measurement Activity in the UK* report explains in detail how the dataset was used, in conjunction with others, to estimate the volume of instrumentation by each component of total demand. In this analysis we employ the 2005 IOATs to extrapolate additional detail from those estimates by estimating the distribution of consumption of said instrumentation across different industries, as well as the various primary inputs of the instrument making industry.

In an intermediate step we draw data from the Use Tables of the year 2005, published within the **SUTs (1997 – 2017)**. These tables offer the combined-use table for all years between 1997 and 2007, where products and industries are defined by CPA 08 and SIC 07 classifications, respectively.

Finally, the **2016 IOATs** provide the foundation for the IOMTs. *Table 12* indicates which elements of the Use tables are included in each of the sources listed above.

Dataset	Industry/product classification	Domestic-use table	Imports-use table	Combined-use table
2005 IOATs	IO 123/IO 123	YES	YES	YES
2016 IOATs	SIC 07/CPA 08	YES	YES	NO
1997 – 2017 SUTs	SIC 07/CPA 08	NO	NO	YES

Table 12: List of Use Tables included in each ONS data source

In addition, estimation of the inputs of the Instrumentation industry are assisted by data from the **Annual Business Survey (ABS)**, plus, a combination of the **Annual Population Survey (APS)**, the **Census (2011)**, and the **Annual Survey of Hours and Earnings (ASHE)** is used to estimate the compensation of employees for measurement related activities. The contents of these data sources are explained in detail in the *Quantifying Measurement Activity in the UK* report.

3.2. DEMAND FOR INSTRUMENTATION

This section refers to row 1 of *Table 11*.

Each component of total demand for instrumentation is estimated within the *Quantifying Measurement Activity in the UK* report. These figures are summarised in *Table 13*.

Component of Total Demand		Value of Instrumentation
Intermediate demand	Domestic	£ 3.94 bn
	Imported	£ 4.78 bn
Household	Domestic	£ 0.04 bn
	Imported	£ 0.04 bn
NPISHs and government	Domestic	£ 0
	Imported	£ 0
GFCF	Domestic	£ 0
	Imported	£ 3.46 bn
Exports		£ 9.20 bn

Table 13: Estimated value of instrumentation, 2016 (purchasers' prices)

The figures in *Table 13* have been calculated using product data from various sources where the value of products includes any taxes less subsidies on those products – i.e. the value the purchaser pays for the product. These figures cannot be directly implemented into the IOMTs as they are in purchasers' prices rather than basic prices.

Before filling in row 1 of *Table 11*, we must first establish the coding of instrumentation products in the national statistics. The estimates in *Table 13* are derived from data based on the Harmonised System 1992 (HS 92) classification. HS 92 compromises of more than 5,000 commodity groups, each identified by a six-digit code, of which there are 230 individual products of instrumentation grouped between sections 90 – 92. These HS 92 codes can be traced directly to the CPA 08 codes CPA_**26.5** (*Measuring, testing and navigating equipment; watches and clocks*) and CPA_**26.6** (*Irradiation, electromedical and electrotherapeutic equipment*) and CPA_**26.7** (*Optical instruments and photographic equipment*).

The three three-digit CPA 08 codes that represent all products of instrumentation are a subset of the broader two-digit product group CPA_**26** (Computer, electronic and optical equipment). The demand for CPA_26 is represented in both the 2016 IOATs and the 1997 – 2017 SUTs but, because this product group combines the value of instrumentation with other computer and electronic equipment, it is impossible to determine the demand for instrumentation from these sources alone.

The solution lies within the 2005 IOATs which are the last IOATs to be published in the IO 123 classification – a series of 123 two-digit product/industry codes which, as aforementioned, offer a more granular grouping of products than two-digit CPA 08 codes. In the *Quantifying Measurement Activity in the UK* report it is established that the IO 123 code **76** (*Medical and precision instruments*) corresponds to the HS 92 instrumentation group and therefore to CPA_26.5, CPA_26.6 and CPA_26.7. Thus, for the year 2005, it is possible to calculate the fraction of the value of CPA_26 products that are instrumentation by cross-referencing the 2005 IOATs with the 2005 SUTs.

