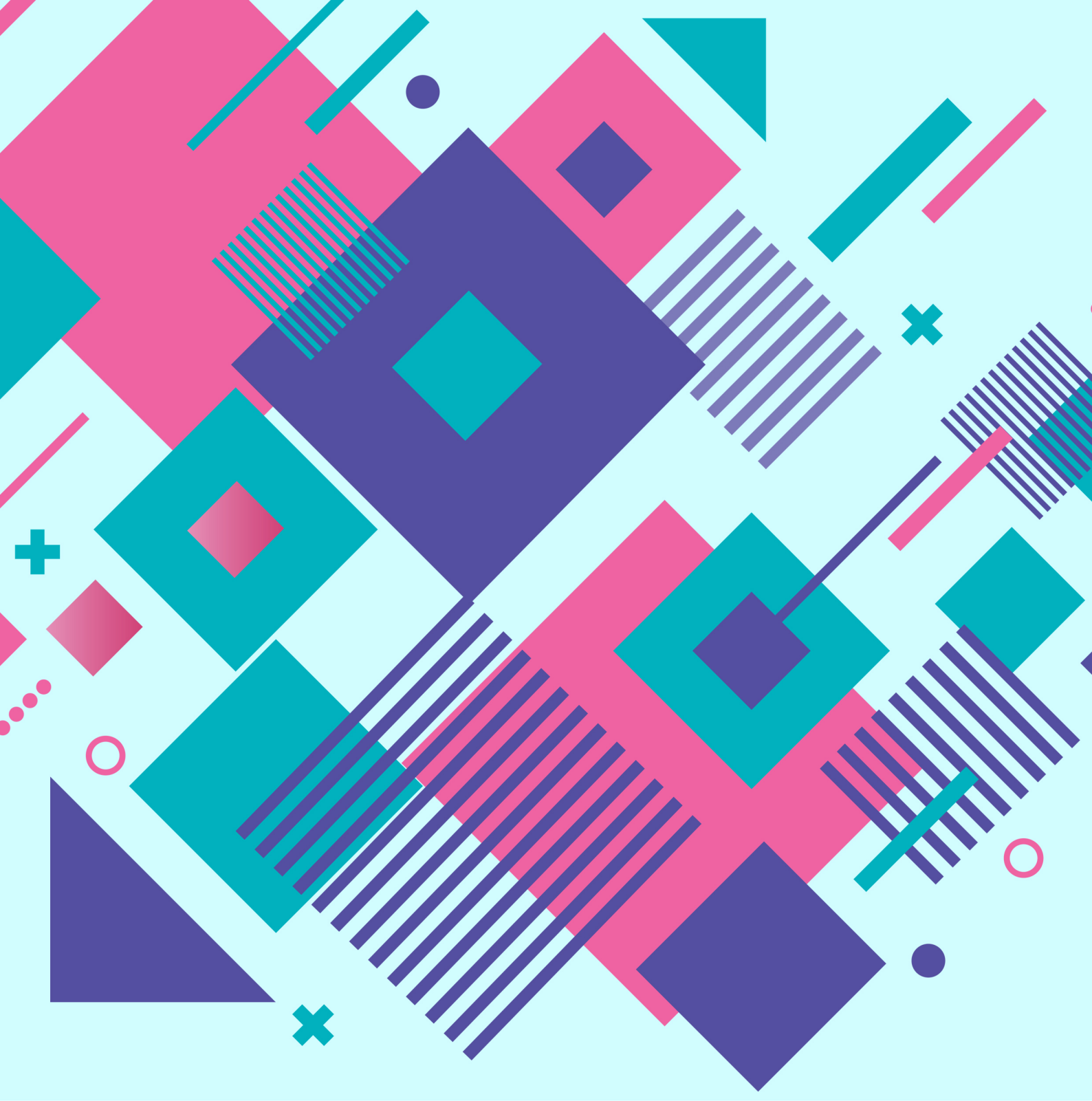

Singapore Supply, Use and Input-Output Tables 2015

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DEPARTMENT OF STATISTICS SINGAPORE

SINGAPORE SUPPLY, USE AND INPUT-OUTPUT TABLES 2015
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PREFACE

The Singapore Supply, Use and Input-Output tables provide a comprehensive and integrated framework for the derivation and reconciliation of key national accounts aggregates. They contain detailed information on the intricate relationships among the various economic sectors and are used for a variety of purposes such as cross-validating data from various sources, impact studies, policy formulation and evaluation.

With the release of the 2015 tables, Singapore Department of Statistics (DOS) has completed 14 Supply, Use and Input-Output tables for Singapore. This publication discusses the basic structure, methodology and findings of these tables, including the applications of Input-Output tables. Annexes explaining the theoretical basis and derivation of the various Input-Output models and applications are also included.

The compilation of the Supply, Use and Input-Output tables is a massive exercise which involves consolidating voluminous data and reconciling the intermediate transaction flows of products through thorough analysis. DOS conducts regular methodological reviews to improve the estimates and ensure that they adhere to international guidelines. In addition, efforts have also been made to streamline and enhance the data compilation process. These improvements have resulted in a set of Supply and Use tables that is reflective of the economic structure. The release of the 2015 Supply, Use and Input-Output tables will also help to better meet the needs of users in analysing the recent economic structure of Singapore.

The data used in the compilation of 2015 Supply, Use and Input-Output tables include both administrative and survey data. I would like to take this opportunity to extend my deep appreciation to all the government ministries and departments, statutory boards and private organisations that have contributed to the success of this publication and look forward to their continued support.

Wong Wee Kim
Chief Statistician
Singapore

July 2019

Our Vision

National Statistical Service of Quality, Integrity and Expertise

Our Mission

We Deliver Insightful Statistics and Trusted Statistical Services that Empower Decision Making

Our Guiding Principles

Professionalism & Expertise	We adhere to professional ethics and develop statistical competency to produce quality statistics that comply with international concepts and best practices.
Relevance & Reliability	We produce statistics that users need and trust.
Accessibility	We make our statistics readily available through user-friendly platforms.
Confidentiality	We protect the confidentiality of information collected by us.
Timeliness	We disseminate statistics at the earliest possible date while maintaining data quality.
Innovation	We constantly seek ways to improve our processes, leveraging on new technology where feasible, to deliver better products and services to users.
Collaboration	We engage users on data needs, data providers and respondents on supply of data, and undertake the role of national statistical coordination.
Effectiveness	We optimise resource utilisation, leveraging on administrative and alternative data sources to ease respondent burden.

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1. Introduction

1.1. The Singapore Supply, Use and Input-Output Tables are made up of the Supply and Use Tables (SUTs) and the Input-Output Tables (IOTs).

1.2. The SUTs provide detailed information on production activities of an economy by recording transactions between producers and consumers in an economic system. In addition, they also serve as a framework for checking the consistency of data obtained from different data sources and are used to derive and reconcile the three approaches to measure Gross Domestic Product (GDP), namely production, expenditure and income. The IOTs, on the other hand, provide an integrated and comprehensive framework for economic modelling and impact studies when supplemented with relevant information.

1.3. With the release of the 2015 tables, the Singapore Department of Statistics (DOS) has, to date, published ten sets of benchmark SUTs for reference years 1973, 1978, 1983, 1988, 1990, 1995, 2000, 2005, 2010 and 2015, one set of intermediate SUTs for reference year 2007 and three sets of annual tables for reference years, 2012, 2013 and 2014[1]. Similar to earlier years, the 2015 benchmark SUTs have been used to reconcile the three GDP estimates in the recently completed benchmarking of Singapore's national accounts. In addition, the 2010 benchmark SUTs have also been revised such that they are comparable with the 2015 SUTs.[2]

[1] As part of the ongoing efforts to provide more timely statistics to users, DOS has released SUTs and IOTs annually from reference year 2012 onwards. Unlike the benchmark tables which have been used to reconcile the three different measures of GDP, the annual tables are used to narrow the statistical discrepancies among the three GDP measures and provide more timely data for economic modelling and impact studies.

[2] An infographic comparing the findings of the 2015 and 2010 SUTs/ IOTs has been released together with this report.

1.4. Chapter 2 of this publication provides the main findings from the 2015 SUTs, and the methodology and the structure of the 2015 SUTs. Chapter 3 discusses the results from the 2015 IOTs, the transformation of the SUTs to the Industry by Industry IOT and its applications. The theoretical basis and derivation of the Industry by Industry IOT and its applications are given in the Annexes.

1.5. The complete set of 2015 SUTs and IOTs at the detailed industry and product levels in Excel format can be downloaded from the DOS website at www.singstat.gov.sg.

2. Singapore Supply and Use Tables

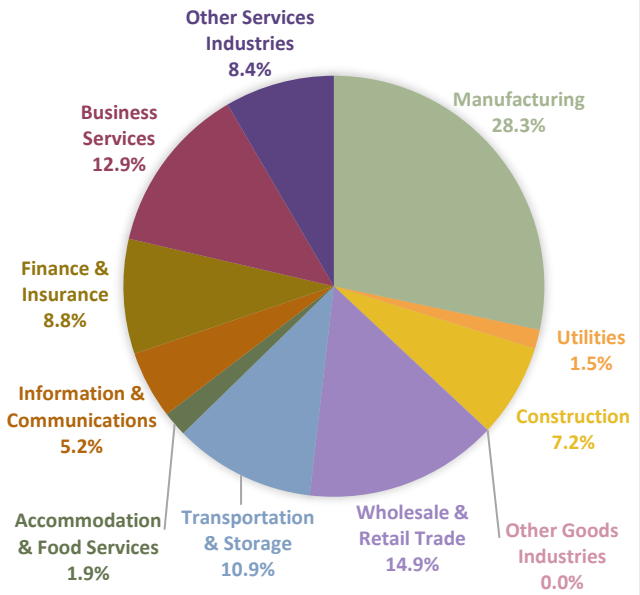
2.1. The compilation of Supply and Use Tables (SUTs) involves reconciling voluminous data from various sources within a single framework. This chapter first presents an overview of the production cost structure and the flow of goods and services in Singapore for reference year 2015. The rest of this chapter describes how the SUTs are compiled, starting with the concepts and principles behind the compilation of SUTs, followed by the structure of SUTs and the balancing process to arrive at a consistent set of SUTs.

Overview of Production and Demand Structures of Singapore in 2015

Production Cost Structure in Singapore for Reference Year 2015

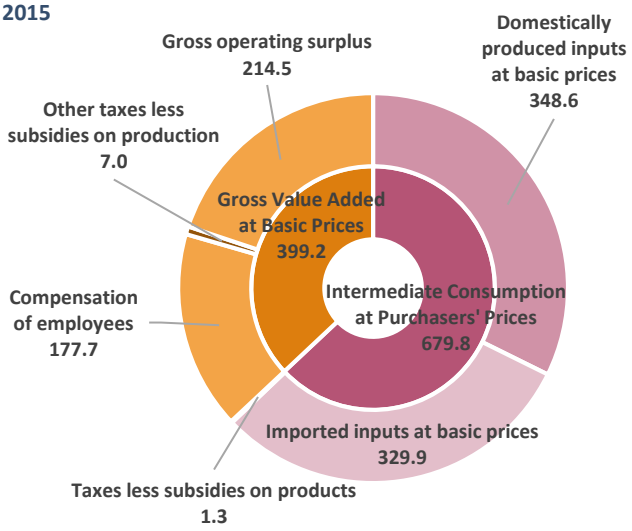
1. In 2015, the Singapore economy produced $1,079.0 billion worth of goods and services. The manufacturing industry was the largest contributing industry and accounted for 28% of total domestic output.

Chart 2-1: Domestic Output by Industry (%), 2015



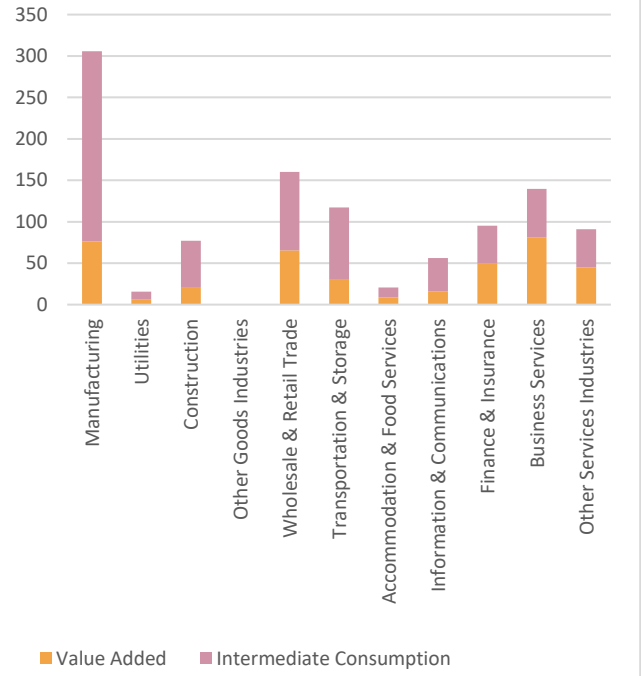
2. The Singapore economy purchased $679.8 billion of intermediate inputs, of which $348.6 billion was supplied by domestic industries, $329.9 billion was imported and $1.3 billion was paid on net taxes on products. Gross value added at basic prices generated was $399.2 billion and comprised $177.7 billion of compensation of employees, $7.0 billion of net taxes on production and $214.5 billion of gross operating surplus.

Chart 2-2: Production Cost Structure of Singapore ($ billion), 2015



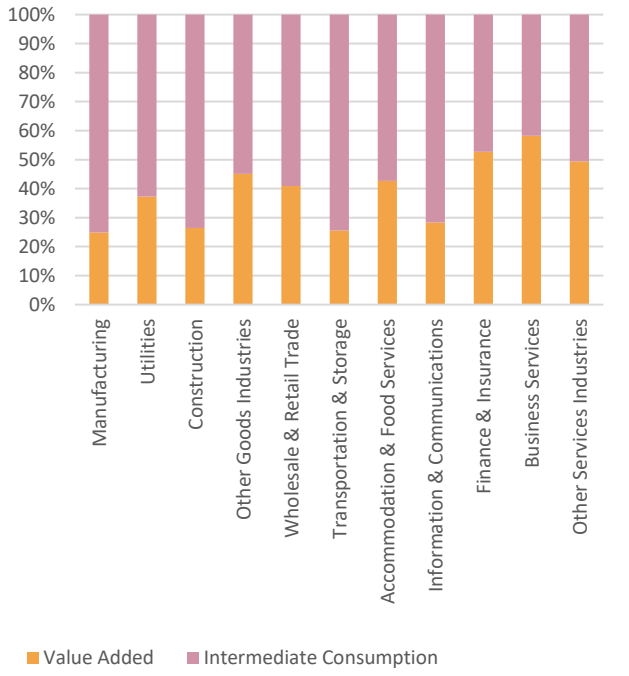
3. The manufacturing industry accounted for the largest share of intermediate consumption. The business services industry, including ownership of dwellings, had the highest value added, followed by the manufacturing industry.

Chart 2-3: Production Cost Structure by Industry ($ billion), 2015



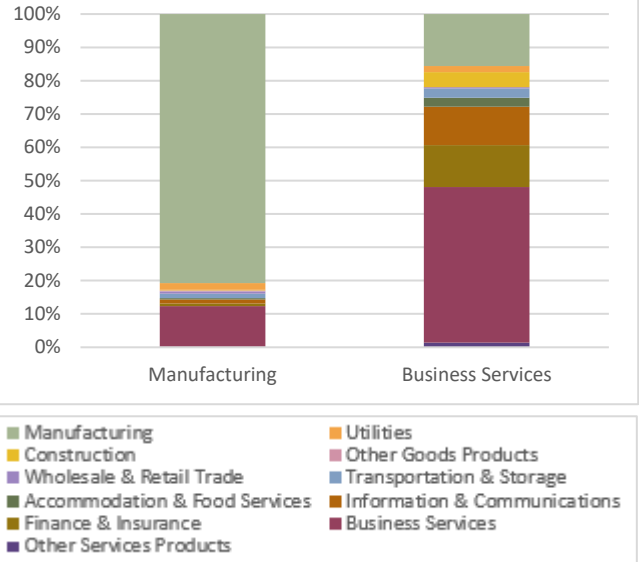
4. Even though the manufacturing industry had contributed a significant amount of value added to the Singapore economy in nominal value, only 25% of the output produced by the manufacturing industry was attributed to value added. The business services industry, on the other hand, generated the highest value added per output of 58%.

Chart 2-4: Production Cost Structure by Industry (%), 2015



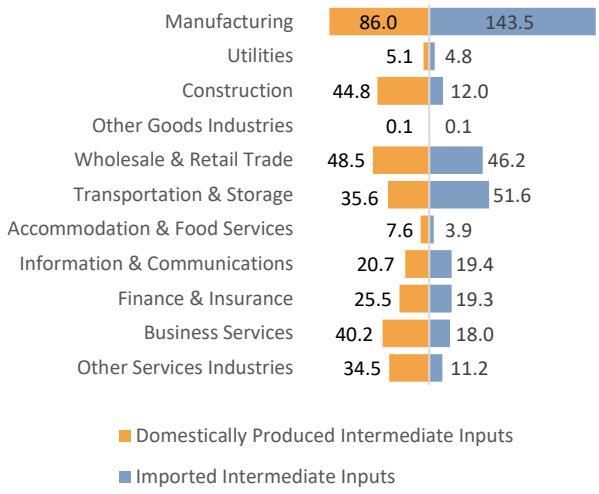
5. The manufacturing industry consumed $185.4 billion of manufacturing product at purchasers' prices which accounted for the largest portion of 81% of intermediate consumption. Compared to the manufacturing industry, the business services industry primarily used services products in its production process instead. The services products included business services, finance & insurance, and information & communications which made up $41.3 billion at purchasers' prices or 71% of intermediate consumption.

Chart 2-5: Intermediate Inputs of Manufacturing and Business Services Industries by Product at Purchasers' Prices (%), 2015



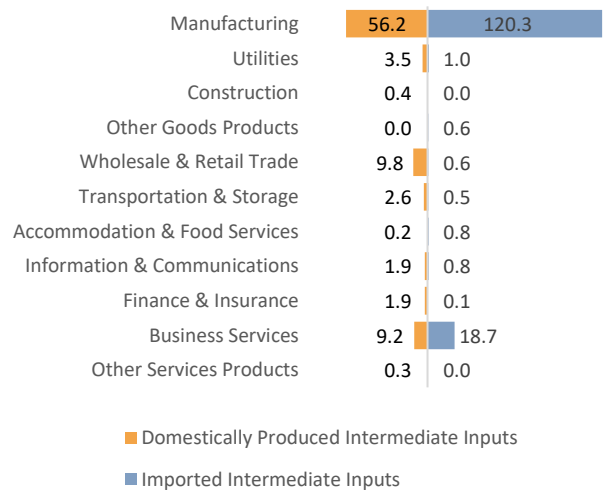
6. Of the $348.6 billion of intermediate inputs supplied by domestic industries, the manufacturing industry consumed the largest share of $86.0 billion or 25%. It also accounted for the biggest share of $143.5 billion or 43% of total imported products for intermediate consumption. Relative to the other industries, the manufacturing industry used more imported intermediate inputs in its production process, accounting for 63% of total intermediate inputs. The business services industry, on the other hand, consumed more domestically produced products for intermediate consumption which constituted 69% of total intermediate inputs.

Chart 2-6: Domestic and Imported Intermediate Inputs by Industry ($ billion), 2015



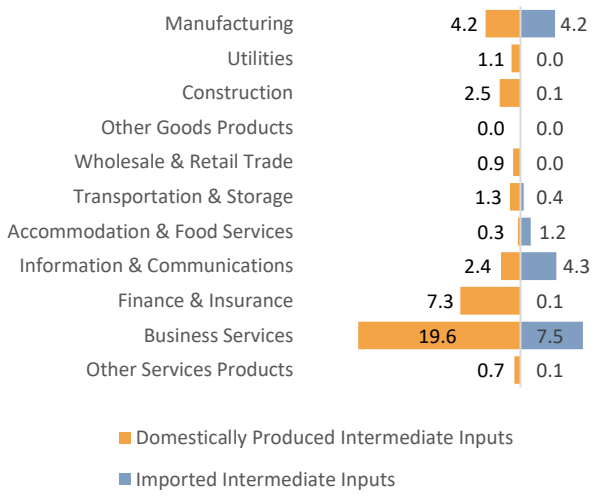
7. At basic prices, manufacturing product accounted for the largest shares of both domestic and imported intermediate inputs used by the manufacturing industry. Domestically produced and imported manufacturing product consumed were valued at $56.2 billion and $120.3 billion respectively. As consumption of manufacturing product at purchasers' prices amounted to $185.4 billion, the total trade and transport margins and net taxes on manufacturing product was $8.9 billion. The trade margin is reflected as part of $9.8 billion of domestically produced wholesale & retail trade product consumed at basic prices.

Chart 2-7: Domestic and Imported Intermediate Inputs Purchased by Manufacturing Industry ($ billion), 2015



8. Finance & insurance services provided by domestic industries formed the second largest share of domestic intermediate inputs consumed by the business services industry at basic prices. In contrast to the $7.3 billion worth of domestic inputs, the industry only used $0.1 billion of imported finance & insurance services. In fact, finance & insurance services provided by Singapore firms made up 99% of the total finance & insurance services consumed by the business services industry at basic prices.

Chart 2-8: Domestic and Imported Intermediate Inputs Purchased by Business Services Industry ($ billion), 2015



Flow of Goods and Services in Singapore for Reference Year 2015

1. In 2015, total supply of goods and services at purchasers' prices in Singapore was valued at $1,743.4 billion, of which 62% was produced by domestic industries, 37% was imported at free on board (FOB) and 1.4% was contributed by taxes less subsidies on products.

2. Output of manufacturing product was worth $293.2 billion and constituted the largest share of total domestic output. Imports of manufacturing product valued at $439.7 billion also accounted for the biggest share of total imports at cost, insurance, freight (CIF). Valuation adjustment of trade and transport margins and net taxes on manufacturing product was valued at $157.4 billion. Total supply of manufacturing product at purchasers' prices thus amounted to $890.3 billion. Output of wholesale & retail trade product includes trade margins which is recorded as a negative valuation adjustment to obtain the supply of the product at purchasers' prices. The sum of this negative adjustment and net taxes on wholesale & retail trade product was negative $149.0 billion.

Chart 2-9: Composition of Total Supply at Purchasers' Prices (%), 2015

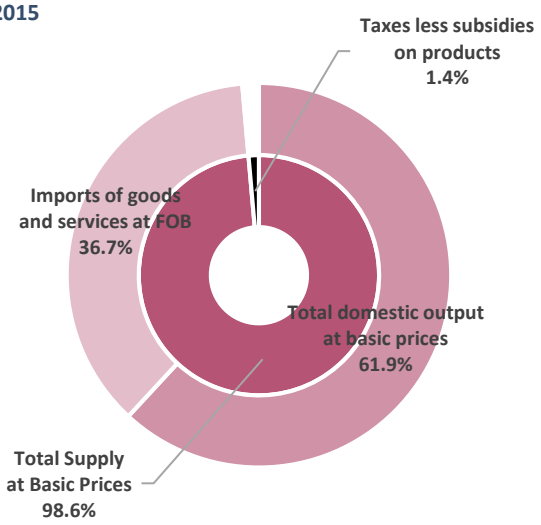
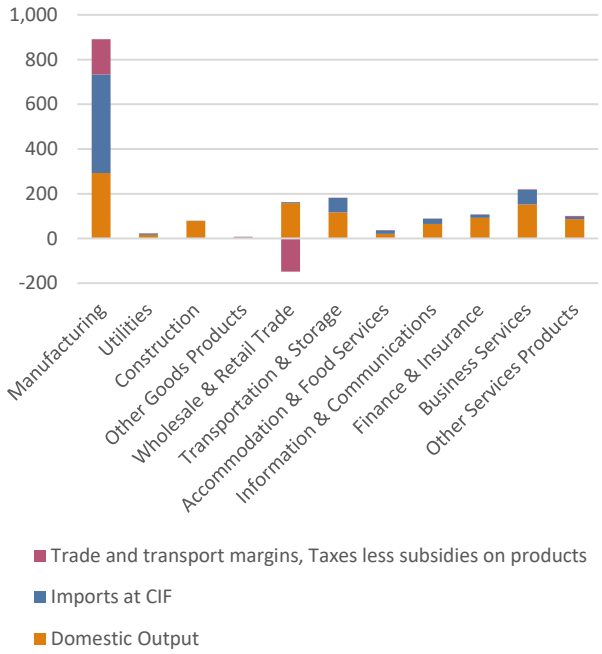


Chart 2-10: Composition of Supply by Product at Purchasers' Prices ($ billion), 2015



3. Of the $1,743.4 billion of total supply of goods and services at purchasers' prices, 43% was exported and the rest was retained for intermediate and final use in Singapore. Intermediate inputs consumed by domestic industries accounted for 39%, and domestic final demand comprises final consumption and gross capital formation which accounted for 12% and 6.2% respectively.

4. 48% of total domestic output in Singapore was exported, reflecting the economy's high dependency on external demand. The remaining domestic output was consumed as intermediate and final use in Singapore, of which 32% was used as intermediate inputs for domestic production and 20% was absorbed by domestic final demand categories.

Chart 2-11: Composition of Total Use at Purchasers' Prices (%), 2015

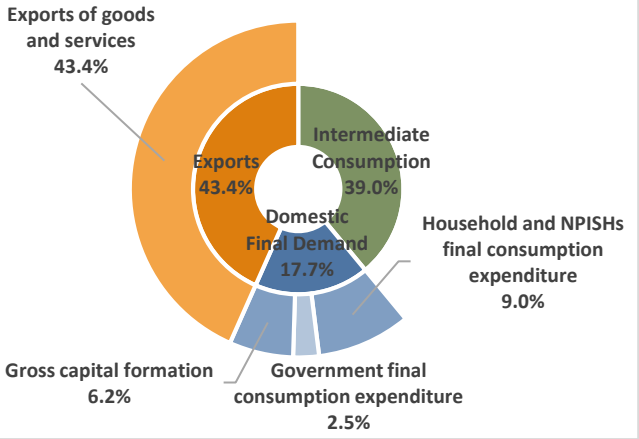
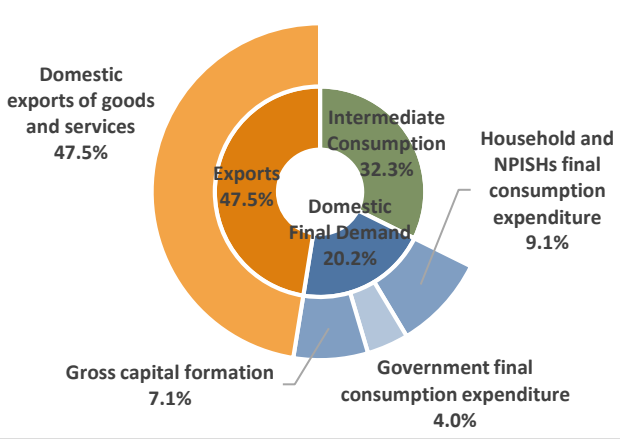


Chart 2-12: Composition of Domestic Use at Basic Prices (%), 2015



Note: NPISHs refer to non-profit institutions serving households

5. Imported products for intermediate consumption of domestic industries accounted for the largest share of 51% of total imports at CIF. 38% of total imports was re-exported while final use in Singapore constituted 10% of total imports.

6. Total taxes less subsidies on products paid to the Singapore government amounted to $24.3 billion, of which 5.4% was paid by domestic industries as part of their intermediate consumption. Household and NPISHs contributed the largest share of 77% of net taxes on products. The remaining 17% of net taxes on products was paid by domestic industries as part of their expenditure on gross capital formation.

Chart 2-13: Composition of Imported Use at CIF (%), 2015

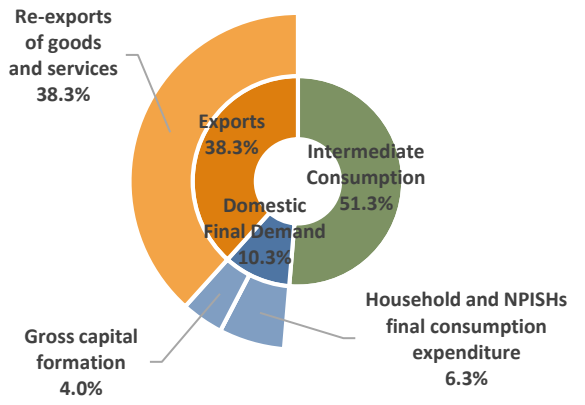
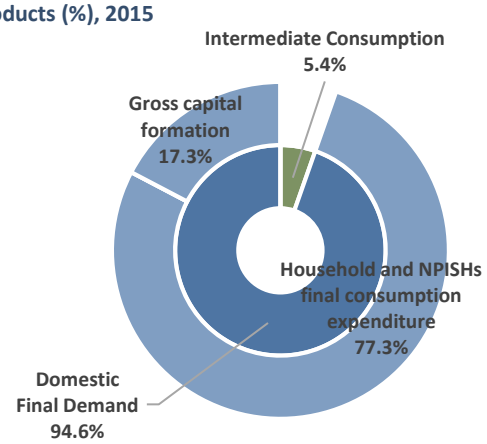


Chart 2-14: Composition of Use on Taxes less Subsidies on Products (%), 2015



7. The majority portion of domestic output of manufacturing product was exported, with domestic exports accounting for $200.5 billion or 68% of output. This is followed by the use of intermediate inputs by domestic industries, representing 28% of domestic output. Likewise, imported manufacturing product in Singapore was mainly re-exported, with re-exports accounting for $245.6 billion or 56% of imports at CIF. This is also followed by the use of intermediate inputs by domestic industries, representing 38% of imports. Domestic exports of manufacturing product made up 45% of total manufacturing product exported out of Singapore. 33% of manufacturing product consumed by domestic industries in their production process are domestically produced.

8. Gross capital formation comprises gross fixed capital formation and changes in inventories. Of the $77.1 billion of domestically produced gross capital formation, $77.9 billion and negative $0.8 billion were attributed to gross fixed capital formation and changes in inventories respectively. Imported gross capital formation consisted of $33.1 billion of gross fixed capital formation and negative $7.1 billion of changes in inventories. Construction product represented the largest share of 52% of domestically produced gross fixed capital formation while manufacturing product constituted the biggest share of 51% of imported gross fixed capital formation. Manufacturing product accounted for the largest share of changes in inventories.

Chart 2-15: Composition of Domestic and Imported Use on Manufacturing Product at Basic Prices ($ billion), 2015

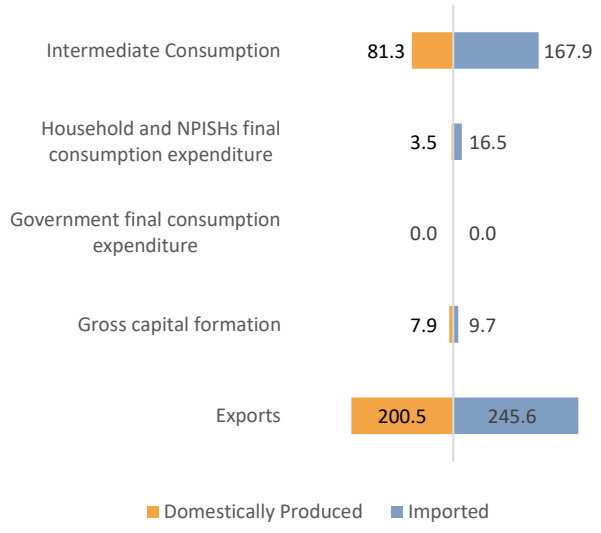
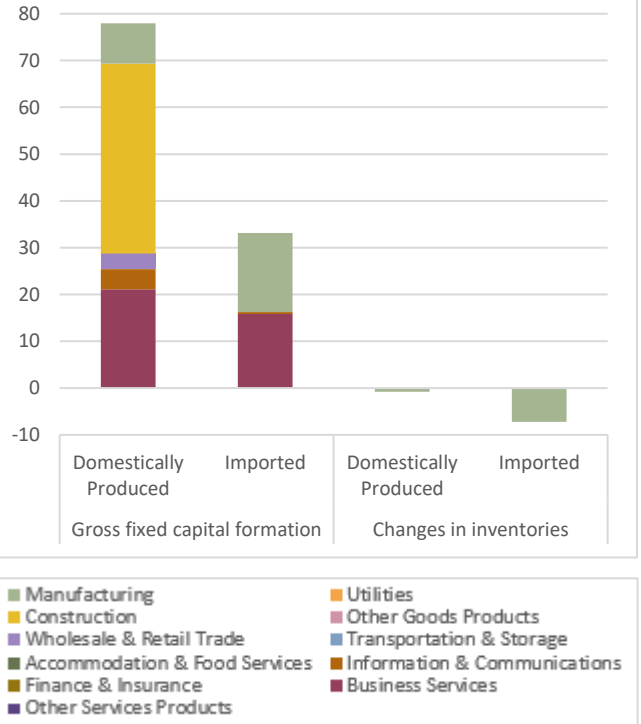


Chart 2-16: Composition of Final Use on Gross Capital Formation at Basic Prices ($ billion), 2015



Fundamentals of Supply and Use Tables

2.2. The compilation of the Singapore SUTs follows closely the concepts and principles recommended in the United Nations (UN) System of National Accounts 2008 (2008 SNA) and Handbook on Supply, Use and Input-Output Tables with Extensions and Applications, as well as International Monetary Fund (IMF) Balance of Payments and International Investment Position Manual Sixth Edition (BPM 6).

Classification

2.3. The 2015 Singapore SUTs are presented at 105 Input-Output (IO) industry/product codes[3]. The industrial classification of IO codes is based on the Singapore Standard Industrial Classification 2015 (SSIC 2015) while the product classification of IO codes is guided by the ASEAN Harmonised Tariff Nomenclature 2017 (AHTN 2017). The UN Central Product Classification Version 2.1 (CPC Ver. 2.1) is used as a reference to link the industrial and product classifications together.

2.4. While the overviews in Chapters 2 and 3 are presented in 11 main industries, the tables in both chapters are further aggregated into two broad industries - goods and services industries[4] - to facilitate analysis and easy understanding. The correspondence between the 105 IO codes and the industry/product classifications is given in Appendix 1. The correspondences between the 11 main industries and the detailed 105 IO codes are given in Appendix 2.

Statistical unit

2.5. An industry is formed by grouping together establishments that are engaged in similar kinds of activity. The establishment, as defined by the 2008 SNA, "is an enterprise, or part of an enterprise, that is situated in a single location and in which only a single productive activity is carried out or in which the principal productive activity accounts for most of the value-added." The establishment is the basic building block as it is the statistical unit used in most of the main data sources and its homogeneous quality reduce the presence of secondary production in each industry. Product groups are formed by grouping the principal goods and services produced by the industries.

[3] The level of detail reflected in the Singapore SUTs was developed based on three key factors: (1) users' needs and the specific interest for economic policy making, (2) data confidentiality, and (3) availability of resources (e.g. data, system and human) for the compilation of SUTs.

[4] The goods industry refers to the goods-producing industries comprising manufacturing, utilities, other goods and construction (IO codes 001 to 053) while the services industry refers to the service-producing industries comprising the remaining industries, including wholesale and retail trade, accommodation and food services, transportation and storage, information and communications, finance and insurance, business services, and other services (IO codes 054 to 105).

Valuation

2.6. Domestic output is valued at basic prices as recommended in the 2008 SNA whereas intermediate consumption and final consumption are valued at purchasers' prices. To ensure uniform valuation to balance the SUTs at purchasers' prices, trade and transport margins as well as taxes less subsides on products are added to the supply of products at basic prices to obtain the supply of products at purchasers' prices. Box 2-1 summarises the differences between basic, producers' and purchasers' prices.

Box 2-1: Basic, Producers' and Purchasers' Prices

Basic prices
+
Taxes on products excluding invoiced value-added tax[5] (VAT)
-
Subsidies on products
=
Producers' prices
+
VAT not deductible by purchaser
+
Separately invoiced transport charges
+
Wholesalers' and retailers' margins
=
Purchasers' prices

2.7. Imports of goods are valued at cost, insurance, freight (CIF) at the domestic customs frontier while exports of goods are valued free on board (FOB), i.e. at the prices at the domestic customs frontier before being shipped out. The CIF and FOB valuations are regarded as the basic price of imports of goods and the purchasers' price of exports of goods respectively in the SUTs framework.

2.8. As total imports are required to be valued at FOB in the 2008 SNA and BPM 6, a total CIF/FOB adjustment row on imports is added in the Supply Table to reconcile the different valuations. Since the CIF/FOB adjustment on imports should not have any balancing or analytical purposes, a balancing adjustment of the same value needs to be made for exports as well. The main objective of the CIF/FOB adjustments is to ensure consistency in the valuation of estimates among SUTs, National Accounts and Balance of Payments.

[5] VAT refers to Goods and Services Tax (GST) in Singapore's context.

Data sources

2.9. The data used for compiling the SUTs come from surveys conducted by DOS and various public sector agencies as well as administrative data from a wide range of sources. Box 2-2 lists the main data sources used in compiling the Singapore SUTs.

Box 2-2: Data Sources for Compiling Singapore SUTs

Survey data	Administrative data
Annual Census of Manufacturing Activities	Merchandise Trade Statistics
Annual Return of the Construction Industry	Government Revenue and Expenditure Data
Annual Survey of Services	Audited Company Financial Statements
Survey of Services on Finance and Insurance	
International Trade in Services Survey	
Household Expenditure Survey	

Structure of Supply and Use Tables

2.10. The Singapore SUTs consist of four tables, namely the Total Supply Table at purchasers' prices, Total Use Table at purchasers' prices, Domestic Use Table at basic prices and Import Use Table at basic prices. These tables bring together the production, expenditure and income measures of GDP and constitute the basis to derive the Input-Output Tables (IOTs).

2.11. The Total Supply Table at purchasers' prices replaces the Domestic Supply Table in previous publications while the Total Use Table at purchasers' prices is newly introduced in this publication. The Domestic Use Table at basic prices and Import Use Table at basic prices were known as the Domestic Use Table and the Import Use Table respectively in previous publications.

Total Supply Table at purchasers' prices

2.12. The Total Supply Table at purchasers' prices shows information by product on total domestic output at basic prices, total supply at basic prices and total supply at purchasers' prices. The total supply at basic prices comprises the domestic output matrix at basic prices and imports of goods and services by product at CIF. The total supply at purchasers' prices is obtained by adding total valuation adjustments by product on trade and transport margins and taxes less subsidies on products to the total supply at basic prices.

2.13. Figure 2-1 provides a schematic representation of the Total Supply Table at purchasers' prices. The 2015 Total Supply Table at purchasers' prices is presented in Table 2-1.

Figure 2-1: Schematic Representation of Total Supply Table at Purchasers' Prices

Supply by product	Output by industry: Industry 1	Industry 2	...	...	Industry n	Total domestic output at basic prices	Imports of goods and services	Total supply at basic prices	Trade and transport margins, Taxes less subsidies on products	Total supply at purchasers 'prices
Product 1	Domestic output at basic prices by producing industries in columns and by products in rows						Imported supply at CIF by products in rows		Total valuation adjustments by products in rows	
Product 2										
...										
...										
Product n										
Total supply before adjustments										
CIF/FOB adjustments on imports	-					-	CIF/FOB adjustments		-	
Total supply after adjustments										

Corresponds to aggregates shown as components of GDP, by expenditure approach

Corresponds to aggregates shown as components of GDP, by production/income approach

Total or sub-total

\- Nil

2.14. The domestic output matrix records the domestic production of all industries by products at basic prices. The total of each column gives the total output of an industry and the total of each row presents the total output of a particular product. The diagonal entries of the domestic output matrix always show a higher value vis-à-vis the off-diagonal entries as they reflect the principal products produced by establishments in each industry. The off-diagonal entries in the domestic output matrix refer to secondary products produced by the establishments.

2.15. In 2015, the total domestic output of Singapore was $1,079.0 billion with the goods industry accounting for $399.0 billion or 37% of total output. The goods industry produced $381.6 billion of goods and $17.3 billion of services. Total output of goods was $387.9 billion, representing 36% of total domestic production in Singapore.

Table 2-1: Total Supply Table at Purchasers' Prices ($ billion), 2015

Supply by product	Output by industry		Total domestic output at basic prices	Imports of goods and services	Total supply at basic prices	Trade and transport margins, Taxes less subsidies on products	Total supply at purchasers 'prices
	Goods	Services					
Goods	381.6	6.3	387.9	449.4	837.3	161.4	998.7
Services	17.3	673.7	691.1	193.4	884.4	-137.2	747.3
Total supply before adjustments	399.0	680.0	1,079.0	642.7	1,721.7	24.3	1,746.0
CIF/FOB adjustments on imports	-	-	-	-2.5	-2.5	-	-2.5
Total supply after adjustments	399.0	680.0	1,079.0	640.2	1,719.2	24.3	1,743.4

Note: Figures may not add up to the total due to rounding.

2.16. While data on imports of goods from merchandise trade statistics are valued at CIF, total imports of goods are required to be valued at FOB in the 2008 SNA and BPM 6. To transform the valuation of total imports from CIF to FOB, a negative entry for imports of goods and services is added to the row on CIF/FOB adjustments. Estimates on residents' expenditure abroad by products have also been included in the imports of goods and services.

2.17. Of the $642.7 billion worth of goods and services imported into Singapore in 2015, $449.4 billion or 70% was goods product. Total supply of goods and services at basic prices in Singapore was $1,721.7 billion with goods product constituting $837.3 billion or 49% of total supply at basic prices. A negative adjustment of $2.5 billion was added to total imports at CIF to derive $640.2 billion of total imports at FOB.

2.18. Previously, in the domestic supply table, trade and transport margins were recorded as the output of wholesale/retail and transport services. To transform total supply from basic prices to purchasers' prices for each product, trade and transport margins are reallocated from wholesale/retail and transport services (negative entries in valuation adjustments) to the traded and transported products (positive entries in valuation adjustments). Thus, total valuation adjustments on trade and transport margins are always zero. As a result, total valuation adjustments on trade and transport margins and taxes less subsidies on products correspond to total taxes less subsidies on products.

2.19. Total trade and transport margins and taxes less subsidies on goods products were $161.4 billion in 2015. A negative entry is recorded in the valuation adjustments on services product. This negative entry means that the total trade and transport margins reallocated from wholesale/retail or transport services exceeded taxes less subsidies on services products by $137.2 billion. Total taxes less subsidies on products paid to the Singapore government amounted to $24.3 billion in 2015. Total supply of goods and services at purchasers' prices was $1,746.0 billion, with goods making up $998.7 billion or 57% of total supply at purchasers' prices.

Total Use Table at purchasers' prices

2.20. A schematic representation of the Total Use Table at purchasers' prices is shown in Figure 2-2. The Total Use Table shows information on the products purchased by industries as intermediate inputs to current production and consumed by final demand at purchasers' prices (Matrices 1 and 2 respectively in Figure 2-2). Income components of value added by industry are also included (Matrix 3 in Figure 2-2). Table 2-2 shows the Total Use Table at purchasers' prices for the year 2015.

2.21. A change in terminology is made to one of the final demand categories in the Use Tables of Singapore SUTs with effect from SUT 2015. Private consumption expenditure (PCE) is now termed household and NPISHs final consumption expenditure whereby NPISHs refer to non-profit institutions serving households.

2.22. In addition, refinements are also made to the recording of residents' expenditure abroad and non-residents' expenditure locally. Previously, purchases of non-residents in Singapore, which are treated as exports, were captured as a negative value in the row for imports of goods and services for PCE in the Domestic Use Table. Likewise, direct purchases of residents abroad, which are treated as imports, were recorded as a positive entry in the row for imports of goods and services for PCE.

2.23. In compiling the 2015 SUTs, data on non-residents' expenditure locally have been allocated to products and reclassified from household and NPISHs final consumption expenditure to exports of goods and services in the Total Use Table at purchasers' prices. Thus, household and NPISHs final consumption expenditure by product presented in the Total Use Table at purchasers' prices excludes purchases of non-residents in Singapore. Data on residents' expenditure abroad have also been allocated by products but continued to be recorded under household and NPISHs final consumption expenditure.