Before doing so, we must translate the classification of industries in the 2005 IOATs from IO 123 codes to SIC 07 codes so that the tables match the 2005 SUTs. This process is aided by another ONS publication, *Blue Book 2011: Reclassification of the UK Supply and Use Tables*, which includes a table that maps IO 123 codes to SIC 07 codes. For example, SIC_08 (Other mining and quarrying) is equal to the sum of:

- 11.3% of IO 123 code **4** (*Coal extraction*)

- 99.6% of IO 123 code **6** (*Metal ores extraction*)
- 99.6% of IO 123 code **7** (*Other mining a quarrying*)

And SIC_11&12 is equal to the sum of:

- 99.9% of IO 123 code **18** (*Alcoholic beverages*)
- 99.6% of IO 123 code **19** (*Soft drinks and mineral water*)
- 100% of IO 123 code **20** (*Tobacco products*)

Applying this mapping to all IO 123 codes translates *Table 14* into *Table 15*, which has the same number of columns as the 2005 SUTs.

Product (IO 123 codes)	Industry (IO 123 codes) …	4 Coal extraction	5 Oil and gas extraction	6 Metal ores extraction	7 Other mining and quarrying	…	18 Alcoholic beverages	19 Soft drinks and mineral water	20 Tobacco	…
…	…	…	…	…	…	…	…	…	…	…
76 Medical and precision instruments	…	3.50 x0.113	1.07	0.86 x0.996	0.00 x0.996	…	4.64 x0.999	2.37 x0.996	0.53	…
…	…	…	…	…	…	…	…	…	…	…

Table 14: Intermediate demand (£ millions) IO 123 industry codes, 2005

Product (IO 123 codes)	Industry (SIC 07 codes) …	08 Other mining and quarrying	09 Mining support service	10 Manufacture of food products	11&12 Manufacture of beverages and tobacco products	…
…	…	…	…	…	…	…
76 Medical and precision instruments	…	15.49	0.14	30.73	7.52	…
…	…	…	…	…	…	…

Table 15: Intermediate demand (£ millions) SIC 07 industry codes, 2005

We then further reduce the number of columns in both the 2005 IOATs and 2005 SUTs by combining SIC 07 codes into the broad industry groups listed in *Table 6*. This allows us to calculate the fraction of an industries' intermediate demand for CPA_26 that is solely instrumentation. We call this fraction 'R':

$$R_i = \frac{IO\_76_{i,05}}{CPA\_26_{i,05}}$$

where IO_76 is the value of intermediate demand for Medical and precision instruments, CPA_26 is the value of intermediate demand for Computer, electronic and electrical equipment, i is the broad industry group and 05 is the year 2005.

It is important to note that because the 2005 SUTs only offer the Combined-Use Table (as stated in *Table 12*), both IO_76 and CPA_26 represent the Combined-Use value of intermediate demand for their respective products.

There are nine industries (excluding Instrumentation) in the IOMTs and so there are nine R's. Their values are listed in *Table 16*.

Industry	R
Manufacturing	43.1%
Other production	21.2%
Wholesale, retail and transport	14.0%
ICT	18.6%

Technical testing and analysis	13.4%
R&D	27.6%
Central gov. activities	27.7%
Health	49.7%
Other	8.5%

Table 16: Intermediate demand for instrumentation as a percentage of intermediate demand for all computer, electronic and optical equipment (R)

Assuming R remains constant over time, we can multiply the value of intermediate demand for CPA_26 of each industry by its respective R to obtain an estimate of the value of intermediate demand for instrumentation, 'I', for any year, t:

$$I_{i,t} = CPA\_26_{i,t} \cdot R_i$$

Since this analysis is based on the most recent version of the IOATs, t is 2016. Applying the equation to the data, if CPA_26 is taken from the Combined-Use Table, the sum of I in 2016 is £11.12bn. This is about 28% more than the estimated value of both domestic and imported intermediate demand for instrumentation calculated in the *Quantifying Measurement Activity in the UK* report (refer to *Table 13*). This outcome is intuitive because, as explained in the *Quantifying Measurement Activity in the UK* report, the latter figure rejects the value of products under the Medical and precision instruments grouping that are determined to not make measurements (e.g. Sheets/plates of polarising material) whereas the former does not.