Figure 2-2: Schematic Representation of Total Use Table at Purchasers' Prices

Sales by product	Purchases by industry: Industry 1	Industry 2	…	Industry n	Total intermediate use at purchasers prices	Purchases by final demand: Household and NPISHs final consumption expenditure	Government final consumption expenditure	Gross fixed capital formation	Changes in inventories	Exports of goods and services	Total final use at purchasers' prices	Total use at purchasers' prices
Product 1	**Matrix 1** Intermediate consumption at purchasers' prices by purchasing industries in columns and by products in rows					**Matrix 2** Final consumption at purchasers' prices by final demand categories in columns and by products in rows						
Product 2												
…												
…												
…												
Product n												
Total use at purchasers' prices before adjustments												
CIF/FOB adjustments on exports	-					-	-	-	-	CIF/ FOB adjustment		
Total use at purchasers' prices after adjustments												
Compensation of employees	**Matrix 3** Income generated by producing industries in columns and by value added categories in rows											
Other taxes less subsidies on production												
Gross operating surplus												
Value added at basic prices												
Total inputs at basic prices												

Total or sub-total

\- Nil

Corresponds to aggregates shown as components of GDP, by production approach

Corresponds to aggregates shown as components of GDP, by expenditure approach

Corresponds to aggregates shown as components of GDP, by income approach

Table 2-2: Total Use Table at Purchasers' Prices ($ billion), 2015

Sales by product	Purchases by industry: Goods	Purchases by industry: Services	Total intermediate use at purchasers' prices	Purchases by final demand: Final consumption	Purchases by final demand: Gross capital formation	Purchases by final demand: Exports of goods and services	Total final use at purchasers' prices	Total use at purchasers' prices
Goods	251.3	70.1	321.4	45.8	63.1	568.4	677.3	998.7
Services	45.1	313.3	358.4	154.7	44.3	189.9	388.9	747.3
Total use at purchasers' prices before adjustments	296.4	383.4	679.8	200.5	107.4	758.3	1,066.2	1,746.0
CIF/FOB adjustments on exports	-	-	-	-	-	-2.5	-2.5	-2.5
Total use at purchasers' prices after adjustments	296.4	383.4	679.8	200.5	107.4	755.8	1,063.7	1,743.4
Compensation of employees	39.0	138.7	177.7					
Other taxes less subsidies on production	3.1	3.9	7.0					
Gross operating surplus	60.5	154.0	214.5					
Value added at basic prices	102.6	296.6	399.2					
Total inputs at basic prices	399.0	680.0	1,079.0					

Note: Figures may not add up to the total due to rounding.

2.24. In 2015, $679.8 billion worth of intermediate inputs at purchasers' prices were required to produce $1,079.0 billion of domestic output with the goods industry accounting for $296.4 billion or 44% of total intermediate inputs (Matrix 1 in Table 2-2). With these inputs, the goods industry produced $399.0 billion of output, generating $102.6 billion of value added (Matrix 3 in Table 2-2). Of the $296.4 billion of intermediate inputs, $251.3 billion or 85% was goods product and $45.1 billion or 15% was services product (Matrix 1 in Table 2-2).

2.25. Income components of value added at basic prices for the goods industry comprised $39.0 billion of compensation of employees, $3.1 billion of other taxes less subsidies on production and $60.5 billion of gross operating surplus (Matrix 3 in Table 2-2). Gross value added (GVA) in 2015 amounted to $399.2 billion which was 37% of total domestic output.

2.26. Total supply of goods and services at purchasers' prices in 2015 was $1,746.0 billion of which $679.8 billion or 39% was consumed by domestic industries for use in their production process (Matrix 1 in Table 2-2). Of the $679.8 billion of intermediate consumption at purchasers' prices, $321.4 billion or 47% was goods product and $358.4 billion or 53% was services product.

2.27. The remaining $1,066.2 billion or 61% of total supply was absorbed by final demand categories, namely final consumption, gross capital formation, and exports of goods and services (Matrix 2 in Table 2-2). Of the $1,066.2 billion of final demand at purchasers' prices, $677.3 billion or 64% was goods product and $388.9 billion or 36% was services product. Exports of goods and services accounted for $758.3 billion or 71% of final demand and constituted the largest proportion of total use at purchasers' prices.

2.28. To transform the valuation of total imports from CIF to FOB, a row for CIF/FOB adjustments on imports was added in the Total Supply Table at purchasers' price. The same negative entry, i.e. negative adjustment of $2.5 billion, would have to be recorded in the row on CIF/FOB adjustments for exports of goods and services in the Total Use Table at purchasers' prices.

2.29. The Total Supply Table and Total Use Table at purchasers' prices presented together, allow for the computation of GDP by each of the three approaches, namely the production approach, expenditure approach and income approach, using the equations shown in Box 2-3.

Box 2-3: Derivation of GDP at Current Market Prices ($ billion), 2015

GDP = 423.4	Production Approach
	Output – Intermediate consumption + Taxes less subsidies on products = 1,079.0 – 679.8 + 24.3
	Expenditure Approach
	Final demand – Imports of goods and services = 1,063.7 - 640.2
	Income Approach
	Compensation of employees + Other taxes less subsidies on production + Gross operating surplus + Taxes less subsidies on products = 177.7 + 7.0 + 214.5 + 24.3

Note: Figures may not add up to the total due to rounding.

2.30. By removing the trade and transport margins and taxes less subsidies from each product at purchasers' prices, the Total Use Table at purchasers' prices will be converted to the Total Use Table at basic prices, which will form the basis of compiling the Domestic Use Table and Imported Use Table at basic prices.

Domestic Use Table at basic prices

2.31. The Domestic Use Table records the domestically produced products purchased by industries for intermediate consumption and by final demand at basic prices. A schematic representation of the Domestic Use Table at basic prices is shown in Figure 2-3.

Figure 2-3: Schematic Representation of Domestic Use Table at Basic Prices

Sales by product	Purchases by industry: Industry 1	Industry 2	…		Industry n	Total intermediate use at basic prices	Purchases by final demand: Household and NPISHs final consumption expenditure	Government final consumption expenditure	Gross fixed capital formation	Changes in inventories	Exports of goods and services	Total final use at basic prices	Total use at basic prices
Product 1	**Matrix 1** Intermediate consumption at basic prices by purchasing industries in columns and by domestically produced products in rows						**Matrix 2** Final consumption at basic prices by final demand categories in columns and by domestically produced products in rows						
Product 2													
…													
…													
Product n													
Total domestic use at basic prices													
Imports of goods and services	**Matrix 4** Intermediate consumption at basic prices by purchasing industries in columns and by imports in row						**Matrix 6** Final consumption at basic prices by final demand categories in columns and by imports in row						
Taxes less subsidies on products	**Matrix 5** Taxes on products paid by purchasing industries in columns						**Matrix 7** Taxes on products paid by final demand categories in columns						
Total use at purchasers' prices													
Compensation of employees	**Matrix 3** Income generated by producing industries in columns and by value added categories in rows												
Other taxes less subsidies on production													
Gross operating surplus													
Value added at basic prices													
Total inputs at basic prices													

Total or sub-total

2.32. The structure of the Domestic Use Table at basic prices is the same as the Total Use Table at purchasers' prices except for two additional rows on the use of imports of goods and services, and taxes less subsidies on products by industries and final demand categories. The total use of imports of goods and services, and taxes less subsidies on products correspond to the total imports at CIF, and total taxes less subsidies on products as part of the valuation adjustments respectively in the Total Supply Table at purchasers' prices. The Domestic Use Table at basic prices is one of the primary tables used to transform the SUT into the IOT. As the row on CIF/FOB adjustments on exports has no methodological functions in the IOT, this row is removed from the Domestic Use Table at basic prices.

2.33. The 2015 Domestic Use Table at basic prices is presented in Table 2-3. In 2015, total use at purchasers' prices comprised $1,079.0 billion of domestically produced products at basic prices, $642.7 billion of imported products at basic prices and $24.3 billion of taxes less subsidies on products. Of the $1,079.0 billion of domestic output, $348.6 billion or 32% was used by domestic industries for production and $730.4 billion or 68% was consumed by final demand (Matrices 1 and 2 in Table 2-3). Domestic exports of goods and services were $512.0 billion and constituted the largest portion of final demand (Matrix 2 in Table 2-3).

2.34. Total imports of goods and services at basic prices in 2015 were $642.7 billion of which $329.9 billion or 51% was purchased by industries as intermediate inputs for their production (Matrix 4 in Table 2-3). The remaining $312.9 billion or 49% was consumed as final demand, with re-exports accounting for the largest portion of $246.3 billion or 79% of final demand (Matrix 6 in Table 2-3). In other words, $396.4 billion or 62% of total imports were retained in Singapore for intermediate and final consumption.

2.35. Of the $24.3 billion of taxes less subsidies on products paid to the Singapore government, $1.3 billion or 5.4% was paid by domestic industries as part of the intermediate consumption (Matrix 5 in Table 2-3). The remaining $23.0 billion or 95% was paid by the final demand categories, with final consumption accounting for the largest proportion of $18.8 billion or 82% of final demand (Matrix 7 in Table 2-3).

2.36. Total intermediate inputs supplied by domestic industries in 2015 amounted to $348.6 billion with the goods industry accounting for $135.9 billion or 39% of total domestically produced intermediate inputs (Matrix 1 in Table 2-3). The goods industry consumed $102.6 billion and $33.3 billion of domestically produced goods and services products respectively. Total domestically produced goods product used for intermediate consumption was $131.2 billion, representing 38% of total domestic use at basic prices. The remaining $256.7 billion of goods product produced in Singapore was consumed by final demand (Matrix 2 in Table 2-3).

Table 2-3: Domestic Use Table at Basic Prices ($ billion), 2015

Sales by product	Purchases by industry		Total intermediate use at basic prices	Purchases by final demand			Total final use at basic prices	Total use at basic prices
	Goods	Services		Final consumption	Gross capital formation	Exports of goods and services		
Goods	102.6	28.6	131.2	5.6	48.3	202.8	256.7	387.9
Services	33.3	184.1	217.4	135.7	28.8	309.2	473.7	691.1
Total domestic use at basic prices	135.9	212.7	348.6	141.3	77.1	512.0	730.4	1,079.0
Imports of goods and services	160.3	169.6	329.9	40.5	26.0	246.3	312.9	642.7
Taxes less subsidies on products	0.1	1.2	1.3	18.8	4.2	0.0	23.0	24.3
Total use at purchasers' prices	296.4	383.4	679.8	200.5	107.4	758.3	1,066.2	1,746.0
Compensation of employees	39.0	138.7	177.7					
Other taxes less subsidies on production	3.1	3.9	7.0					
Gross operating surplus	60.5	154.0	214.5					
Value added at basic prices	102.6	296.6	399.2					
Total inputs at basic prices	399.0	680.0	1,079.0					

Note: Figures may not add up to the total due to rounding.

Import Use Table at basic prices

2.37. Similar to the Domestic Use Table at basic prices, the Import Use Table records the purchases of imported products by industries as intermediate inputs and the purchases by final demand categories as consumption or capital formation at basic prices. The Import Use Table at basic prices is an expansion of the row vector for imports of goods and services in the Domestic Use Table at basic prices. Figure 2-5 is a schematic representation of the Import Use Table at basic prices.

Figure 2-4: Schematic Representation of Import Use Table at Basic Prices

Sales by product	Purchases by industry: Industry 1	Industry 2	…	…	Industry n	Total intermediate use at basic prices	Purchases by final demand: Household and NPISHs final consumption expenditure	Government final consumption expenditure	Gross fixed capital formation	Changes in inventories	Re-exports of goods and services	Total final use at basic prices	Total use at basic prices
Product 1	Intermediate consumption at basic prices by purchasing industries in columns and by imported products in rows						Final consumption at basic prices by final demand categories in columns and by imported products in rows						
Product 2													
…													
…													
Product n													
Total imports at basic prices													

2.38. Table 2-4 shows the Import Use Table at basic prices for the year 2015. Of the $160.3 billion of imported goods and services used by goods industry for intermediate consumption in 2015, $138.2 billion and $22.1 billion were spent on goods and services products respectively. Final consumption on imported goods and services was $40.5 billion of which $17.9 billion or 44% was spent on goods product. Gross capital formation on imported goods and services was $26.0 billion, with goods product accounting for $9.8 billion or 38% of gross capital formation.

2.39. $449.4 billion of goods product was imported into Singapore in 2015 which made up 70% of total imports. The goods industry used $138.2 billion of imported goods product while the services industry used $37.1 billion of imported goods product. Of the remaining $274.1 billion of imported goods product, $27.7 billion or 10% was retained in Singapore for final consumption or gross capital formation.

Table 2-4: Import Use Table at Basic Prices ($ billion), 2015

Sales by product	Purchases by industry		Total intermediate use at basic prices	Purchases by final demand			Total final use at basic prices	Total use at basic prices
	Goods	Services		Final consumption	Gross capital formation	Exports of goods and services		
Goods	138.2	37.1	175.3	17.9	9.8	246.3	274.1	449.4
Services	22.1	132.4	154.6	22.6	16.2	0.0	38.8	193.4
Total imports at basic prices	160.3	169.6	329.9	40.5	26.0	246.3	312.9	642.7

Note: Figures may not add up to the total due to rounding.

2.40. There are two main changes between the 2015 Import Use Table and the Import Use Table in former SUTs. Firstly, re-exports, which are goods exported from Singapore in the same form as they have been imported, were excluded in the compilation of previous SUTs. They are now included in the Import Use Table at basic prices.

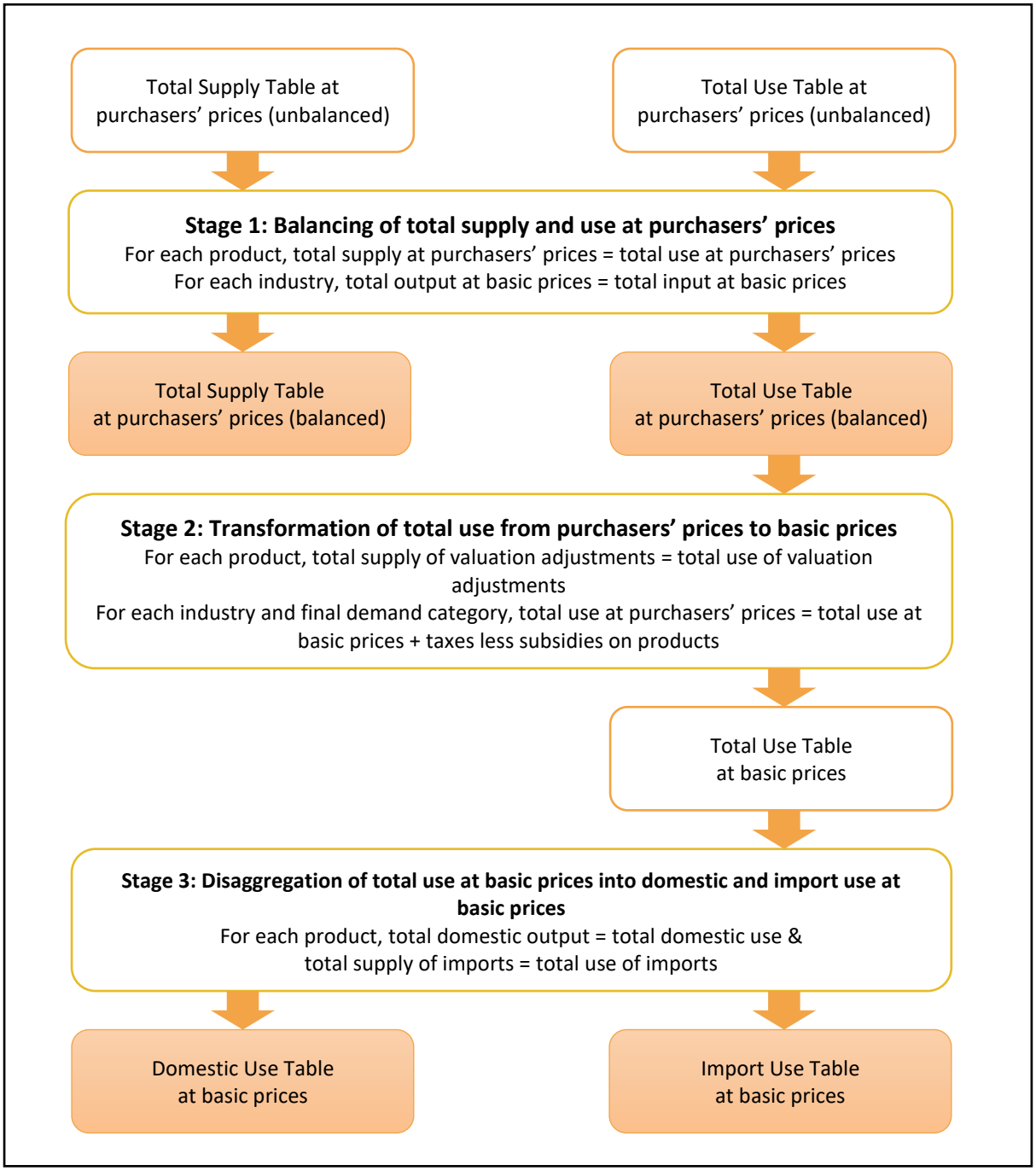
2.41. Secondly, the Import Use Table in previous SUTs captured residents' expenditure abroad net of non-residents' expenditure locally in PCE of other goods and services. Data on residents' expenditure abroad are now allocated to products and recorded under household and NPISHs final consumption expenditure in the Import Use Table at basic prices while imported products purchased by non-residents in Singapore at basic prices are recorded under re-exports by product in the Import Use Table.

Overview of Compilation Flows

2.42. Balancing of SUTs involves reconciling the voluminous data from various sources during the compilation of SUTs. When data are initially put together in the SUTs, the basic identities of SUTs are not satisfied due to various reasons, such as differences in coverage, definitions, estimation methods, classifications, recording periods and valuation across data sources. After balancing the SUTs, a single and coherent estimate of GDP can be obtained from the balanced set of SUTs.

2.43. Figure 2-5 gives an overview of the compilation flows of the Singapore SUTs, starting from the initial unbalanced Total Supply and Use Tables at purchasers' prices.

Figure 2-5: Overview of Compilation Flows of Supply and Use Tables



Stage 1: Balancing of total supply and use at purchasers' prices

2.44. For Total Supply and Use Tables at purchasers' prices to be balanced, two balancing identities must hold:

(1) For each product, Total supply at purchasers' prices = Total use at purchasers' prices
(2) For each industry, Total output at basic prices = Total input at basic prices

2.45. Balancing identity (1) can be expressed as:

(1a) For each product, $O_{BP} + M_{BP} + TTM + TOP = IC_{PP} + HFCE_{PP} + GFCE_{PP} + GFCF_{PP} + CII_{PP} + X_{PP}$

where

O = Domestic output	Supply components
M = Imports	
TTM = Trade and transport margins	Types of valuation adjustment in Supply Table at purchasers' prices
TOP = Taxes less subsidies on products	
IC = Intermediate consumption	Use components
HFCE = Household and NPISHs final consumption expenditure	
GFCE = Government final consumption expenditure	
GFCF = Gross fixed capital formation	
CII = Changes in inventories	
X = Exports	
PP = Purchasers' prices	Types of valuation
BP = Basic prices	

As trade and transport margins are part of domestic output of goods and services at basic prices, identity (1a) reduces to the following equation for the whole economy:

(1b) $O_{BP} + M_{BP} + TOP = IC_{PP} + HFCE_{PP} + GFCE_{PP} + GFCF_{PP} + CII_{PP} + X_{PP}$

Rearranging identity (1b) gives:

$O_{BP} - IC_{PP} + TOP = HFCE_{PP} + GFCE_{PP} + GFCF_{PP} + CII_{PP} + X_{PP} - M_{BP}$

⇒ GDP by production approach = GDP by expenditure approach

2.46. Balancing identity (2) can be expressed as:

(2a) For each industry, $O_{BP} = IC_{PP} + COE + OTP + GOS$

where

COE = Compensation of employees
OTP = Other taxes less subsidies on production
GOS = Gross operating surplus

The above identity is the same for the whole economy. Rearranging the identity gives:

(2b) O_{BP} - IC_{PP} = COE + OTP + GOS

⇒ GVA by production approach = GVA by income approach

2.47. GDP by production and income approaches can be obtained by adding taxes less subsidies on products to both sides of identity (2b). The balanced Total Supply and Use Tables at purchasers' prices thus determine a single estimate of GDP from the production, expenditure and income approaches.

Stage 2: Transformation of total use from purchasers' prices to basic prices

2.48. The Total Use Table at purchasers' prices is transformed to basic prices by removing trade and transport margins and taxes less subsidies on products from the use of products at purchasers' prices. Trade and transport margins are reflected as the use of wholesale/retail or transport services at basic prices, while taxes less subsidies on products are shown separately in the Total Use Table at basic prices.

2.49. The trade and transport margins and taxes less subsidies on products removed from the use of products at purchasers' prices can be viewed as a use table on total valuation adjustments. The total use of the balanced use table on total valuation adjustments must equate to the total valuation adjustments in the Total Supply Table at purchasers' prices at each product level. In other words, the following balancing identity holds:

(3) For each product, Total supply of valuation adjustments = Total use of valuation adjustments

2.50. The transformation of the balanced Total Use Table at purchasers' prices to basic prices only involves reallocating the trade and transport margins and taxes less subsidies on products within each industry and final demand category. Thus, the following balancing identity holds from the balanced Total Supply and Use Tables at purchasers' prices.

(4) For each industry and final demand category, Total use at purchasers' prices = Total use at basic prices + Taxes less subsidies on products

2.51. The Total Supply and Use Tables at basic prices is balanced once balancing identities (3) and (4) hold.

Stage 3: Disaggregation of total use at basic prices into domestic and import use at basic prices

2.52. The Import Use Table at basic prices is constructed and is balanced such that the following balancing identity holds:

(5) For each product, Total supply of imports = Total use of imports

2.53. The Domestic Use Table at basic prices can be derived by subtracting the Import Use Table at basic prices from the Total Use Table at basic prices. Once the Total Use and Import Use Tables at basic prices are balanced, the Domestic Use Table at basic prices is also balanced. The following balancing identity thus holds:

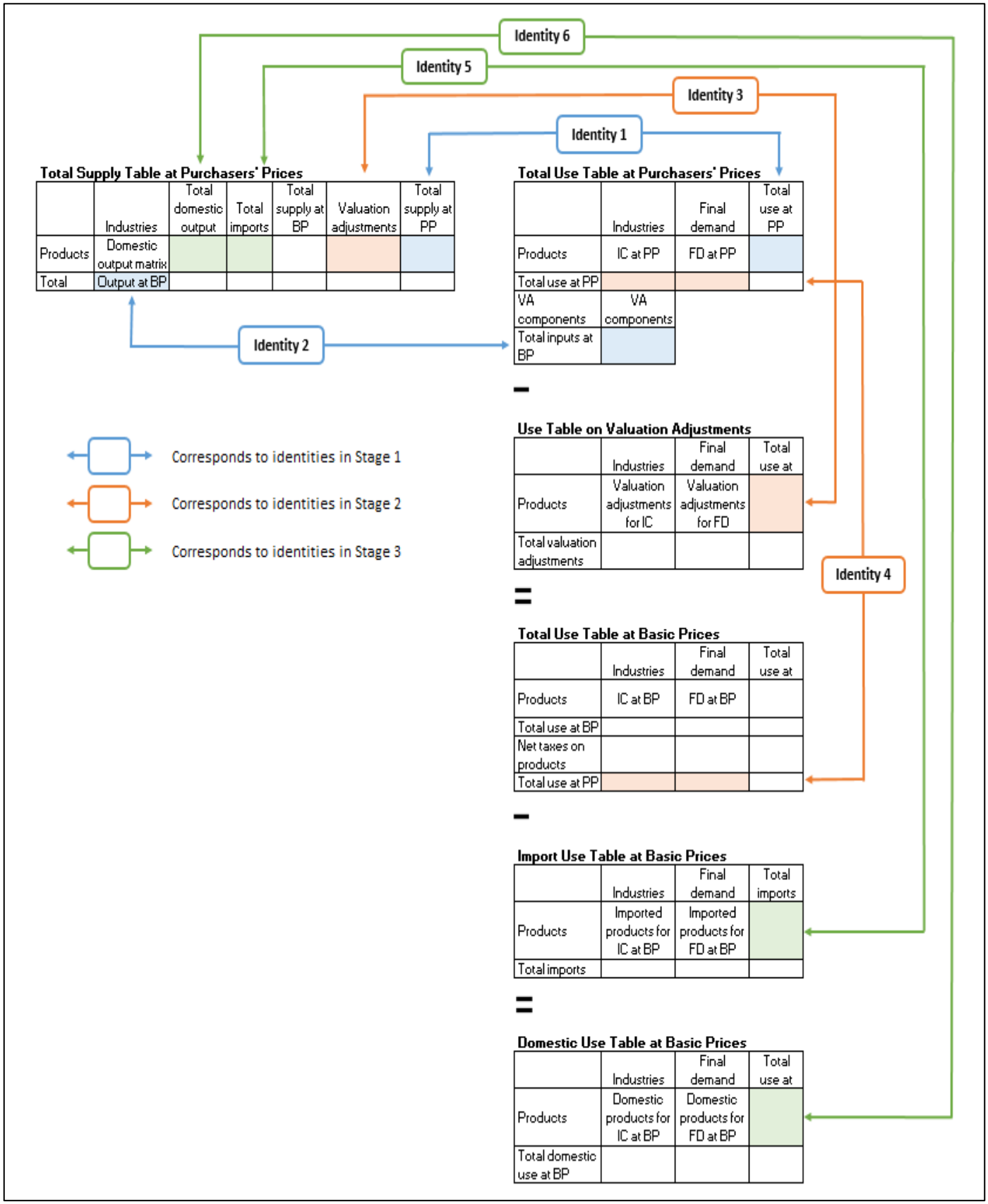
(6) For each product, Total domestic output = Total domestic use

2.54. The balancing identities discussed above provide a framework where inconsistencies in data, coverage and methodologies are identified. If any of the identities is not met, investigations on the discrepancy will be carried out on the relevant components of the identity. Data from various sources are reconciled by making adjustments and estimations to address the discovered discrepancies. More comprehensive administrative data are also used to improve the estimates from surveys.

2.55. Balancing at each of the three stages in the compilation process are interrelated. For example, balancing the Import Use Table at basic prices at Stage 3 may necessitate an adjustment to be made to the supply of imports for a particular product to satisfy the balancing identity. However, this adjustment may cause the total supply and use of the product at purchases' prices to be unbalanced at Stage 1. Thus, balancing of the SUTs is an iterative process involving Stages 1 to 3 simultaneously to arrive at a broadly balanced set of SUTs. Figure 2-6 illustrates the relationships of the identities in the balanced SUTs.

2.56. After establishing a broadly balanced set of tables describing the plausible flows in the economy through the balancing exercise, an iterative proportional fitting procedure known as the RAS method is used to automatically distribute the residual imbalances to balance the tables. More details on this mathematical procedure can be found in the Annex.

Figure 2-6: Main Identities in the Balanced SUTs



Methodological Improvements

2.57. The SUTs are necessary for benchmarking of Singapore's national accounts. The benchmarking exercise reconciles the three estimates of GDP from the output, expenditure and income approaches, and provides the opportunity to introduce major conceptual and methodological improvements. The key conceptual changes and methodological improvements implemented in the 2015 SUTs include the treatment of goods for processing and insurance service charge[6].

2.58. Besides incorporating the methodological improvements for the benchmarking exercise, changes are made to the structure and balancing process of the SUTs. Refinements to the recording of non-residents' expenditure locally and residents' expenditure abroad are also incorporated in the 2015 SUTs. A summary of these changes to the compilation of SUTs is listed in Table 2-5.

Table 2-5: Summary of Changes Incorporated in 2015 SUTs

	2015 SUTs	Previous SUTs
Valuation		
Valuation of imports	CIF & FOB	CIF only
Valuation of total supply	Purchasers' prices & Basic prices	Basic prices only
Valuation of intermediate, final and total use	Purchasers' prices & Basic prices	Basic prices only
Treatment of imports and exports		
Recording of imports for re-exports	✓	✘
Recording of re-exports	✓	✘

(Continued on next page)

[6] A more detailed discussion on the changes and improvements can be found in the Information Paper: *Benchmarking of Singapore's National Accounts to Reference Year 2015*.

Table 2-5: Summary of Changes Incorporated in 2015 SUTs (continued)

	2015 SUTs	Previous SUTs
Other methodological changes		
Product balancing	Tables are balanced at total use at purchasers' prices prior to obtaining domestic and import use at basic prices.	Tables were balanced at both domestic and import use at basic prices.
Recording of non-residents' expenditure locally	Household and NPISHs final consumption expenditure at product level excludes purchases by non-residents in Singapore. Non-residents' expenditure locally are now recorded as exports of goods and services at product level.	A lump sum negative entry was recorded under Private consumption expenditure in the import use table to exclude purchases by non-residents.
Recording of residents' expenditure abroad	Household and NPISHs final consumption expenditure at product level includes overseas purchases by residents.	A lump sum positive entry was recorded under Private consumption expenditure in the import use table to include purchases by residents abroad.

3. Singapore Input-Output Tables

3.1. This chapter first presents an overview of the impact of final demand, linkages and multipliers for reference year 2015. The rest of this chapter explains the relationships between the Supply and Use Tables (SUTs) and Input-Output Tables (IOTs). It also provides a summary of the published IOTs and the different types of Input-Output models. Annexes A, B and C to Chapter 3 provide the technical derivations of the Industry by Industry IOT, and other derived tables or Input-Output models.

Overview of Impact on the Singapore Economy in 2015

Impact of Final Demand, Linkages and Multipliers for Reference Year 2015

1. In 2015, the Singapore economy produced $1,079.0 billion worth of output for final demand. This comprises the direct effect of $730.4 billion of final output purchased by final demand and the indirect effect of $348.6 billion of intermediate output purchased by domestic industries as intermediate inputs for production of the total final output.

Chart 3-1: Total Output by Final Demand ($ billion), 2015

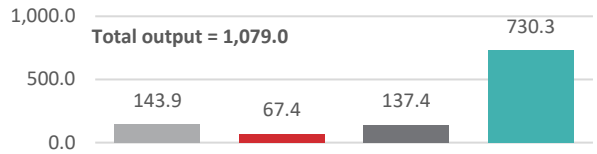


Chart 3-2: Final Output by Final Demand ($ billion), 2015

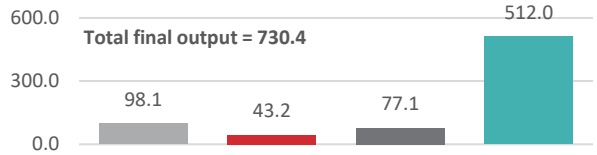
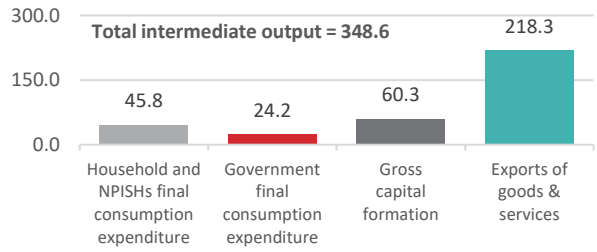


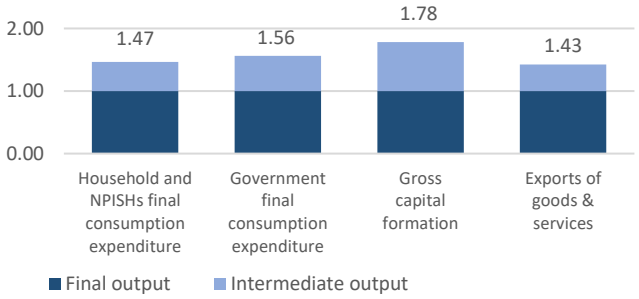
Chart 3-3: Intermediate Output by Final Demand ($ billion), 2015



2. Domestic industries produced $730.3 billion of output for export, which is the highest among the final demand categories. Of the $730.3 billion, $512.0 billion of final output was exported and $218.3 billion of intermediate output was supplied to domestic industries to support production of final output for export.

Even though the level of gross capital formation was relatively low among the final demand categories, it generated the highest impact of $1.78 of total output per $1 of final output. For every $1 of final output produced by the basket of industries (*Note1*) for gross capital formation, an additional $0.78 of intermediate output was generated within the economy by gross capital formation.

Chart 3-4: Impact on Output Per Unit Final Output



Note 1: The group of industries producing final output in which the weighted average is used to measure the value of final output.

3. $399.2 billion of value added was generated from the production of outputs for final demand. This comprises the direct effect of $267.0 billion of value added generated from production of final output and the indirect effect of $132.1 billion of value added generated from production of intermediate output.

Chart 3-5: Total Value Added by Final Demand ($ billion), 2015

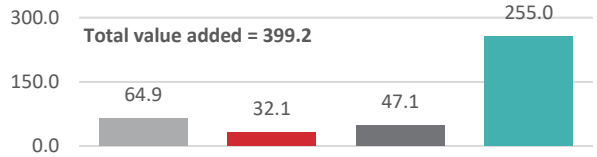


Chart 3-6: Direct Value Added by Final Demand ($ billion), 2015

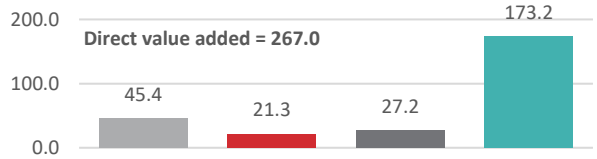
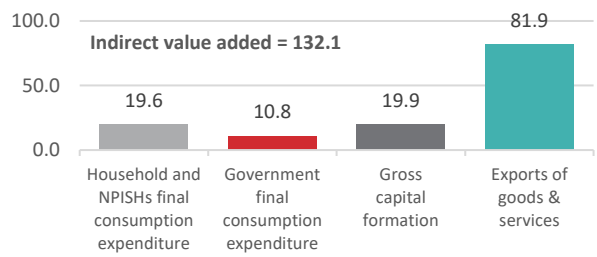


Chart 3-7: Indirect Value Added by Final Demand ($ billion), 2015



4. Similar to output, exports generated the highest impact on value added. However, it had the least impact on value added per unit of final output. This implies that the production of outputs either directly or indirectly for export had higher import requirements as compared to the production of outputs for other final demand categories.

On the other hand, government generated the highest impact of $0.74 of total value added per $1 of final output, with 66% of the value added attributed to direct effect.

Chart 3-8: Impact on Value Added Per Unit Final Output, 2015

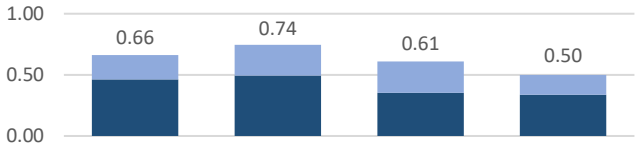
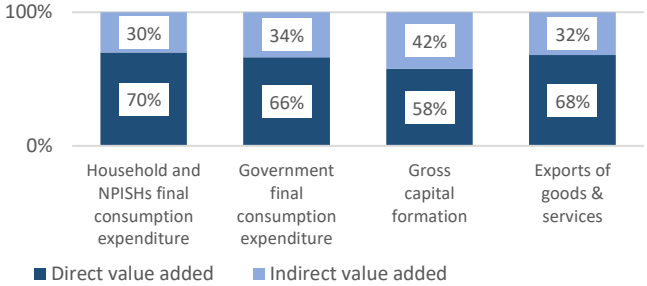


Chart 3-9: Composition of Final Demand in terms of Direct and Indirect Value Added (%), 2015



5. $177.7 billion of remuneration were paid to employees working at all stages of production for final demand. This comprises the direct effect of $121.1 billion of remuneration paid to employees working at stages of production of final output and indirect effect of $56.6 billion of remuneration paid to employees working at stages of production of intermediate output.

Chart 3-10: Total Remuneration by Final Demand ($ billion), 2015

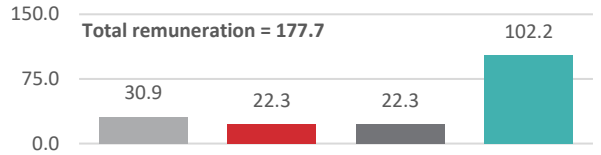


Chart 3-11: Direct Remuneration by Final Demand ($ billion), 2015

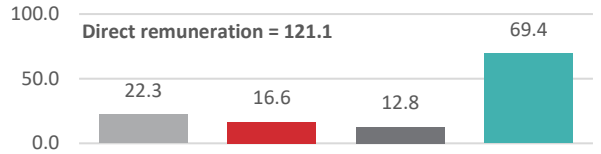
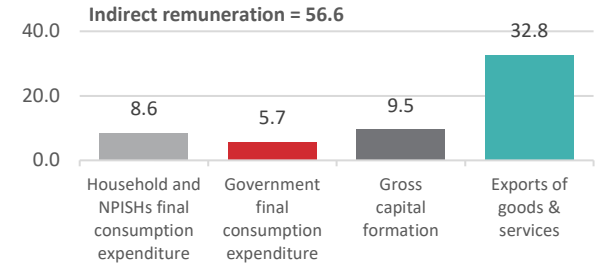


Chart 3-12: Indirect Remuneration by Final Demand ($ billion), 2015



6. Exports generated the highest impact on remuneration due to its high share in final demand. However, government final consumption expenditure generated the highest impact on remuneration per unit final output. Government final consumption expenditure generated an additional $0.52 of remuneration per $1 of final output, with 75% of the remuneration attributed to direct effect.

Chart 3-13: Impact on Remuneration Per Unit Final Output

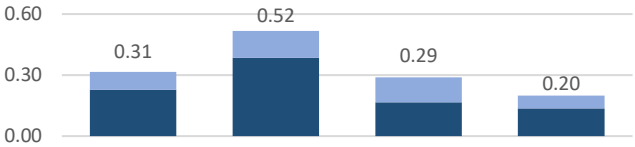
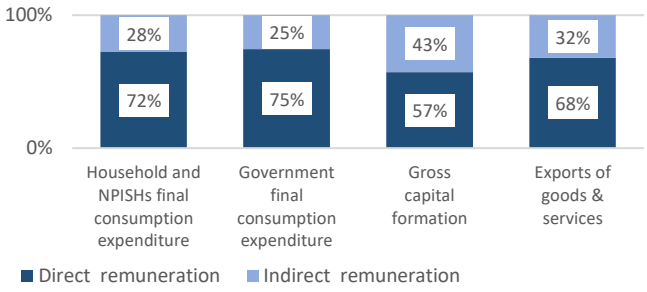
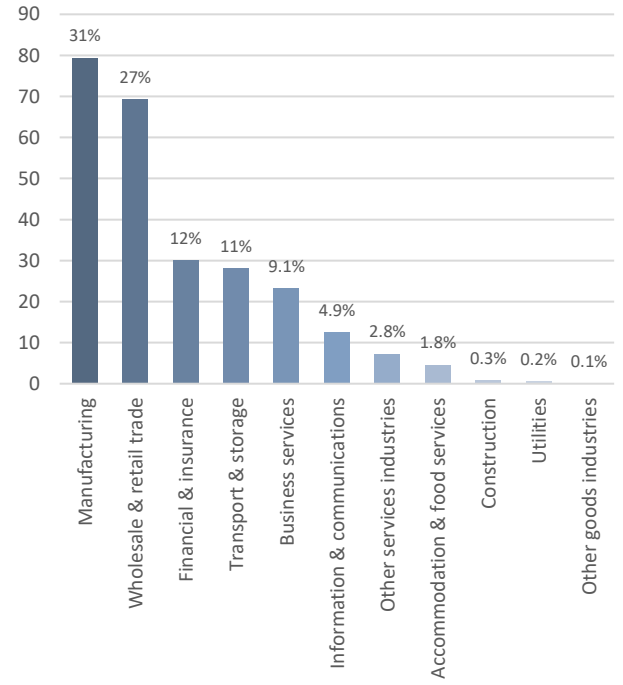


Chart 3-14: Composition of Final Demand in terms of Direct and Indirect Remuneration (%), 2015



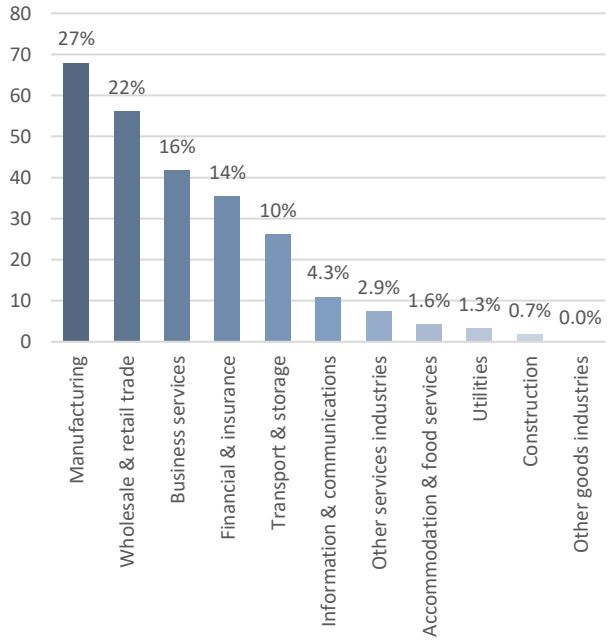
7. In 2015, total net foreign exchange earnings amounted to $255.7 billion. Exports from manufacturing industry generated $79.4 billion worth of net foreign exchange earnings (or 31%), followed by the wholesale and retail industry which generated $69.2 billion (or 27%).

Chart 3-15: Net Foreign Exchange Earnings from Exports ($ billion), 2015



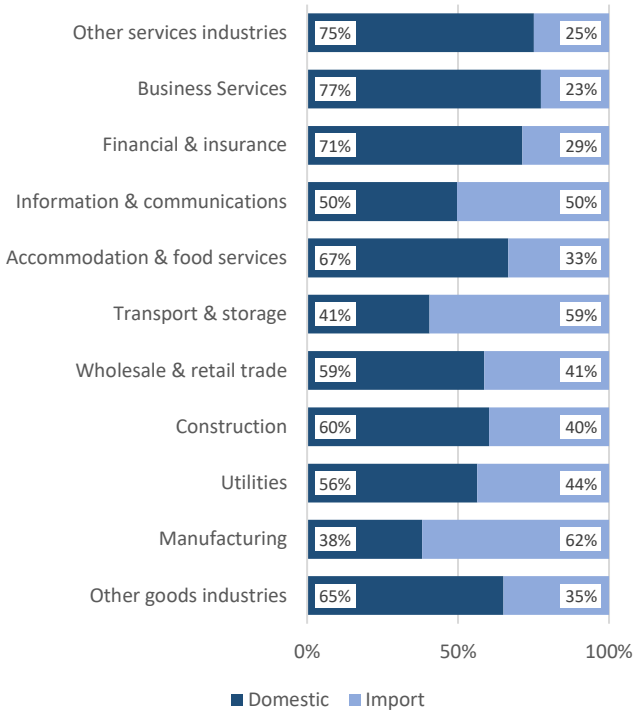
8. The manufacturing industry had the highest value added contribution of $67.9 billion (or 27%) to the total generated net foreign exchange earnings of $255.7 billion in 2015, followed by wholesale and retail industry with a value added contribution of $56.1 billion (or 22%) of net foreign exchange earnings.

Chart 3-16: Industry Contribution to Net Foreign Exchange Earnings from Exports ($ billion), 2015



9. Despite the high net foreign exchange earnings, the domestic content of manufacturing industry's export was only 38%, which is relatively low compared to other industries' exports. Business services' export had the highest domestic content which accounted for 77% of their export.