However, if CPA_26 is taken from the Domestic-Use Table, the sum of I in 2016 is £2.18bn. This is 41% less than the estimated value of domestic intermediate demand for instrumentation calculated in the *Quantifying Measurement Activity in the UK* report. Although this difference can be partially explained by the difference in basic and purchasers' prices, the findings hint that there is a discernible difference between the R based on Combined-Use and R based on Domestic-Use. Since we do not know the latter and trust that the R we do know is a sensible representative measure of an industry's instrumentation usage intensity, we apply a final step in which we scale up the value of I by 41% to bring the total value of instrumentation up to the value estimated via the rigorous methodology of the *Quantifying Measurement Activity in the UK* report. Thus, I becomes:

$$I_{i,t} = \frac{CPA\_26_{i,t} \cdot R_i}{0.59}$$

Applying the final equation for I to the data in the 2016 Domestic-Use Table gives an estimate the distribution of intermediate demand for instrumentation across sectors of the economy in purchasers' prices:

	A	B	C	D	E	F	G	H	I	J	K
1		1404	122	105	193	17	4	775	820	222	3663

In the diagram above, the cell A1 is blank because instrumentation as an industry is not visible in the 2005 SUTs. To fill A1, we first calculate the value of instrumentation consumed by the Instrumentation industry as a percentage of the value of instrumentation consumed by the whole Manufacturing industry. This is the cell on the diagonal of the Combined-Use Table from the 2005 IOATs where the IO 123 **76** product code intersects with the IO 123 **76** industry code divided by the sum of instrumentation consumption by all Manufacturing industries from the same table. This gives us 25.8% which we multiply by B1 to give us A1. Lastly, we subtract A1 from B1 to ensure that K1 does not change:

	A	B	C	D	E	F	G	H	I	J	K
1	363	1041	122	105	193	17	4	775	820	222	3663

The final step in the intermediate demand section is to convert the figures to basic prices by subtracting an estimate of taxes less subsidies on products. We do this on a by industry basis because the amount of taxes and subsidies vary by product and industry. This is achieved simply by calculating the ratio of taxes less subsidies on products to total consumption (both domestic and imported) for each industry, 'r', and then multiplying the figures in purchasers' prices by (1 – r). The difference is absorbed by row 13. For Instrumentation, r is the same as the r for Manufacturing as Instrumentation is a subset of Manufacturing and should therefore display the highest correlation in taxes less subsidies on products.

For the final demand section (columns L to O) we implement the estimates in *Table 6* to the corresponding cells after subtracting taxes less subsidies on products in a similar method.

3.3. COMPENSATION OF EMPLOYEES

This section refers to rows 15, 16 and 17.

The cost of labour for all measurement related activities is calculated in chapter 2 of the *Quantifying Measurement Activity in the UK* report. The methodology allows for the distinction between Calibration, Testing and Non-measurement activities by sorting every four-digit Standard Occupation Classification 2010 (SOC 10) code into one of these three categories based on whether the required tasks of each occupation match the activity.

Occupation by industry data is gathered from the 2011 Census which is then cross referenced with total employment by occupation data from the APS to estimate occupation by industry in 2016.

The key difference in the methodology of this analysis is the grouping of industries. For our purposes we calculate occupation by industry to match the grouping of the 10 industries in the IOMTs. We established earlier in the analysis that products of instrumentation are classified under the following three three-digit CPA 08 codes: CPA_26.5, CPA_26.6 and CPA_26.7. As SIC 07 industries are designed to correspond directly to CPA 08 products, the industries of instrumentation are classified under SIC_26.5, SIC_26.6 and SIC_26.7. Fortunately, the 2011 Census contains data for industries at the four-digit SIC 07 level meaning that we are easily able to separate employees working in the Instrumentation industry from employees working in the Manufacturing industry.

Once we have estimated the number of employees in Calibration and Testing occupations by industry, we multiply those figures by the gross annual pay of each respective occupation (obtained from AHSE Table 14.7a) in 2016 to find the total compensation of employees.

Compensation of employees in Calibration occupations by industry slots into row 15 and compensation of employees in Testing occupations by industry slots into row 16. To calculate compensation of employees in Non-measurement occupations (row 17) we subtract rows 15 and 16 from the reported value of total compensation of employees for each industry from the 2016 Domestic-Use Table.

3.4. INPUTS OF THE INSTRUMENTATION INDUSTRY

This section refers to column A.