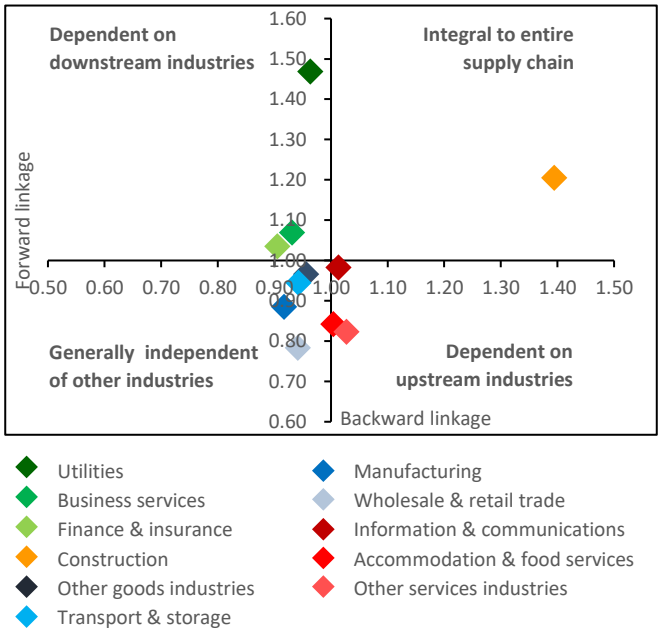
Chart 3-17: Domestic and Import Content of Exports (%), 2015



Industrial linkages

10. The construction industry had above average backward and forward linkages with values greater than 1 indicating high dependence on both their upstream supplying and downstream consuming industries. Construction could be classified as a key industry integral to the entire supply chain in the Singapore economy. The utilities industry had the highest forward linkage, indicating that its output was essential to all other domestic industries in the economy.

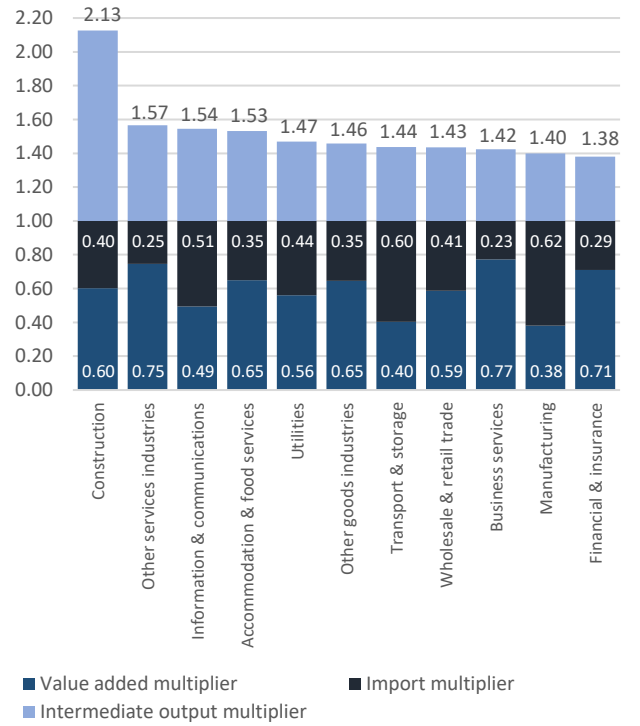
Chart 3-18: Normalised Backward and Forward linkages by Industry, 2015



Industrial multipliers

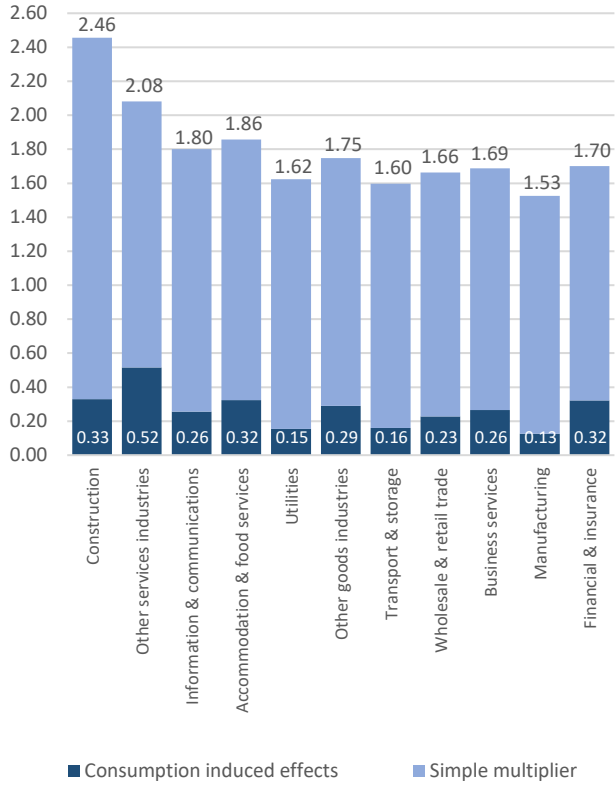
11. For simple multipliers, construction had the highest output multiplier of 2.13, business services had the highest value added multiplier of 0.77, manufacturing had the highest import multiplier of 0.62.

Chart 3-19: Simple Multipliers, 2015



12. Construction had the highest total output multiplier of 2.46, which includes consumption induced effect. Other services industries had the highest consumption induced effects of 0.52.

Chart 3-20: Total Multipliers, 2015



Relationships between Supply and Use Tables and Input-Output Tables

3.2. The SUTs form a central part of the Singapore System of National Accounts by providing a framework to ensure coherency and consistency between the various parts of National Accounts. In addition to balancing the National Accounts, SUTs constitute the basis to derive the IOTs for economic modelling and impact analysis.

3.3. The starting point of deriving the IOTs consists of the domestic output matrix of the Total Supply Table at purchasers' prices and the Domestic Use Table at basic prices. The domestic output matrix of the Total Supply Table and the intermediate use matrix of Domestic Use Table are always product by industry tables. On the other hand, the intermediate use part of the IOTs can be either a Product by Product table or an Industry by Industry table.

3.4. The intuition behind the IO analytical model is that a change in output will have an impact on the inputs required to produce the output. However, in the product by industry SUTs, the outputs or inputs associated with the secondary production cannot be separated from those of the primary production. Hence, the data from the SUTs are adjusted to allocate the inputs to the industries producing the outputs.

Treatment of Secondary Production

3.5. An industry may produce a wide range of products which are not among the primary products of the industry in which they are classified. The production of other products not characteristic for this industry is called secondary production. An example is the petroleum refining industry producing refined petroleum as its primary output and processed natural gas as the secondary output.

3.6. In the case where there is no secondary production in the economy, national accountants will not be required to compile the domestic output matrix of the Total Supply Table as the outputs of each industry will be reported only on the diagonal. In addition, the Domestic Use Table will be equivalent to the IOT, and there will be no difference between Product by Product IOTs and Industry by Industry IOTs.

3.7. There are four commonly used assumptions for the treatment of secondary production. These assumptions, as defined in the 2008 SNA, are summarised in Box 3-1. The 'Industry Technology' and 'Product Technology' assumptions are used to derive the Product by Product IOTs, while the 'Fixed Product Sales Structure' and 'Fixed Industry Sales Structure' assumptions are used to derive the Industry by Industry IOTs.

Box 3-1: Assumptions to Derive the Input-Output Tables

Product by Product	Technology Assumption	
	Industry Technology	Product Technology
	Each industry has its own specific means of production, irrespective of its product mix.	Each product is produced in its own specific way, irrespective of the industry where it is produced.
Industry by Industry	Fixed Sales Structure Assumption	
	Fixed Product Sales Structure	Fixed Industry Sales Structure
	Allocation of demand to users depends on the product and not the industry selling the product.	Users always demand the same mix of products from an industry.

3.8. A Product by Product IOT describes the technological relationship between products and homogeneous units of production (branches). A unit of homogenous production is a producer which carries out only a single production activity. For example, production units of the homogeneous branch agriculture only produce agricultural products. On the other hand, an Industry by Industry IOT describes the flows of goods and services between all industries of the economy.

3.9. The choice of the types of table depends on the objectives of the economic analysis. The Product by Product IOT may be more suited for analysing new technologies in the economy, while the Industry by Industry IOT may be more suitable to study the economic impact of government spending.

3.10. DOS compiles the Industry by Industry IOT using the 'Fixed Product Sales Structure' assumption. Similar to the Domestic Use Table, the Industry by Industry IOT records transactions at basic prices, and the industry dimension of the Singapore IOTs is 105 IO industries. A schematic representation of the Industry by Industry IOT is presented in Figure 3-1 .

Figure 3-1: Schematic Representation of Industry by Industry Input-Output Table

Sales by industry	Purchases by industry: Industry 1	Industry 2	....	....	Industry n	Total intermediate output at basic prices	Purchases by final demand: Household and NPISHs final consumption expenditure	Government final consumption expenditure	Gross fixed capital formation	Changes in inventories	Exports of goods & services	Total final output at basic prices	Total output at basic prices
Industry 1	**Matrix 1** Intermediate consumption by purchasing industries in columns and by selling industries in rows						**Matrix 2** Final consumption by final demand categories in columns and by selling industries in rows						
Industry 2													
….													
….													
Industry n													
Total domestic use at basic prices													
Imports of goods and services	**Matrix 4** Intermediate consumption by purchasing industries in columns and by imports in row						**Matrix 6** Final consumption by final demand categories in columns and by imports in row						
Taxes less subsidies on products	**Matrix 5** Taxes on products paid by purchasing industries in columns						**Matrix 7** Taxes on products paid by final demand categories in columns						
Total use at purchasers' prices													
Compensation of employees	**Matrix 3** Income generated by producing industries in the columns and by value added categories in rows												
Taxes less subsidies on production													
Gross operating surplus													
Value added at basic prices													
Total inputs at basic prices													

Total or sub-total

3.11. The Industry by Industry IOT looks similar to the Domestic Use Table. However, there are a few key differences, which are summarised in Box 3-2.

Box 3-2: Industry by Industry IOT Versus Domestic Use Table

Matrix	Industry by Industry IOT	Domestic Use Table
1	This matrix shows the intermediate consumption by purchasing industries in the columns and by selling industries in the rows.	This matrix shows the intermediate consumption by purchasing industries in the columns and by products in the rows.
2	This matrix shows the final consumption by final demand categories in the columns and by selling industries in the rows.	This matrix shows the final consumption by final demand categories in the columns and by products in the rows.
3 to 7	No differences	

3.12. In addition to the Industry by Industry IOT, DOS also publishes other application tables derived from the Industry by Industry IOT. Table 3-1 shows the list of published tables, which can be classified into three main categories – the Industry by Industry IOT, coefficients tables and impact of final demand tables. Detailed information on each table will be discussed in the subsequent sections.

Table 3-1: List of Published IOTs

Table	Type of table	Dimension	
		Row	Column
5	Industry by Industry Input-Output Table	Industry and Primary Input	Industry and Final Demand

(Continued on next page)

Table 3-1: List of Published IOTs (continued)

Table	Type of table	Dimension	
		Row	Column
Coefficients tables			
6	Direct Requirement Coefficients	Industry and Primary Input	Industry
7	Total Requirement Coefficients	Industry	Industry
8	Total Requirement Coefficients in Terms of Value added	Industry	Industry
9	Primary Input Requirement Coefficients of Final Demand	Industry	Primary input
10	Forward and Backward Linkages	Industry	Linkage
Impact of final demand tables			
11	Industrial Output by Final Demand	Industry	Final demand
12	Industrial Value Added by Final Demand	Industry	Final demand
13	Primary Inputs by Final Demand	Primary input	Final demand
14	Net Foreign Exchange Earnings from Exports	Industry	Net foreign exchange earnings

Derivation of the Industry by Industry Input-Output Table

3.13. For the purpose of understanding the IOT, all tables are presented in terms of two broad industries: goods industry and services industry[7].

3.14. 'Compensation of employees', 'taxes less subsidies on production' and 'gross operating surplus' are presented as 'value added' when a breakdown is not necessary for understanding the IOT. Similarly, 'household and NPISHs final consumption expenditure', 'government final consumption expenditure', 'gross fixed capital formation', 'changes in inventories' and 'exports of goods & services' are presented as 'final demand'. 'Imports' refers to imports of goods and services, and 'taxes on products' refers to 'taxes less subsidies on products.

[7] Figures in this chapter may differ slightly from the corresponding estimates in the detailed tables due to aggregation bias. Aggregation bias in IOTs arises when these tables are computed from aggregated versions of supply and use tables, leading to slight differences when comparing disaggregated and aggregated versions of the same table.

3.15. The 'Fixed Product Sales Structure' assumes that each product has its own specific sales structure, irrespective of the industry where it is produced. For example, if the services industry produces 2% of the total produced goods in the economy, then 2% of the goods purchased by each industry or final demand category would be produced by the services industry.

3.16. To derive the Industry by Industry IOT, the first step is to compute the market shares of output for each industry by dividing all row elements with the row total in the domestic part of the Total Supply Table in Table 3-2. Table 3-3 shows the resulting market share coefficients.

Table 3-2: Domestic Output Matrix of the Total Supply Table ($ billion), 2015

	Goods industry	Services industry	Total output
Goods	381.6	6.3	387.9
Services	17.3	673.7	691.1
Total output	399.0	680.0	1,079.0

Table 3-3: Market Share Coefficients, 2015

	Goods industry	Services industry	Total
Goods	0.98	0.02	1.00
Services	0.03	0.97	1.00

The services industry produced 2% (= 6.3/ 387.9 × 100%) of the goods in the economy.

3.17. The second step is to subdivide all row elements in Matrices 1 and 2 of the Domestic Use Table in Table 3-4 according to the market shares computed in Table 3-5. This intermediate step to derive the Industry by Industry IOT is displayed in Table 3-65.

Table 3-4: Domestic Use Table at Basic Prices ($ billion), 2015

	Goods industry	Services industry	Final demand	Total use
Goods	102.6	28.6	256.7	387.9
Services	33.3	184.1	473.7	691.1
Imports	160.3	169.6	312.9	642.7
Taxes on products	0.1	1.2	23.0	24.3
Value added	102.6	296.6	-	399.2
Total inputs	399.0	680.0	1,066.2	2,145.2

Table 3-5: Intermediate Step to Industry by Industry IOT, 2015

	Goods industry	Services industry	Final demand
Goods from goods industry	102.6 × 0.98	28.6 × 0.98	256.7 × 0.98
Goods from services industry	102.6 × 0.02	28.6 × 0.02	256.7 × 0.02
Services from goods industry	33.3 × 0.03	184.1 × 0.03	473.7 × 0.03
Services from services industry	33.3 × 0.97	184.1 × 0.97	473.7 × 0.97

The 'Fixed Product Sales Structure' assumes that 2% of the goods purchased by the goods industry were produced by the services industry.

Similarly, 2% of the goods purchased by the services industry were produced by the services industry.

Table 3-6: Industry by Industry IOT ($ billion), 2015

	Goods industry	Services industry	Final demand	Total output
Goods industry	101.8	32.7	264.4	399.0
Services industry	34.2	179.9	465.9	680.0
Imports	160.3	169.6	312.9	642.7
Taxes on products	0.1	1.2	23.0	24.3
Value added	102.6	296.6	-	399.2
Total inputs	399.0	680.0	1,066.2	2,145.2

The goods industry purchased $34.2 billion of output from the services industry for production. Note: 34.2 = 102.6 × 0.02 + 33.3 × 0.97

For the Industry by Industry IOT, this part of the table is the same as that of the Domestic Use Table.

3.18. The final step is to sum up the rows corresponding to the same industry to derive the Industry by Industry IOT in Table 3-6. It is to be noted that each row sum equals the output of the respective industry. Matrices 3 to 7 of the Industry by Industry IOT are the same as those of the Domestic Use Table.

Basic Assumptions of Input-Output Model

3.19. While IOTs are useful tools for economic modelling and impact studies, users need to bear in mind the following basic underlying assumptions, and the extent to which they can be met when performing Input-Output analysis.

Homogeneity

3.20. All establishments classified in the same industry have the same production process and inputs requirements. If a new establishment uses new production technologies which require significantly fewer inputs as compared to other establishments classified in the same industry, then the actual impact of the new company will be different from the simulated impact. This is because the Input-Output model assumes the new establishment will stimulate the same level of production per unit of demand within the economy.

Fixed proportion

3.21. Industries have fixed input requirements proportion relative to output. If an industry doubles its output, its input requirements such as intermediate inputs, imports and employment for production must also double.

3.22. If an industry is operating at below capacity with under-utilised inputs and can increase its output without increasing its inputs proportionately, the direct requirement coefficients used for the I-O model may not be applicable. In such a case, the actual impact will be lower than the simulated impact.

No supply constraint

3.23. The required amount of intermediate inputs and labour can be provided to meet the increase in demand at the same fixed price. If there are limited supplies of domestic resources, industries may have to consider alternatives such as raising imports. In such a case, the actual impact of an increase in final demand will be lower since local production is unable to fully satisfy the demand and hence the multiplier effects will be correspondingly lower.

Input-Output Coefficients and Linkages

Direct Requirement Coefficients

3.24. Analysis using the Industry by Industry IOT starts with the calculation of direct requirement coefficients (or input coefficients). The Direct Requirement Coefficients table shows how much each different type of inputs is required by an industry to produce 1000 units of output. They represent the technological structure of industries.

3.25. The direct requirement coefficients are calculated by dividing the column elements of Matrices 1 and 3 to 5 in the Industry by Industry IOT (Table 3-6) by the total output of that industry. As the coefficients cover all direct inputs, including value added, they sum up to unity. Table 3-7 shows the Direct Requirement Coefficients table for the goods and services industries.

Table 3-7: Direct Requirement Coefficients, 2015

	Goods industry	Services industry
Goods industry	255	48
Services industry	86	265
Imports	402	249
Taxes on products	0	2
Value added	257	436
Total	1,000	1,000

The services industry required $48 of output from the goods industry to produce $1,000 of output.

The services industry generated $436 of value added from the production of $1,000 of output.

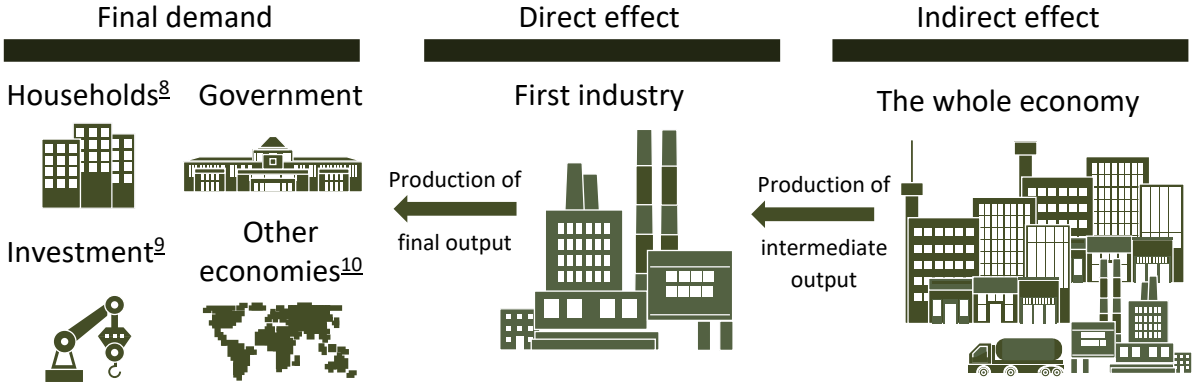
Total Requirement Coefficients

3.26. An industry requires more inputs to increase production of output for final demand. Indirectly, the immediate upstream industries supporting the initial industry would require more inputs to increase production of output. Similarly, all further upstream industries would need to increase production to support the downstream industries. Hence, an increase in final demand for an industry's output will stimulate production of output in other industries.

3.27. Unlike the Direct Requirement Coefficients table, the Total Requirement Coefficients table does not measure the input requirements of industries. Instead, the Total Requirement Coefficients table measures the total production of output required by each industry to support the first industry's production of 1,000 units of final output for final demand.

3.28. The production of final output by the first industry to meet the final demand is known as the direct effect of the change in final demand. The production of intermediate output provided to all industries as inputs to support the production of final output by the first industry is known as the indirect effect of the change in final demand. A simple illustration is provided in Figure 3-2.

Figure 3-2: Direct and Indirect Effects of Final Demand



3.29. Figure 3-3 illustrates the recording of the direct, indirect and total effects in the Total Requirement Coefficients table. The output requirement of the first industry is represented on the diagonal. As the output requirement of the first industry consists of final output produced for the final demand categories (direct effect) and the intermediate output supplied as inputs to all industries (indirect effect), the diagonal will always be greater than 1,000. On the other hand, the output requirements of other industries, reported on the off-diagonal, consist of the intermediate output supplied as inputs only (indirect effect).

3.30. The column sum will represent the total output produced by all industries as a result of the changes in the first industry's production final output for final demand. This is also known as the output multiplier of the first industry. Table 3-8 shows the Total Requirement Coefficients table for the goods and services industries.

Figure 3-3: Schematic Representation of Total Requirement Coefficients Table

	Goods industry	Services industry
Goods industry		
Services industry		
Total		

Consists of direct and indirect effects

Consists of indirect effect

Total effects

[8] 'Households' includes non-profit institutions serving households (NPISHs).
[9] 'Investment' refers to 'Gross fixed capital formation', 'Changes in inventories'.
[10] 'Other economies' refers to 'Exports of goods and services'.

Table 3-8: Total Requirement Coefficients, 2015

	Goods industry	Services industry
Goods industry	1,353	89
Services industry	157	1,370
Total	1,510	1,459

The goods industry produced $89 of intermediate output. This is the indirect effect of services industry's production of $1,000 of final output for final demand.

$1,459 of output is produced in the economy as a result of production of $1,000 of final output for final demand by the services industry. This is also known as the output multiplier of the services industry.

The services industry produces $1,370 of output as a result of services industry's production of $1,000 of final output for final demand. The direct effect of $1,000 consists of the services industry's final output, and the indirect effect of $370 consists of the services industry's intermediate output provided to all industries as inputs.

Total Requirement Coefficients in Terms of Value Added

3.31. As industries change their production in response to the change in final demand, the value added generated from the production activities also changes. The Total Requirement Coefficients table, expressed in terms of output, in Table 3-8, can be expressed in terms of value added to measure the value added generated from industries in order to support the first industry's production of 1,000 units of final output for final demand categories.

3.32. The coefficients can be computed using the Direct Requirement Coefficients table in Table 3-7 and the Total Requirement Coefficients table. The row elements in the total requirement coefficients table are multiplied with the direct requirement coefficients for value added of the corresponding industry.

3.33. Similar to the Total Requirement Coefficients table, the diagonal measures both the direct and indirect effects on the first industry in terms of value added as a result of a change in final demand. The off-diagonal measures indirect effects on the other industries in terms of value added as a result of a change in final demand. The column sum is the value added multiplier of that industry.

3.34. The direct effect on the first industry can be found in the direct requirement coefficients table, and the indirect effect on the first industry can be computed by subtracting the total effects with the direct effect.

3.35. The intermediate computation step is presented in Table 3-9 and the Total Requirement Coefficients in Terms of Value Added for the goods and services industries are presented in Table 3-10.

Table 3-9: Intermediate Step to Total Requirement Coefficients in Terms of Value Added, 2015

	Goods industry	Services industry
Goods industry	1353 × 257/1,000	89 × 257/1,000
Services industry	157 × 436/1,000	1370 × 436/1,000

From Table 3-8, the goods industry produced $89 of output as inputs to all industries to support the services industry's production of $1,000 of output for final demand.

From Table 3-7, the goods industry generated $257 of value added from production of $1,000 of output.

The goods industry generated $89 × 257/1,000 of value-added from the production of output supplied as inputs to all industries to support the services industry's production of $1,000 of output for final demand.

Table 3-10: Total Requirement Coefficients in Terms of Value Added, 2015

	Goods industry	Services industry
Goods industry	348	23
Services industry	68	597
Total	416	620

The goods industry generated $23 of value added from production of output as inputs to all industries. This is the indirect effect of services industry's production of $1,000 of final output for final demand.

$620 of value added is generated from all production activities as a result of services industry's production of $1,000 of final output for final demand. This is also known as the value added multiplier of the services industry.

The services industry generates $597 of value added as a result of its production of $1,000 of final output for final demand.
The $597 worth of value added consists of the direct effect of $ 436 and indirect effect of $161. $436 is also the direct value added requirement coefficient of the services industry.

Primary Input Requirement Coefficients of Final Demand

3.36. The Total Requirement Coefficients in Table 3-8 can also be expressed in terms of primary inputs. Primary inputs include imports, taxes on products, compensation of employees, taxes on products and gross operating surplus. The Primary Input Requirement Coefficients of Final Demand table can be computed in a similar fashion to the Total Requirement Coefficients in Terms of Value Added in Table 3-10 as explained in paragraph 3.32. Similarly, the breakdown of the coefficients by direct and indirect effects can be derived using the same method as explained in paragraph 3.34.

3.37. Table 3-11 presents the Total Requirement Coefficients in Terms of Primary Inputs for the goods and services industries. Some of the commonly used multipliers such as import and income (or compensation of employees) can also be found in this table where each row element represents the corresponding multiplier of that industry. For example, the services industry's import multiplier of $377 indicates that all industries would require $377 of imports of goods and services as inputs to support the services industry's production of $1,000 of output for final demand.

Table 3-11: Primary Input Requirement Coefficients of Final Demand, 2015

	Imports	Taxes on products	Taxes on production[11]	Income[12]	Gross operating surplus	Total
Goods industry	583	1	12	164	241	1,000
Services Industry	377	2	9	288	324	1,000

All industries required $377 of imports of goods and services as inputs to production to support the services industry's production of $1,000 of final output.
This is also known as the import multiplier of the services industry.

All industries paid $288 of remuneration to employees as inputs to production to support the services industry's production of $1,000 of final output.
This is also known as the income multiplier of the services industry.

3.38. Table 3-12 lists the multipliers which are available in the published tables.

Table 3-12: Multipliers in Published Tables, 2015

Types of multipliers	Table
Output	Total Requirement Coefficients
Value added	Total Requirement Coefficients in Terms of Value Added
Compensation of employees (or income)	Primary Input Requirement Coefficients of Final Demand
Other taxes less subsidies on production	
Gross operating surplus	
Imports of goods and services	
Taxes less subsidies on products	

[11] Taxes on production refers to 'other taxes less subsidies on production'.
[12] Income refers to 'compensation of employees'.

Forward and Backward Linkages

3.39. Linkage analysis, which is often used to identify key industries with high multipliers in the economy, can also be derived from the Industry by Industry IOT. There are two main types of linkages: backward and forward linkages.

3.40. Backward linkages are demand oriented, and they measure an industry's dependence on the production by other upstream industries. Forward linkages are supply oriented, and they measure an industry's dependence on the purchases by other downstream industries.

3.41. Linkages, when expressed in normalised form, have an average value of 1. Industries with above average linkages have values greater than 1, while industries with below average linkages have values less than 1. The classification of industries based on the normalised linkages is summarised in Box 3-3.

Box 3-3: Classification of Industries based on Linkages

		Backward Linkage	
		< 1	> 1
Forward Linkage	> 1	Industry is relatively more dependent on downstream industries	Industry is generally integral to entire supply chain
	< 1	Industry is generally independent of other industries	Industry is relatively more dependent on upstream industries

3.42. In addition to linkages, a coefficient of variation can be computed to measure whether the linkages are biased towards only a few industries. A low coefficient of variation in a particular industry means that expansion of that particular industry will stimulate production activities in other industries in an even manner. Conversely, a high coefficient of variation means that the benefits of an expansion of a particular industry are unevenly shared among all industries.

Impact of Final Demand

3.43. The information presented in Table 3-8 Total Requirement Coefficients, Table 3-10 Total Requirement Coefficients in Terms of Value Added and Table 3-11 Primary Input Requirement Coefficients of Final Demand can be used to estimate the levels of production and inputs required to meet a given level of final demand.

Industrial Output by Final Demand

3.44. The Industrial Output by Final Demand table in Table 3-13 shows how much output each industry produced either directly or indirectly for final demand in 2015. The output include final output produced directly for the final demand categories (direct effect) and the intermediate output supplied as inputs to all industries (indirect effect).

3.45. The level of final demand in Table 3-14, which can be extracted from Matrix 2 of the Industry by Industry IOT in Table 3-6, shows the final output purchased by the various final demand categories in 2015. The table excludes the imports of goods and services purchased directly by the final demand categories.

Table 3-13: Industrial Output by Final Demand ($ billion), 2015

	Household expenditure[13]	Government expenditure[14]	Gross capital formation[15]	Domestic exports	Total output
Goods Industry	18.6	5.2	67.9	307.4	399.0
Services Industry	124.9	57.8	47.1	450.1	680.0
Total	143.5	63.0	115.0	757.5	1,079.0

The goods industry produced $18.6 billion of output to meet the final demand of $98.1 billion (from Table 3-14 by households. Of the $18.6 billion, $7.8 billion was the final output for households (direct effect) and $10.8 billion was the intermediate output supplied to all industries to support productions to meet the final demand of households (indirect effect).

The services industry produced $124.9 billion of output to meet the final demand of $98.1 billion by households. Of the $124.9 billion, $90.3 billion was the final output for households (direct effect) and $34.6 billion was the intermediate output supplied to all industries to support productions to meet the final demand of households (indirect effect).

Table 3-14: Final Output by Final Demand ($ billion), 2015

	Household expenditure	Government expenditure	Gross capital formation	Domestic exports	Total final output
Goods Industry	7.8	1.1	48.3	207.3	264.4
Services Industry	90.3	42.1	28.9	304.7	465.9
Total	98.1	43.2	77.1	512.0	730.4

[13] Household expenditure refers to 'Household and NPISHs final consumption expenditure'.
[14] Government expenditure refers to 'Government final consumption expenditure'.
[15] Gross capital formation refers to 'Gross fixed capital formation', 'Changes in inventories'.

Industrial Value Added by Final Demand

3.46. The Industrial Value Added by Final Demand table in Table 3-15 shows how much value added was generated from production activities either directly or indirectly to meet the level of final demand in 2015.

Table 3-15: Industrial Value Added by Final Demand ($ billion), 2015

	Household expenditure	Government expenditure	Gross capital formation	Domestic exports	Total value added
Goods Industry	4.8	1.3	17.5	79.0	102.6
Services Industry	54.5	25.2	20.6	196.3	296.6
Total	59.3	26.5	38.0	275.4	399.2

The goods industry generated $4.8 billion of value added from production of output to meet the final demand of $98.1 billion by households.

The services industry generated $54.5 billion of value added from production of output to meet the final demand of $98.1 billion by households.

Primary Inputs by Final Demand

3.47. The Primary Inputs by Final Demand table in Table 3-16 shows how much primary inputs were required either directly or indirectly to meet the level of final demand in 2015.

Table 3-16: Primary Inputs by Final Demand ($ billion), 2015

	Household expenditure	Government expenditure	Gross capital formation	Exports	Total final demand
Imports	79.1	16.5	65.0	482.1	642.7
Taxes on products	19.0	0.1	4.3	0.9	24.3
Income	27.3	12.3	16.2	121.8	177.7
Taxes on production	0.9	0.4	0.8	5.0	7.0
Gross operating surplus	31.1	13.9	21.0	148.5	214.5
Total	157.3	43.2	107.4	758.3	1,066.2

Imports
$79.1 billion of goods and services were imported to meet demand from households in 2015. The $79.1 billion consists of imports purchased directly by households as well as by industries for production of output to meet the final demand of $98.1 billion by households.

Taxes on products
$19.0 billion of taxes on products were paid directly by households and by industries for production of output to meet the final demand of $98.1 billion by households.

Income
$27.3 billion of remuneration was paid to employees involved in the production of output to meet the final demand of $98.1 billion by households.

Taxes on production
$0.9 billion of taxes on production was paid by industries for the production of output to meet the final demand of $98.1 billion by households.

Gross operating surplus
$31.1 billion of operating surplus was generated from the production of output to meet the final demand of $98.1 billion by households.

Net Foreign Exchange Earnings from Exports

3.48. The Net Foreign Exchange Earnings from Exports table in Table 3-17 shows the impact of domestic exports on net foreign exchange earnings. Net foreign exchange earnings are defined as the total foreign exchange earnings from domestic exports minus the import requirements to produce the output for exports.

3.49. Another interpretation of net foreign exchange earnings is that it estimates the domestic content, which includes value added and taxes on products, in producing the goods and services for export. The import requirements can be interpreted as the import content of exports or the total imports required by all industries to produce the goods and services for export. The ratio of net foreign exchange earnings to domestic exports gives an indication of the domestic content embedded in the exports.

Table 3-17: Net Foreign Exchange Earnings from Exports ($ billion), 2015

	Domestic Exports	Import Requirements of Domestic Exports	Net Foreign Exchange Earnings	Net Foreign Exchange Earnings – Exports Ratio
Goods Industry	207.3	120.8	86.5	0.42
Services Industry	304.7	114.9	189.8	0.62

$114.9 billion of goods and services were imported by all industries to support services industry's production of output for export.

$189.8 billion of net foreign exchange earnings were generated from the exports by services industry.

Both goods and services industries contributed to the $189.8 billion of net foreign exchange earnings, which account for 62% of the services industry's exports.

Other Input-Output Analysis

Input-Output Models with Endogenous Final Demand

3.50. Thus far, the presented tables represent an open Input-Output model where the final demand categories are considered exogenous. In a closed model, final demand categories can be treated as endogenous and interdependent.

3.51. For example, household and NPISHs final consumption expenditure can be treated like an industry in a closed model. It is assumed that the income earned by households from wages and salaries is spent to a large extent as household and NPISHs final consumption expenditure. Therefore, an increase in production activities due to changes in final demand induces higher income, which again induces more household and NPISHs final consumption expenditure until a new equilibrium is reached. This additional effect due to endogenous final demand categories is also known as consumption induced effects.

3.52. The choice of the types of Input-Output models depends on the nature of the economic study. If the nature of the study is to rank the industries in terms of their importance to the economy, then it may not be essential to consider the consumption induced effects. On the other hand, if the study is to estimate the impact of government spending on the total income generated in the economy, then it may be more useful to include the consumption induced effects. The differences between the open and closed models are summarised in Box 3-4.

Box 3-4: Open Versus Closed Models and Types of Multiplier Effects

Type of model	Direct effect	Indirect effect	Consumption induced effect
Open	✓	✓	✗
Closed	✓	✓	✓

Leontief vs Ghosh Input-Output Model

3.53. Economic analysis using IOTs is usually based on input coefficients. This is commonly known to IO practitioners as the Leontief model. There is another model known as the Ghosh model which is based on output coefficients.

3.54. The Leontief model is a demand model that can be used to study the economic impact of changes in final demand, while the Ghosh model is a supply model that can be used to study the economic impact of changes in imports, taxes on products or primary inputs. The backward linkages are based on the Leontief model while the forward linkages are based on the Ghosh model.

4. Conclusion

4.1. Similar to earlier sets of benchmark Supply and Use Tables (SUTs), the benchmark 2015 SUTs were used to derive and reconcile the three GDP estimates in the benchmarking of Singapore's National Accounts to reference year 2015. Various conceptual changes and methodological improvements have been incorporated in the 2015 SUTs, such as the treatment of goods for processing and insurance service charge. Changes were also made to the structure and balancing process of the SUTs.

4.2. In 2015, the Singapore economy produced $1,079.0 billion worth of goods and services and consumed $679.8 billion worth of intermediate inputs. Of the $679.8 billion of intermediate inputs, $348.6 billion was supplied by domestic industries, $329.9 billion was imported and $1.3 billion was paid on taxes less subsidies on products. Imports of goods and services at CIF totalled $642.7 billion, of which $329.9 billion was purchased by domestic industries for intermediate consumption and $246.3 billion was re-exported, with only $66.5 billion retained for final use in Singapore. Domestic exports of goods and services accounted for $512.0 billion or 48% of total domestic output in 2015, reflecting Singapore's dependence on external demand. GVA amounted to $399.2 billion with the business services industry contributing $79.8 billion or 20% of GVA.

4.3. Input-Output Tables (IOTs), transformed from the SUTs, embody a wealth of information which enables policy formulation and evaluation, economic analysis and forecasting. IOTs can be used to assess the impact of changes in final demand on the economy, examine linkages to various industries, and analyse structural changes of the economy.

4.4. Multiplier analysis shows that the construction industry had the highest simple output multiplier, while the business services industry had the highest simple VA multiplier. A change in demand of the final output of the other services industries had the highest consumption induced effects per unit of final output. Although the manufacturing industry had the highest output and the second largest VA in nominal terms, its VA multiplier was the lowest due to its high import content.

4.5. Similarly, while the manufacturing industry's exports generated 32% of the net foreign exchange earnings in Singapore, the domestic content of manufacturing industry's exports was relatively low compared to other industries' exports due to its higher import requirements for exports. In terms of industry's contribution, manufacturing industry contributed 27% of the total domestic value added towards the net foreign exchange earnings from exports.

4.6. The utilities industry had the highest forward linkage coefficient as it provided essential services to all other domestic industries in the economy. The construction industry had above average backward and forward linkages with values greater than 1, indicating high dependence on both its upstream supplying and downstream consuming industries.

4.7. In conclusion, this publication has summarised the results, methodology and structure of the 2015 SUTs, the transformation of the SUTs to the Industry by Industry IOT and its applications. Users may also refer to other resources on the applications of IOTs.

Resource	Types	Who is it useful for?
Output multipliers	Infographic	Basic level user to interpret results derived from multipliers
Connecting the Dots between Industries: Linkages	Infographic	Basic level user to interpret results derived from multipliers
Using Input-Output Tables in Simulation	Statistics Singapore Newsletter March 2015	Intermediate level user to simulate the level of productions to meet a given level of final demand

Annexes

Annex A to Chapter 2: RAS Method

2A.1. This Annex presents the technical details to the RAS method.

2A.2. The RAS method is an iterative proportional fitting procedure which utilises a set of known row and column totals to successively scale rows and columns in the intermediate transactions coefficient matrix, $\mathbf{A}$, until the matrix is fully reconciled with the column and row totals. It is widely used to automatically distribute the residual imbalances after the manual balancing process has been concluded and also to update the SUT using an earlier benchmark table. In this section, the RAS procedure is explained in the context of deriving an estimate of the matrix $\mathbf{A}^*$ for year 1, based on the reference matrix $\mathbf{A}$ for year 0.

Notation

$\mathbf{x}$	Column vector of total sales (or output) by industry for year 1.
$\mathbf{u}^*$	Column vector of known total inter-industry sales for year 1
$\mathbf{v}^*$	Row vector of known total inter-industry purchases for year 1
$\mathbf{A}$	Matrix of known intermediate transactions in coefficient form for year 0
$\mathbf{A}^*$	Matrix of unknown intermediate transactions in coefficient form for year 1. The objective is to derive an estimate of this matrix
$\mathbf{A^k}$	k^{th} iterative estimate of $\mathbf{A}^*$, where $k = 0,1,2,\mathrm{K}$
$\mathbf{A^T}$	Transpose of matrix $\mathbf{A}$
$\hat{\mathbf{x}}$	Diagonalisation of vector $\mathbf{x}$
$\mathbf{e}$	Column vector of 1s

RAS Method

2A.3. The RAS method is used to estimate the unknown $\mathbf{A}^*$, using $\mathbf{A}$ as the starting point for estimation, such that the column and row sums of the resulting $\mathbf{A}^*$ equate to the column vector $\mathbf{u}^*$ and row vector $\mathbf{v}^*$.

2A.4. The initial estimate $\mathbf{A^0}$ is simply set to the matrix for the previous year **A**. However, in general, $\mathbf{A^0\hat{x}e} \neq \mathbf{u}^*$ (i.e. the row sums of the matrix $\mathbf{A^0\hat{x}}$ do not match the known row sums for year 1). The first iterative estimate for **A**, $\mathbf{A^1}$, is obtained by adjusting the elements of $\mathbf{A^0}$ by rows, such that the row sums of $\mathbf{A^1\hat{x}}$ fit the known inter-industry sales $\mathbf{u}^*$. If

$$\mathbf{u^1} = \mathbf{A^0\hat{x}e} \tag{2A-1}$$

and

$$\mathbf{r^1} = (\mathbf{\hat{u}^1})^{-1}\mathbf{u}^* \tag{2A-2}$$

then the matrix $\mathbf{A^1}$ is obtained by pre-multiplying $\mathbf{A^0}$ by $\mathbf{\hat{r}^1}$, the diagonalised vector of ratios of row sums:

$$\mathbf{A^1} = \mathbf{\hat{r}^1 A^0} \tag{2A-3}$$

2A.5. Now the row sums of the matrix $\mathbf{A^1\hat{x}}$ tally with $\mathbf{u}^*$. However, in general, the column sums do not tally with $\mathbf{v}^*$. The next estimate $\mathbf{A^2}$ is obtained by adjusting the elements of $\mathbf{A^1}$ by columns such that the column sums of $\mathbf{A^2\hat{x}}$ are equal to $\mathbf{v}^*$. If

$$\mathbf{v^2} = \mathbf{e^T A^1\hat{x}} \tag{2A-4}$$

and

$$\mathbf{s^2} = \mathbf{v}^*(\mathbf{\hat{v}^2})^{-1} \tag{2A-5}$$

then the matrix $\mathbf{A^2}$ is defined by:

$$\mathbf{A^2} = \mathbf{A^1}\,\mathbf{\hat{s}^2} \tag{2A-6}$$

or in a more recognisable form

$$\mathbf{A^2} = \mathbf{\hat{r}^1 A^0 \hat{s}^2} \tag{2A-7}$$

$$\mathbf{A^2} = \begin{bmatrix} {r_1}^1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & {r_n}^1 \end{bmatrix} \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \begin{bmatrix} {s_1}^1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & {s_n}^1 \end{bmatrix}$$

where r_{ij} is the matrix element in the ith row and ith column of matrix $\mathbf{\hat{r}^1}$,
a_{ij} is the matrix element in the ith row and ith column of matrix $\mathbf{A^0}$,
s_{ij} is the matrix element in the ith row and ith column of matrix $\mathbf{\hat{s}^2}$

2A.6. However, while the column sums of $\mathbf{A^2\hat{x}}$ have now been adjusted, the row sums will now require further adjustments, and this alternating process of adjusting rows and columns will continue until no further adjustments are necessary. In general, where *k* is even, the following are defined:

$$\mathbf{u^{k+1}} = \mathbf{A^k\hat{x}e} \qquad \text{(2A-8)}$$
$$\mathbf{u^{k+1}} = \mathbf{A^k\hat{x}e}$$

$$\mathbf{r^{k+1}} = (\hat{\mathbf{u}}^{\mathbf{k+1}})^{-1}\mathbf{u}^* \qquad \text{(2A-9)}$$

$$\mathbf{A^{k+1}} = \hat{\mathbf{r}}^{\mathbf{k+1}}\mathbf{A^k} \qquad \text{(2A-10)}$$

to move to the next iterative estimate $\mathbf{A^{k+1}}$ by adjusting the elements by rows, and where *k* is odd, the following are defined:

$$\mathbf{v^{k+1}} = \mathbf{e}^{\mathrm{T}}\mathbf{A^k\hat{x}} \qquad \text{(2A-11)}$$

$$\mathbf{s^{k+1}} = \mathbf{v}^*(\hat{\mathbf{v}}^{\mathbf{k+1}})^{-1} \qquad \text{(2A-12)}$$

$$\mathbf{A^{k+1}} = \mathbf{A^k}\ \hat{\mathbf{s}}^{\mathbf{k+1}} \qquad \text{(2A-13)}$$

to move to the next estimate by adjusting the elements by columns.

2A.7. The sequence of estimates $\mathbf{A^0}, \mathbf{A^1}, \ldots$ converges[16] and the resulting limit matrix is the estimate of $\mathbf{A}^*$, the intermediate transactions matrix in coefficient form for year 1.

$$\mathbf{A}^* = \lim_{\mathbf{k}\to\infty} \mathbf{A^k} = \ldots \hat{\mathbf{r}}^{\mathbf{5}}\hat{\mathbf{r}}^{\mathbf{3}}\hat{\mathbf{r}}^{\mathbf{1}}\mathbf{A^0}\ \hat{\mathbf{s}}^{\mathbf{2}}\hat{\mathbf{s}}^{\mathbf{4}}\hat{\mathbf{s}}^{\mathbf{6}} \ldots \qquad \text{(2A-14)}$$

Incorporating Exogenous Information

2A.8. The RAS method can also be modified to estimate $\mathbf{A}^*$ in the case where some of the matrix elements a_{ij}^* are already known. If an element $a_{ij}{}^*$ is known, then the corresponding element a_{ij} is set to zero before running the iterative steps, and the known elements are added back after the iterative limit is obtained.