With this information we can retrieve some figures of the inputs of the Instrumentation industry directly from the ABS for 2016. The ABS is a yearly census of production in the UK, published by the ONS, that covers the non-financial business economy; it reports detailed revenue and cost statistics for industries up to the four-digit SIC 07 level. Of the variables included in the ABS we are interested in 'total turnover', 'gross value added', 'total purchases of goods and

materials and services' and 'total employment costs' which correspond to rows 20, 19, (11 + 12 + 13) and (15 + 16 + 17), respectively. We sum the values of these variables for industries SIC_26.5, SIC_26.6 and SIC_26.7.

ABS variable	Equivalent Measurement-Use Table variable	Instrumentation industry value
Total turnover	Total output (20)	£12.52 bn
Gross value added	Gross value added (19)	£4.95 bn
Total purchases of goods and materials and services	Total consumption + Imports of goods and services + Taxes less subsidies on products (11 + 12 + 13)	£7.53 bn
Total employment costs	Compensation of employees (Calibration + Testing + Non-measurement) (15 + 16 + 17)	£3.29 bn

Table 17: Instrumentation industry data from ABS, 2016

Assuming that the distribution of 'total purchases of goods and materials and services' across its various components is the same for Instrumentation as its broader two-digit industry group Computers, electronics and optical equipment, we ratio the sum of rows 1 to 13 (excluding row 11) for industry SIC_26 in the 2016 Domestic-Use Table amongst each of its components and multiply the resulting fractions by £6.63bn to estimate the individual values of those inputs for the Instrumentation industry. *Table 18* summarises the findings:

Product	Consumption by SIC_26 (£m)	Ratio	Estimated consumption by Instrumentation industry
Manufacturing	3,217	35.2%	2,329
Other production	178	2.0%	130
Wholesale, retail and transport	1,941	21.2%	1,405
ICT	142	1.5%	103
Technical testing and analysis	0	0.0%	0
R&D	0	0.0%	0
Central gov. activities	10	0.1%	7
Health	79	0.9%	57
Other	968	10.6%	701

Imports of goods and services	2,590	28.3%	1,875
Taxes less subsidies on production	26	0.3%	19
SUM	9,153	100%	6,625

Table 18: Working for the estimation of consumption by Instrumentation industry

Implementing these estimates (ensuring to subtract the consumption of Instrumentation products by the Instrumentation industry (cell A1) from the consumption of Manufacturing products by the Instrumentation industry) plus the values of other variables from *Table 17 into the* Domestic-Use IOMT:

	A
1	360
2	2287
3	147
4	1597
5	117
6	0
7	0
8	8
9	65
10	797
11	5377
12	2131
13	21
14	
15	14
16	13
17	3267
18	
19	4950
20	12518

For the two outstanding cells in column A, we subtract compensation of all employees (rows 15 + 16 + 17) from gross value added (row 19) which is equal to taxes less subsidies on production plus gross operating surplus (rows 14 + 18).

Then, referring to the 2016 Domestic-Use Table, applying the same ratio of taxes less subsidies on production to gross operating surplus as SIC_26 (1:127) we can split the combined value of those two variables between cells A14 and A18.

Finally, as Instrumentation is a subset of the Manufacturing industry, we ensure to subtract all inputs of the Instrumentation industry (excluding A1) from the Manufacturing industry to get our final columns A and B.

4. THE FINAL INPUT-OUTPUT MEASUREMENT TABLES

Application of the method detailed in Chapter 3 to the 2016 IOATs produces two IOMTs products: the Domestic-Use IMOT (*Table 19*) and the Imports-Use IMOT (*Table 20*). Both IMOTs for 2016 are presented below.