2A.9. Let $\mathbf{\Phi}$ be the matrix $\mathbf{A}$ except that $\Phi_{ij} = 0$ whenever a_{ij}^* is known, and $\mathbf{\Omega}^*$ be the matrix with $\Omega_{ij}^* = a_{ij}^*$ whenever a_{ij}^* is known, and $\Omega_{ij}^* = 0$ otherwise.

$$\Phi_{ij} = \begin{cases} 0 & \text{when } a_{ij}^* \text{ is known} \\ a_{ij} & \text{when } a_{ij}^* \text{ is unknown} \end{cases} \qquad \text{(2A-15)}$$

[16] The proof that the matrices eventually converge is beyond the scope of this publication. For the proof and more details on the properties of these matrices, please refer to United Nations publication *Handbook of Input-Output Table Compilation and Analysis* (UN 1999).

$$\Omega_{ij}^{*} = \begin{cases} a_{ij}^{*} & \text{when } a_{ij}^{*} \text{ is known} \\ 0 & \text{when } a_{ij}^{*} \text{ is unknown} \end{cases} \quad \text{(2A-16)}$$

where Φ_{ij} is the matrix element in the i^{th} row and j^{th} column of $\mathbf{\Phi}$,
Ω_{ij}^{*} is the matrix element in the i^{th} row and j^{th} column of $\mathbf{\Omega}$,
a_{ij}^{*} is the matrix element in the i^{th} row and j^{th} column of $\mathbf{A}^{*}$,
a_{ij} is the matrix element in the i^{th} row and j^{th} column of $\mathbf{A}$,

2A.10. The iterative procedure is now run on $\mathbf{\Phi}$ in place of $\mathbf{A}$, and with:

$$\tilde{\mathbf{u}} = \mathbf{u}^{*} - \mathbf{\Omega}^{*}\hat{\mathbf{x}}\mathbf{e} \quad \text{(2A-17)}$$

$$\tilde{\mathbf{v}} = \mathbf{v}^{*} - \mathbf{e}^{\mathbf{T}}\mathbf{\Omega}^{*}\hat{\mathbf{x}} \quad \text{(2A-18)}$$

used in place of $\mathbf{u}^{*}$ and $\mathbf{v}^{*}$ respectively. After the iterative limit $\mathbf{\Phi}^{*}$ is obtained, the known elements in $\mathbf{\Omega}^{*}$ are added back and gives the following equation:

$$\mathbf{A}^{*} = \mathbf{\Omega}^{*} + \mathbf{\Phi}^{*} = \mathbf{\Omega}^{*} + \cdots \hat{\mathbf{r}}^{\mathbf{5}}\hat{\mathbf{r}}^{\mathbf{3}}\hat{\mathbf{r}}^{\mathbf{1}}\mathbf{\Phi}\hat{\mathbf{s}}^{\mathbf{2}}\hat{\mathbf{s}}^{\mathbf{4}}\hat{\mathbf{s}}^{\mathbf{6}} \ldots \quad \text{(2A-19)}$$

Annex A to Chapter 3: Derivation of Input-Output Tables

3A.1. This Annex presents the technical details of the transformation of the Singapore Supply and Use Tables (SUTs) to the Industry by Industry Input-Output Table (IOT) via the fixed product sales structure assumption.

The Input-Output framework

3A.2. Box 3A-1 presents the Input-Output framework where the information of the SUTs and the IOTs can be integrated into a single table.

3A.3. A letter in bold, upper case denotes a matrix, a letter in bold, lower case denotes a vector, while a letter in lower case and not in bold, denotes the sum of all elements of the vector denoted in same lower case but bold letter. A transpose operator is denoted by a superscript 'T'. A vector is written as a column vector and a row vector is written as a transposed column vector. A vector with the accent '^' on top denotes the diagonalisation of the vector.

Box 3A-1: Input-Output Framework

Total Supply Table at basic prices

	Industries	Total output	Imports	Total supply
Products	$\mathbf{P}^{\mathbf{T}}$	$\mathbf{x}$	$\mathbf{m}$	$\mathbf{q}$
Total output	$\mathbf{g}^{\mathbf{T}}$			

Domestic Use Table at basic prices

	Industries	Final demand	Total use
Domestic products	$\mathbf{U_d}$	$\mathbf{Y_d}$	$\mathbf{x}$
Imports	$\mathbf{u_m}^{\mathbf{T}}$	$\mathbf{y_m}^{\mathbf{T}}$	m
Taxes on products	$\mathbf{u_t}^{\mathbf{T}}$	$\mathbf{y_t}^{\mathbf{T}}$	t
Value added	$\mathbf{V}$		$\mathbf{v}$
Total input	$\mathbf{g}^{\mathbf{T}}$	$\mathbf{y}^{\mathbf{T}}$	

Integrated Input-Output framework table

	Domestic products	Industries	Final demand	Total
Industries	$\mathbf{P}$			$\mathbf{g}$
Domestic products		$\mathbf{U_d}$	$\mathbf{Y_d}$	$\mathbf{x}$
Imports		$\mathbf{u_m}^{\mathbf{T}}$	$\mathbf{y_m}^{\mathbf{T}}$	m
Taxes on products		$\mathbf{u_t}^{\mathbf{T}}$	$\mathbf{y_t}^{\mathbf{T}}$	t
Value added		$\mathbf{V}$		$\mathbf{v}$
Total	$\mathbf{x}^{\mathbf{T}}$	$\mathbf{g}^{\mathbf{T}}$	$\mathbf{y}^{\mathbf{T}}$	

Legend

$\mathbf{P}$	Domestic make matrix	$\mathbf{x}$	Domestic product output vector
$\mathbf{U_d}$	Intermediate consumption (domestic) matrix	$\mathbf{g}$	Industry output vector
$\mathbf{Y_d}$	Final consumption (domestic) matrix	$\mathbf{y}$	Final consumption vector
$\mathbf{V}$	Value added matrix	$\mathbf{v}$	Value added vector
$\mathbf{u_m}^T$	Intermediate consumption (import) vector	$\mathbf{m}$	Import vector
$\mathbf{u_t}^T$	Intermediate consumption (taxes) vector	$\mathbf{q}$	Total supply vector
$\mathbf{y_m}^T$	Final consumption (import) vector	m	Total imports
$\mathbf{y_t}^T$	Final consumption (taxes) vector	t	Total taxes on products

3A.4. In the Integrated Input-Output framework table in Box 3A-1, matrix $\mathbf{P}$ is the domestic make matrix which shows the output produced by industries in the rows and by the types of products in columns. The row sums of the matrix $\mathbf{P}$ give the industry output vector $\mathbf{g}$ while the column sums give the transpose of the domestic product output vector $\mathbf{x}^T$.

3A.5. The second row on domestic products shows the intermediate consumption (domestic) matrix $\mathbf{U_d}$ and the final consumption (domestic) matrix $\mathbf{Y_d}$. The two matrices show intermediate consumption of domestic products in the rows; industries and final demand categories in the columns. The row sums of matrices $\mathbf{U_d}$ and $\mathbf{Y_d}$ give the total consumption of output which should equate to domestic product output vector $\mathbf{x}$.

3A.6. The third row on imports shows the intermediate consumption (import) vector $\mathbf{u_m}^T$ and the final consumption (import) vector $\mathbf{y_m}^T$[17]. The row sums of two vectors give the total consumption of imports which should equate to the m which is the sum of all the elements in import vector $\mathbf{m}$. Similarly, the fourth row on taxes on products shows the intermediate consumption (taxes) vector $\mathbf{u_t}^T$ and the final consumption (taxes) vector $\mathbf{y_t}^T$. The row sums of two vectors give the total taxes on products which is denote by t.

3A.7. Matrix $\mathbf{V}$ in the last row shows the value added by industries in the columns and by the types of income components of value added in rows.

[17] The intermediate consumption (import) vector and final consumption (import) vector can be expanded to become the intermediate consumption (import) matrix and final consumption (import) matrix by using the data from the Import Use Table at basic prices.

3A.8. The column sums of $\mathbf{U_d}$, $\mathbf{u_m}^{\mathbf{T}}$, $\mathbf{u_t}^{\mathbf{T}}$ and $\mathbf{V}$ give the transpose of the industry output vector $\mathbf{g}^{\mathbf{T}}$ while the column sums of $\mathbf{Y_d}$, $\mathbf{y_m}^{\mathbf{T}}$, $\mathbf{y_t}^{\mathbf{T}}$ give the transpose of the final consumption vector $\mathbf{y}^{\mathbf{T}}$.

Transformation of SUTs to Industry by Industry IOT via fixed product sales structure assumption

3A.9. For the purpose of this exposition, the formulae are illustrated for an economy with $\boldsymbol{n}$ industries, $\boldsymbol{n}$ products and $\boldsymbol{m}$ final demand categories.

3A.10. From the integrated Input-Output framework, the total output of a product can be obtained by adding up the intermediate and final consumption of that domestic product:

$$\begin{array}{rcccccccccccccc} x_1 & = & u_{11} & + & \dots & + & u_{1j} & + & \dots & + & u_{1n} & + & y_{11} & + & \dots & + & y_{1m} \\ & \vdots & & & & & & & & & & & & & & & \\ x_{\mathrm{i}} & = & u_{i1} & + & \dots & + & u_{ij} & + & \dots & + & u_{in} & + & y_{i1} & + & \dots & + & y_{im} \\ & \vdots & & & & & & & & & & & & & & & \\ x_n & = & u_{n1} & + & \dots & + & u_{nj} & + & \dots & + & u_{nn} & + & y_{n1} & + & \dots & + & y_{nm} \end{array} \qquad \text{(3A-1)}$$

or

$$\mathbf{x} = \mathbf{U_d e} + \mathbf{Y_d e}$$

where x_i is the sales of output of product i, where I = 1,2,….n
u_{ij} is the purchases of product i by industry j, where j = 1,2,…n
y_{ik} is the purchases of product i by final demand category k, where k = 1, 2, …m

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, \mathbf{U_d} = \begin{bmatrix} u_{11} & \dots & u_{1n} \\ \vdots & \ddots & \vdots \\ u_{n1} & \dots & u_{nn} \end{bmatrix}, \mathbf{Y_d} = \begin{bmatrix} y_{11} & \dots & y_{1m} \\ \vdots & \ddots & \vdots \\ y_{n1} & \dots & y_{nm} \end{bmatrix}, \mathbf{e} = \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}$$

3A.11. The total output of a product can also be obtained by adding up all the domestic products produced by industries:

$$\begin{array}{rcccccccc} x_1 & = & p_{11} & + & \dots & + & p_{j1} & + & \dots & + & p_{n1} \\ & \vdots & & & & & & & & & \\ x_i & = & p_{1i} & + & \dots & + & p_{ji} & + & \dots & + & p_{ni} \\ & \vdots & & & & & & & & & \\ x_n & = & p_{1n} & + & \dots & + & p_{jn} & + & \dots & + & p_{nn} \end{array} \qquad \text{(3A-2)}$$

or

$$\mathbf{x} = \mathbf{P}^{\mathbf{T}}\mathbf{e}$$

where p_{ij} is the sales of product j by industry i,

$$\mathbf{P} = \begin{bmatrix} p_{11} & \dots & p_{1n} \\ \vdots & \ddots & \vdots \\ p_{n1} & \dots & p_{nn} \end{bmatrix}$$

3A.12. Under the fixed product sales structure assumption, the allocation of demand to users depends on the product and not the industry selling the product, i.e. the market share of a product is independent of the industry that produced the product.

3A.13. Therefore, the allocation of secondary production to the producing industry is based on the market shares of the products and the transformation matrix to derive the Industry by Industry IOT is the market shares matrix:

$$d_{ij} = \frac{p_{ij}}{x_i} \qquad \text{(3A-3)}$$

or

$$\mathbf{D} = \mathbf{P}\hat{\mathbf{x}}^{-\mathbf{1}}$$

where d_{ij} is the proportion of total product j output that is produced by industry i,

$$\mathbf{D} = \begin{bmatrix} d_{11} & \dots & d_{1n} \\ \vdots & \ddots & \vdots \\ d_{n1} & \dots & d_{nn} \end{bmatrix}$$

3A.14. The market shares matrix **D** is multiplied with the product by industry intermediate consumption (domestic) matrix and the product by category final consumption (domestic) matrix to derive the new industry by industry intermediate consumption (domestic) matrix and industry by final demand category final consumption (domestic) matrix.

$$z_{ij} = d_{i1}u_{1j} + \ldots + d_{in}u_{nj} \quad \text{(3A-4)}$$

or

$$\mathbf{Z_d} = \mathbf{DU_d}$$

and

$$f_{ik} = d_{i1}y_{1j} + \ldots + d_{in}y_{nk} \quad \text{(3A-5)}$$

or

$$\mathbf{F_d} = \mathbf{DY_d}$$

where z_{ij} is the purchases of industry i's intermediate output by industry j,
f_{ik} is the purchases of industry i's final output by final demand category k,

$$\mathbf{Z_d} = \begin{bmatrix} z_{11} & \cdots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{n1} & \cdots & z_{nn} \end{bmatrix}, \mathbf{F_d} = \begin{bmatrix} f_{11} & \cdots & f_{1m} \\ \vdots & \ddots & \vdots \\ f_{n1} & \cdots & f_{nm} \end{bmatrix}$$

3A.15. Table 3A-1 and Table 3A-2 presents the transformed Industry by Industry IOT and Product by Product IOT in matrix notation, and Box 3A-2 shows the transformation of SUTs to either Product by Product or industry by industry IOTs based on the four assumption models listed in Box 3-1.

Table 3A-1: Industry by Industry Input-Output Table

	Industries	Final demand	Total output
Industries	$\mathbf{Z_d}$	$\mathbf{F_d}$	$\mathbf{g}$
Imports	$\mathbf{u_m}^T$	$\mathbf{y_m}^T$	m
Taxes on products	$\mathbf{u_t}^T$	$\mathbf{y_t}^T$	t
Value added	$\mathbf{V}$		$\mathbf{v}$
Total input	$\mathbf{g}^T$	$\mathbf{y}^T$	

Table 3A-2: Product by Product Input-Output Table

	Products	Final demand	Total output
Products	$\mathbf{S_d}$	$\mathbf{Y_d}$	$\mathbf{x}$
Imports	$\mathbf{s_m}^T$	$\mathbf{y_m}^T$	m
Taxes on products	$\mathbf{s_t}^T$	$\mathbf{y_t}^T$	t
Value added	$\mathbf{W}$		$\mathbf{v}$
Total input	$\mathbf{x}^T$	$\mathbf{y}^T$	

Box 3A-2: Transformation of SUTs to IOTs

Assumption	Product technology	Industry technology	Fixed industry sales structure	Fixed product sales structure
Types of IOTs	Product by product		Industry by industry	
Product mix matrix	$\mathbf{C} = \mathbf{P}^{\mathbf{T}}\hat{\mathbf{g}}^{-1}$			
Market shares matrix	$\mathbf{D} = \mathbf{P}\hat{\mathbf{x}}^{-1}$			
Transformation matrix	$\mathbf{H} = (\mathbf{D}^{\mathbf{T}})^{-1}$	$\mathbf{H} = \mathbf{C}^{\mathbf{T}}$	$\mathbf{H} = \mathbf{C}^{-1}$	$\mathbf{H} = \mathbf{D}$
Intermediate consumption (domestic) matrix	$\mathbf{S_d} = \mathbf{U_d H}$		$\mathbf{Z_d} = \mathbf{H U_d}$	
Intermediate consumption (import) vector	$\mathbf{s_m} = \mathbf{u_m}^{\mathbf{T}}\mathbf{H}$		$\mathbf{u_m}^{\mathbf{T}}$	
Intermediate consumption (taxes on products) vector	$\mathbf{s_t} = \mathbf{u_t}^{\mathbf{T}}\mathbf{H}$		$\mathbf{u_t}^{\mathbf{T}}$	
Value added matrix	$\mathbf{W} = \mathbf{V}\mathbf{H}$		$\mathbf{V}$	
Final consumption (domestic) matrix	$\mathbf{Y_d}$		$\mathbf{F_d} = \mathbf{H Y_d}$	
Final consumption (import) vector	$\mathbf{y_m}^{\mathbf{T}}$		$\mathbf{y_m}^{\mathbf{T}}$	
Final consumption (taxes on products) vector	$\mathbf{y_t}^{\mathbf{T}}$		$\mathbf{y_t}^{\mathbf{T}}$	

Annex B to Chapter 3: Derivation of coefficient tables

3B.1. This Annex presents the technical details to derive the coefficient tables from the Industry by Industry Input-Output Table (IOT).

Direct Requirement Coefficients table

3B.2. From the Industry by Industry IOT, the total output of an industry can be obtained by adding up the sales of intermediate output to industries and final output to final demand categories:

$$\begin{array}{rcccccccccccccc} g_1 & = & z_{11} & + & \dots & + & z_{1j} & + & \dots & + & z_{1n} & + & f_{11} & + & \dots & + & f_{1m} \\ & \vdots & & & & & & & & & & & & & & & \\ g_i & = & z_{i1} & + & \dots & + & z_{ij} & + & \dots & + & z_{in} & + & f_{i1} & + & \dots & + & f_{im} \\ & \vdots & & & & & & & & & & & & & & & \\ g_n & = & z_{n1} & + & \dots & + & z_{nj} & + & \dots & + & z_{nn} & + & f_{n1} & + & \dots & + & f_{nm} \end{array} \qquad (3B\text{-}1)$$

or

$$\mathbf{g} = \mathbf{Z_d e} + \mathbf{F_d e}$$

where g_i is the sales of output by industry i,
z_{ij} is the purchases of industry i's intermediate output by industry j,
f_{ik} is the purchases of industry i's final output by final demand category k,

$$\mathbf{g} = \begin{bmatrix} g_1 \\ \vdots \\ g_n \end{bmatrix}, \mathbf{Z_d} = \begin{bmatrix} z_{11} & \dots & z_{1n} \\ \vdots & \ddots & \vdots \\ z_{n1} & \dots & z_{nn} \end{bmatrix}, \mathbf{F_d} = \begin{bmatrix} f_{11} & \dots & f_{1m} \\ \vdots & \ddots & \vdots \\ f_{n1} & \dots & f_{nm} \end{bmatrix}.$$

3B.3. Each row in the system of equations in (3B-1) represents the distribution of sales of output for each industry. This shows how total sales are linked to the purchases of output among industries and final demand.

3B.4. The total output of an industry can also be obtained by summing the purchases of intermediate output and imported products, costs of taxes less subsidies on products and the value added of that industry:

$$\begin{array}{rcl} g_1 & = & z_{11} + \ldots + z_{n1} + u_1^m + u_1^t + v_{11} + v_{21} + v_{31} \\ & \vdots & \\ g_j & = & z_{1j} + \ldots + z_{nj} + u_j^m + u_j^t + v_{1j} + v_{2j} + v_{3j} \\ & \vdots & \\ g_n & = & z_{1n} + \ldots + z_{nn} + u_n^m + u_n^t + v_{1n} + v_{2n} + v_{3n} \end{array} \qquad \text{(3B-2)}$$

or

$$\mathbf{g} = \mathbf{Z_d}^{\mathbf{T}}\mathbf{e} + \mathbf{u_m} + \mathbf{u_t} + \mathbf{V}^{\mathbf{T}}\mathbf{e}$$

where u_j^m is the purchases of imported products by industry *j*,
u_j^t is the taxes less subsidies on products paid by industry *j*,
v_{1j} is the costs of compensation of employees paid by industry *j*,
v_{2j} is the costs of other taxes less subsidies on production paid by industry *j*,
v_{3j} is the gross operating surplus generated by industry *j*,

$$\mathbf{u_m} = \begin{bmatrix} u_1^m \\ \vdots \\ u_n^m \end{bmatrix}, \mathbf{u_t} = \begin{bmatrix} u_1^t \\ \vdots \\ u_n^t \end{bmatrix}, \mathbf{V} = \begin{bmatrix} v_{11} & \cdots & v_{1n} \\ v_{21} & \cdots & v_{2n} \\ v_{31} & \cdots & v_{3n} \end{bmatrix},$$

3B.5. From (3B-2), the direct requirement coefficients for intermediate inputs can be expressed as:

$$a_{ij} = \frac{z_{ij}}{g_j} \qquad \text{(3B-3)}$$

or

$$\mathbf{A} = \mathbf{Z_d}\hat{\mathbf{g}}^{-\mathbf{1}}$$

where a_{ij} is the proportion of industry *i*'s intermediate output required by industry *j* to produce one unit of output,

$$\mathbf{A} = \begin{bmatrix} a_{11} & \ldots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \ldots & a_{nn} \end{bmatrix}, \hat{\mathbf{g}}^{-\mathbf{1}} = \begin{bmatrix} 1/g_1 & \ldots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \ldots & 1/g_n \end{bmatrix}$$