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		Instrumentation	Manufacturing	Other production	Wholesale, retail and transport	ICT	Technical testing and analysis	R&D	Central gov. activities	Health	Other	Total intermediate demand	Households	Gov. and NPISHs	GFCF	Exports	Total demand
1	Instrumentation	360	1,034	118	101	193	17	4	692	730	210	3,459	42	0	0	3,466	6,926
2	Manufacturing	2,287	78,204	44,940	28,002	2,123	991	917	7,926	10,077	46,891	222,359	65,900	4,227	18,916	139,319	450,762
3	Other production	147	14,396	164,436	11,232	1,141	805	148	7,979	3,626	42,030	245,940	39,632	6,617	140,685	20,661	453,535
4	Wholesale, retail and transport	1,597	60,227	18,889	76,302	2,703	919	461	7,336	9,421	51,108	228,961	174,772	2,863	11,637	81,282	499,515
5	ICT	117	3,235	4,433	9,236	13,328	984	468	3,576	2,080	34,971	72,428	16,445	0	24,327	20,725	133,925
6	Technical testing and analysis	0	2,023	5,088	536	2	8,658	0	916	1,721	4,413	23,359	0	0	7,244	10,477	41,080
7	R&D	0	0	0	0	0	0	7,462	0	0	0	7,462	0	1,044	27,219	6,294	42,019
8	Central gov. activities	8	815	1,508	2,545	44	2,996	18	248	147	4,456	12,785	4,566	130,928	1,069	2,006	151,354
9	Health	65	225	35	0	0	0	0	180	1,671	500	2,676	12,972	135,000	0	193	150,841
10	Other	797	43,633	27,786	62,497	19,239	4,219	3,565	23,208	17,172	262,863	464,979	591,489	141,480	29,959	193,140	1,421,047
11	**Total consumption**	5,377	203,431	267,233	190,451	38,772	19,589	13,043	52,061	46,644	447,444	1,284,047	905,818	422,159	261,056	477,563	3,350,644
12	Imports of goods and services	2,131	93,697	17,703	29,630	12,494	2,688	1,250	8,096	9,186	55,968	232,842	233,513	5,777	48,979	78,709	599,821
13	Taxes less subsidies on products	21	2,197	9,059	8,380	170	185	-126	6,441	6,139	26,653	59,120	113,603	-297	33,658	11,227	217,310
14	Taxes less subsidies on production	13	2,300	4,134	11,564	803	368	66	0	91	7,105	26,444					26,444
15	Compensation of employees (Calibration)	14	312	65	78	12	78	68	33	291	277	1,229					1,229
16	Compensation of employees (Testing)	13	743	425	223	41	670	253	150	482	893	3,893					3,893
17	Compensation of employees (Non-measurement)	3,267	107,312	67,817	173,137	54,386	18,470	6,269	61,440	66,999	403,506	962,602					962,602
18	Gross operating surplus	1,643	65,931	96,840	75,200	30,238	4,673	5,913	25,172	23,416	454,940	783,966					783,966
19	Gross value added	4,950	171,648	169,281	260,202	85,479	24,259	12,570	86,795	91,279	866,721	1,778,134					1,778,134
20	**Total output**	12,518	475,884	463,276	488,664	136,915	46,722	26,737	153,393	153,248	1,396,786	3,354,143	2,158,752	849,798	604,750	1,045,062	8,012,505

Table 19: Domestic-Use IOMT, 2016 (basic prices)

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
		Instrumentation	Manufacturing	Other production	Wholesale, retail and transport	ICT	Technical testing and analysis	R&D	Central gov. activities	Health	Other	Total intermediate demand	Households	Gov. and NPISHs	GFCF	Exports	Total demand
1	Instrumentation	98	1,137	148	15	96	53	3	905	1,945	112	4,513	43	0	3,087	5,544	16,207
2	Manufacturing	1,482	72,238	4,853	14,926	1,079	1,485	370	5,104	6,657	9,010	117,203	162,988	5,775	41,463	72,068	422,123
3	Other production	0	14,045	9,925	74	0	156	0	0	0	513	24,712	352	2	0	63	25,796
4	Wholesale, retail and transport	64	627	126	4,895	152	0	0	0	0	603	6,467	16,367	0	0	6	23,444
5	ICT	47	417	37	806	8,073	72	11	4	0	1,729	11,196	434	0	0	0	13,446
6	Technical testing and analysis	33	683	202	262	27	147	26	2	0	648	2,028	585	0	0	0	3,435
7	R&D	0	0	0	0	0	0	446	0	0	0	446	0	0	4,427	0	5,319
8	Central gov. activities	0	0	85	146	0	278	0	23	0	335	867	0	0	0	0	1,503
9	Health	0	0	0	0	0	0	0	0	6	0	6	1,465	0	0	0	1,477
10	Other	142	4,912	2,328	8,508	3,066	498	393	2,058	578	43,019	65,502	51,279	0	2	1,029	164,358
11	**Total**	1,867	94,058	17,703	29,630	12,494	2,688	1,250	8,096	9,186	55,968	232,941	233,513	5,777	48,979	78,709	677,108

Table 20: Imports-Use IOMT, 2016 (basic prices)

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This work was funded by the UK Government's Department for Business, Energy and Industrial Strategy (BEIS) through the UK's National Measurement System programmes.