3B.6. Similarly, the direct requirement coefficients for imports, taxes and value added categories can be computed similarly:

$$a_j^m = \frac{u_j^m}{g_j} \quad , \quad a_j^t = \frac{u_j^t}{g_j} \quad , \quad a_j^v = a_{1j}^v + a_{2j}^v + a_{3j}^v = \frac{v_{1j}}{g_j} + \frac{v_{2j}}{g_j} + \frac{v_{3j}}{g_j} \qquad \text{(3B-4)}$$

or

$$\mathbf{a_m}^{\mathbf{T}} = \mathbf{u_m}^{\mathbf{T}}\hat{\mathbf{g}}^{-\mathbf{1}}, \quad \mathbf{a_t}^{\mathbf{T}} = \mathbf{u_t}^{\mathbf{T}}\hat{\mathbf{g}}^{-\mathbf{1}}, \quad \mathbf{a_v}^{\mathbf{T}} = \mathbf{e}^{\mathbf{T}}\mathbf{A_v} = \mathbf{e}^{\mathbf{T}}\mathbf{V}\hat{\mathbf{g}}^{-\mathbf{1}}$$

where a_j^m is the proportion of imported products purchased by industry *j* to produce one unit of output,

a_j^t is the proportion of taxes less subsidies on products paid by industry *j* to produce one unit of output,

a_j^v is the proportion of value added generated by industry *j* to produce one unit of output,

a_{1j}^v is the proportion of costs of compensation of employees paid by industry *j* to produce one unit of output,

a_{2j}^v is the proportion of costs of other taxes less subsidies on production paid by industry *j* to produce one unit of output,

a_{3j}^v is the proportion of gross operating surplus generated by industry *j* to produce one unit of output,

$$\mathbf{a_m} = \begin{bmatrix} a_1^m \\ \vdots \\ a_n^m \end{bmatrix}, \mathbf{a_t} = \begin{bmatrix} a_1^t \\ \vdots \\ a_n^t \end{bmatrix}, \mathbf{a_v} = \mathbf{A_v}^{\mathbf{T}}\mathbf{e} = \begin{bmatrix} a_{11}^v & a_{21}^v & a_{31}^v \\ \vdots & \vdots & \vdots \\ a_{1n}^v & a_{2n}^v & a_{3n}^v \end{bmatrix} \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = \begin{bmatrix} a_1^v \\ \vdots \\ a_n^v \end{bmatrix},$$

$$\mathbf{A_v} = \mathbf{V}\hat{\mathbf{g}}^{-\mathbf{1}} = \begin{bmatrix} v_{11} & \dots & v_{1n} \\ v_{21} & \dots & v_{2n} \\ v_{31} & \dots & v_{3n} \end{bmatrix} \begin{bmatrix} 1/g_1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & 1/g_n \end{bmatrix} = \begin{bmatrix} a_{11}^v & \dots & a_{1n}^v \\ a_{21}^v & \dots & a_{2n}^v \\ a_{31}^v & \dots & a_{3n}^v \end{bmatrix}$$

3B.7. Table 3B-1 presents the Direct Requirement Coefficients table in matrix notation:

Table 3B-1: Direct Requirement Coefficients Table

	Industries
Industries	$\mathbf{A} = \mathbf{Z_d}\hat{\mathbf{g}}^{-\mathbf{1}}$
Imports	$\mathbf{a_m}^{\mathbf{T}} = \mathbf{u_m}^{\mathbf{T}}\hat{\mathbf{g}}^{-\mathbf{1}}$
Taxes on products	$\mathbf{a_t}^{\mathbf{T}} = \mathbf{u_t}^{\mathbf{T}}\hat{\mathbf{g}}^{-\mathbf{1}}$
Value added	$\mathbf{A_v} = \mathbf{V}\hat{\mathbf{g}}^{-\mathbf{1}}$
Total	$\mathbf{e}^{\mathbf{T}}$

Total Requirement Coefficients table

3B.8. Substituting equation (3B-3) into the system of equations in (3B-1), the system of equations is re-written as:

$$\begin{array}{rcl} g_1 &=& a_{11}g_1 + \ldots + a_{1j}g_j + \ldots + a_{1n}g_n + f_1 \\ &\vdots& \\ g_i &=& a_{i1}g_1 + \ldots + a_{ij}g_j + \ldots + a_{in}g_n + f_i \\ &\vdots& \\ g_n &=& a_{n1}g_1 + \ldots + a_{nj}g_j + \ldots + a_{nn}g_n + f_n \end{array} \qquad \text{(3B-5)}$$

or

$$\mathbf{g} = \mathbf{Ag} + \mathbf{f}$$

where f_i is the sum of purchases of industry i's final output by all final demand categories

$$\mathbf{f} = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix} = \mathbf{F_d e} = \begin{bmatrix} f_{11} & \ldots & f_{1m} \\ \vdots & \ddots & \vdots \\ f_{n1} & \ldots & f_{nm} \end{bmatrix} \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}$$

3B.9. Rearranging the system of equations in (3B-5), the system of equations is re-written as:

$$\begin{array}{rcl} (1-a_{11})g_1 - \ldots - a_{1i}g_i - \ldots - a_{1n}g_n &=& f_1 \\ &\vdots& \\ -a_{i1}g_1 - \ldots + (1-a_{ii})g_i - \ldots - a_{in}g_n &=& f_i \\ &\vdots& \\ -a_{n1}g_1 - \ldots - a_{ni}g_i - \ldots + (1-a_{nn})g_n &=& f_n \end{array} \qquad \text{(3B-6)}$$

or

$$(\mathbf{I} - \mathbf{A})\mathbf{g} = \mathbf{f} \qquad \text{(3B-7)}$$

where $\mathbf{I} = \begin{bmatrix} 1 & \ldots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \ldots & 1 \end{bmatrix}$.

3B.10. For a given set of f_i, equation (3B-6) is a set of *n* equations with *n* unknowns (i.e. g to g_n). If a positive solution[18] exists for equation (3B-6), then the solution can be expressed as:

$$\begin{array}{rcl} g_1 &=& \theta_{11}f_1 + \ldots + \theta_{1j}f_j + \ldots + \theta_{1n}f_n \\ &\vdots& \\ g_i &=& \theta_{i1}f_1 + \ldots + \theta_{ij}f_j + \ldots + \theta_{in}f_n \\ &\vdots& \\ g_n &=& \theta_{n1}f_1 + \ldots + \theta_{nj}f_j + \ldots + \theta_{nn}f_n \end{array} \qquad \text{(3B-8)}$$

or

$$\mathbf{g} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{\Theta f}$$

where $$\mathbf{\Theta} = \begin{bmatrix} \theta_{11} & \ldots & \theta_{1n} \\ \vdots & \ddots & \vdots \\ \theta_{n1} & \ldots & \theta_{nn} \end{bmatrix} = (\mathbf{I} - \mathbf{A})^{-1} = \begin{bmatrix} (1 - a_{11}) & \ldots & -a_{1n} \\ \vdots & \ddots & \vdots \\ -a_{n1} & \ldots & (1 - a_{nn}) \end{bmatrix}^{-1}.$$

3B.11. $\mathbf{\Theta}$ is the total requirements coefficients matrix which is also known as the Leontief inverse. Each θ_{ij} measures the output produced by industry i when the demand of final output of industry j increases by a dollar. The sum of θ_{1j} to θ_{nj} is also known as the output multiplier of industry j:

$$\begin{array}{rcl} \lambda_1 &=& \theta_{11} + \ldots + \theta_{i1} + \ldots + \theta_{n1} \\ &\vdots& \\ \lambda_j &=& \theta_{1j} + \ldots + \theta_{ij} + \ldots + \theta_{nj} \\ &\vdots& \\ \lambda_n &=& \theta_{1n} + \ldots + \theta_{in} + \ldots + \theta_{nn} \end{array} \qquad \text{(3B-9)}$$

or

$$\mathbf{\lambda^T} = \mathbf{e^T}(\mathbf{I} - \mathbf{A})^{-1} = \mathbf{e^T\Theta}$$

where λ_j is the output multiplier of industry j,

$$\mathbf{\lambda} = \begin{bmatrix} \lambda_1 \\ \vdots \\ \lambda_n \end{bmatrix}$$

3B.12. Table 3B-2 presents the Total Requirement Coefficients table in matrix notation:

Table 3B-2: Total Requirement Coefficients Table

	Industries
Industries	$\mathbf{\Theta} = (\mathbf{I} - \mathbf{A})^{-1}$
Total	$\mathbf{\lambda^T} = \mathbf{e^T\Theta}$

[18] The proof on the existence of positive solution to the equation is beyond the scope of this publication. Interested readers can refer to page 245 – 248 of Econometrica XVII, 1949 *"Note: Some Conditions of Macroeconomic Stability"* by *Hawkins, D., and H. A. Simon.*

Total Requirement Coefficients in Terms of Value Added

3B.13. By multiplying each individual equation in (3B-8) by the respective direct requirement coefficients for value added a_j^v from (3B-4) , the following system of equations is derived:

$$\begin{array}{rcl} v_1^\alpha & = & a_1^v(\theta_{11}f_1 + \ldots + \theta_{1j}f_j + \ldots + \theta_{1n}f_n) \\ & \vdots & \\ v_i^\alpha & = & a_i^v(\theta_{i1}f_1 + \ldots + \theta_{ij}f_j + \ldots + \theta_{in}f_n) \\ & \vdots & \\ v_n^\alpha & = & a_n^v(\theta_{n1}f_1 + \ldots + \theta_{nj}f_j + \ldots + \theta_{nn}f_n) \end{array} \qquad \text{(3B-10)}$$

or

$$\mathbf{v}^{\boldsymbol{\alpha}} = \hat{\mathbf{a}}_{\mathbf{v}}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \hat{\mathbf{a}}_{\mathbf{v}}\boldsymbol{\Theta}\mathbf{f}$$

where v_i^α is the value added generated by industry i,

$$\hat{\mathbf{a}}_{\mathbf{v}} = \begin{bmatrix} a_1^v & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & a_n^v \end{bmatrix}$$

3B.14. Similar to output, $a_i^v\theta_{ij}$ measures the value added generated by industry i when the demand of final output of industry j increases by a dollar. The sum of $a_i^v\theta_{1j}$ to $a_n^v\theta_{nj}$ is known as the value added multiplier of industry j:

$$\begin{array}{rcl} \gamma_1 & = & a_1^v\theta_{11} + \ldots + a_i^v\theta_{i1} + \ldots + a_n^v\theta_{n1} \\ & \vdots & \\ \gamma_j & = & a_1^v\theta_{1j} + \ldots + a_i^v\theta_{ij} + \ldots + a_n^v\theta_{nj} \\ & \vdots & \\ \gamma_n & = & a_1^v\theta_{1n} + \ldots + a_i^v\theta_{in} + \ldots + a_n^v\theta_{nn} \end{array} \qquad \text{(3B-11)}$$

or

$$\boldsymbol{\gamma}^{\mathbf{T}} = \mathbf{e}^{\mathbf{T}}\hat{\mathbf{a}}_{\mathbf{v}}(\mathbf{I} - \mathbf{A})^{-\mathbf{1}} = \mathbf{a_V}^{\mathbf{T}}\boldsymbol{\Theta}$$

where γ_j is the value added multiplier of industry j,

$$\boldsymbol{\gamma} = \begin{bmatrix} \gamma_1 \\ \vdots \\ \gamma_n \end{bmatrix}$$

3B.15. Table 3B-3 presents the Total Requirement Coefficients table in matrix notation:

Table 3B-3: Total Requirement Coefficients in Terms of Value Added Table

	Industries
Industries	$\hat{\mathbf{a}}_{\mathbf{v}}\boldsymbol{\Theta}$
Total	$\boldsymbol{\gamma}^{\mathbf{T}} = \mathbf{a_V}^{\mathbf{T}}\boldsymbol{\Theta}$

Primary Input Requirement Coefficients of Final Demand

3B.16. Other multipliers such as import, taxes on products, compensation of employees (or income), other taxes on production and gross operating surplus can be computed in similar fashion as the systems of equations in (3B-11):

$$\begin{aligned}
\eta_j &= a_1^m\theta_{1j} + \ldots + a_i^m\theta_{ij} + \ldots + a_n^m\theta_{nj} \\
&\vdots \\
\vartheta_j &= a_1^t\theta_{1j} + \ldots + a_i^t\theta_{ij} + \ldots + a_n^t\theta_{nj} \\
&\vdots \\
\rho_j &= a_{11}^v\theta_{1j} + \ldots + a_{1j}^v\theta_{ij} + \ldots + a_{1n}^v\theta_{nj} \\
\sigma_j &= a_{21}^v\theta_{1j} + \ldots + a_{2j}^v\theta_{ij} + \ldots + a_{2n}^v\theta_{nj} \\
\varphi_j &= a_{31}^v\theta_{1j} + \ldots + a_{3j}^v\theta_{ij} + \ldots + a_{3n}^v\theta_{nj}
\end{aligned} \qquad \text{(3B-12)}$$

or

$$\boldsymbol{\eta}^{\mathbf{T}} = \mathbf{a_m}^{\mathbf{T}}\boldsymbol{\Theta} \qquad \boldsymbol{\vartheta}^{\mathbf{T}} = \mathbf{a_t}^{\mathbf{T}}\boldsymbol{\Theta} \qquad \boldsymbol{\phi}^{\mathbf{T}} = \mathbf{A_v}\boldsymbol{\Theta}$$

where η_j is the import multiplier of industry *j*,
ϑ_j is the taxes on products multiplier of industry *j*,
ρ_j is the compensation of employees (or income) multiplier of industry *j*,
σ_j is the other taxes on production multiplier of industry *j*,
φ_j is the gross operating surplus of industry *j*,

$$\boldsymbol{\eta} = \begin{bmatrix}\eta_1 \\ \vdots \\ \eta_n\end{bmatrix}, \boldsymbol{\vartheta} = \begin{bmatrix}\vartheta_1 \\ \vdots \\ \vartheta_n\end{bmatrix}, \boldsymbol{\rho} = \begin{bmatrix}\rho_1 \\ \vdots \\ \rho_n\end{bmatrix}, \boldsymbol{\sigma} = \begin{bmatrix}\sigma_1 \\ \vdots \\ \sigma_n\end{bmatrix}, \boldsymbol{\varphi} = \begin{bmatrix}\varphi_1 \\ \vdots \\ \varphi_n\end{bmatrix}, \boldsymbol{\phi} = [\boldsymbol{\rho} \quad \boldsymbol{\sigma} \quad \boldsymbol{\varphi}]$$

3B.17. Table 3B-4 presents the Primary Input Requirement Coefficients of Final Demand table in matrix notation:

Table 3B-4: Primary Input Requirement Coefficients of Final Demand Table

	Imports	Taxes on products	Value added	Total
Industries	$\boldsymbol{\eta} = \boldsymbol{\Theta}^{\mathbf{T}}\mathbf{a_m}$	$\boldsymbol{\vartheta} = \boldsymbol{\Theta}^{\mathbf{T}}\mathbf{a_t}$	$\boldsymbol{\phi} = [\mathbf{A_v}\boldsymbol{\Theta}]^{\mathbf{T}}$	$\mathbf{e}$

Backward linkages

3B.18. The backward linkage captures the interconnection of an industry j to other industries from which industry j purchases inputs. For example, an increase in demand for the final output of industry j will require industry j to source for more inputs. This in turn increases the intermediate output of the industries from which the industry j purchases its inputs. This is the direction of causation from the demand side perspective and is known as backward linkage.

3B.19. The normalised backward linkage of the j^{th} industry is computed by dividing the gross output multiplier for industry j by the average gross output multiplier for all industries in the economy. In an n-industry economy, the backward linkage of industry j is defined as:

$$\frac{\sum_{i=1}^{n} \theta_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \theta_{ij}} \qquad (3B\text{-}13)$$

or

$$\frac{n}{|\mathbf{e^T \Theta e}|}\mathbf{\Theta^T e}$$

Forward Linkages[19]

3B.20. The forward linkage captures the interconnection of an industry j to other industries which industry j supplies inputs to. For example, an increase in the intermediate output of industry j will result in an increase in supplies of inputs for industries which purchase from industry j. With increased supplies from industry j, the other industries have more inputs for production to increase the output. This is the direction of causation from the supply side perspective and is known as forward linkage.

3B.21. While backward linkages are based on a Leontief demand driven model with a fixed input assumption, forward linkages are formulated using the Ghosh supply driven model with a fixed output structure assumption.

3B.22. The supply driven model relates industrial gross output to primary inputs. The core assumption is that output distribution patterns of inter-industry flows are proportionally fixed by industrial origin.

3B.23. This can be understood by the equations in (3B-2), which relate industry j's purchases of industry i's output to purchases of primary inputs.

[19] The forward linkage presented in this publication is based on the supply driven Input-Output model suggested by Ghosh, 1958. Interested readers on the supply driven Input-Output model suggested by Ghosh can refer to page 58-64 of Economica, Vol. 25, No. 97, 1958 *'Input-Output Approach in an Allocation System'* by *A. Ghosh.*

3B.24. Instead of the input coefficients (or direct requirement coefficients) for the Leontief model, the output coefficients are computed for the Ghosh model:

$$b_{ij} = \frac{z_{ij}}{g_i} \tag{3B-14}$$

or

$$\mathbf{B} = \hat{\mathbf{g}}^{-1}\mathbf{Z_d}$$

where b_{ij} is the proportion of industry i's intermediate output that is sold to industry j,

$$\mathbf{B} = \begin{bmatrix} b_{11} & \cdots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{n1} & \cdots & b_{nn} \end{bmatrix}$$

3B.25. Substituting equation (3B-14) into the system of equations in (3B-2), the system of equations is re-written as:

$$\begin{aligned} g_1 &= b_{11}g_1 + \ldots + b_{j1}g_j + \ldots + b_{n1}g_n + u_1^{\beta} \\ &\vdots \\ g_i &= b_{1i}g_1 + \ldots + b_{ji}g_j + \ldots + b_{ni}g_n + u_i^{\beta} \\ &\vdots \\ g_n &= b_{1n}g_1 + \ldots + b_{jn}g_j + \ldots + b_{nn}g_n + u_n^{\beta} \end{aligned} \tag{3B-15}$$

or

$$\mathbf{g} = \mathbf{B^T g} + \mathbf{u_\beta}$$

where $u_j^{\beta} = u_j^m + u_j^t + v_{1j} + v_{2j} + v_{3j}$

$\mathbf{u_\beta} = \mathbf{u_m e} + \mathbf{u_t e} + \mathbf{V^T e}$

3B.26. Rearranging the system of equations in (3B-15), the system of equations is re-written as:

$$\begin{aligned} (1-b_{11})g_1 - \ldots - b_{i1}g_i - \ldots - b_{n1}g_n &= u_1^{\beta} \\ &\vdots \\ -b_{1i}g_1 - \ldots + (1-b_{ii})g_i - \ldots - b_{ni}g_n &= u_i^{\beta} \\ &\vdots \\ -b_{1n}g_1 - \ldots - b_{in}g_i - \ldots + (1-b_{nn})g_n &= u_n^{\beta} \end{aligned} \tag{3B-16}$$

Or

$$(\mathbf{I} - \mathbf{B^T})\mathbf{g} = \mathbf{u_\beta}$$

3B.27. For a given set of u_i^{β}'s, equation (3B-16) is a set of n equations with n unknowns, namely, x_1 to x_n. Similar to the Leontief demand driven models, if a positive solution exists for the system of equations in (3B-16), then the solution can be expressed as:

$$\begin{array}{rcccccccc} g_1 & = & \Lambda_{11}u_1^{\beta} & + & \dots & + & \Lambda_{1j}u_j^{\beta} & + & \dots & + & \Lambda_{1n}u_n^{\beta} \\ & \vdots & & & & & & & & & \\ g_i & = & \Lambda_{i1}u_1^{\beta} & + & \dots & + & \Lambda_{ij}u_j^{\beta} & + & \dots & + & \Lambda_{in}u_n^{\beta} \\ & \vdots & & & & & & & & & \\ g_n & = & \Lambda_{n1}u_1^{\beta} & + & \dots & + & \Lambda_{nj}u_j^{\beta} & + & \dots & + & \Lambda_{nn}u_n^{\beta} \end{array} \qquad \text{(3B-17)}$$

or

$$\mathbf{g} = (\mathbf{I} - \mathbf{B}^{\mathbf{T}})^{-1}\mathbf{u}_{\boldsymbol{\beta}} = \boldsymbol{\Lambda}\mathbf{u}_{\boldsymbol{\beta}}$$

where $\boldsymbol{\Lambda} = \begin{bmatrix} \Lambda_{11} & \dots & \Lambda_{1n} \\ \vdots & \ddots & \vdots \\ \Lambda_{n1} & \dots & \Lambda_{nn} \end{bmatrix} = (\mathbf{I} - \mathbf{B}^{\mathbf{T}})^{-1} = \begin{bmatrix} (1 - b_{11}) & \dots & -b_{n1} \\ \vdots & \ddots & \vdots \\ -b_{1n} & \dots & (1 - b_{nn}) \end{bmatrix}^{-1}$.

3B.28. Each Λ_{ij} represents the change in total output of industry i in response to a dollar change in primary inputs available to industry j as an input in production. Thus the exogenous variables are primary inputs of the economy, whereas the exogenous variables in the Leontief system are final demand components.

3B.29. In an *n*-industry economy, the forward linkage of industry *j* is defined as:

$$\frac{\sum_{i=1}^{n}\Lambda_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n}\Lambda_{ij}} \qquad \text{(3B-18)}$$

or

$$\frac{n}{|\mathbf{e}^{\mathbf{T}}\boldsymbol{\Lambda}\mathbf{e}|}\boldsymbol{\Lambda}^{\mathbf{T}}\mathbf{e}$$

Coefficients of Variation (CVs)

3B.30. The coefficients of variation (CVs) for a sample of observations are obtained by dividing the standard error by the sample mean. The CVs of input and output dependencies (θ_{ij} and Λ_{ij} respectively) in an industry measure whether the backward and forward linkages tend towards only a few industries.

3B.31. An industry with a high CV indicates that its dependencies are concentrated on a few industries. An industry with a low CV indicates that its dependencies are spread across many industries.

3B.32. For an n-industry economy, the CV for the backward linkage of industry j is defined as:

$$\mathrm{cv}_j^{\mathrm{BL}} = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\theta_{ij} - \frac{1}{n}\sum_{i=1}^{n}\theta_{ij}\right)^2}}{\frac{1}{n}\sum_{i=1}^{n}\theta_{ij}} \qquad \text{(3B-19)}$$

or

$$\mathbf{CV_{BL}} = \frac{n}{\sqrt{n-1}}\left(\widehat{\boldsymbol{\Theta}^{\mathbf{T}}\mathbf{e}}\right)^{-1}\left(\mathbf{I} \circ \left(\boldsymbol{\Theta}^{\mathbf{T}}\mathbf{Q}\boldsymbol{\Theta}\right)\right)^{\frac{1}{2}}$$

where $\mathbf{CV_{BL}} = \begin{bmatrix} \mathrm{cv}_1^{\mathrm{BL}} \\ \vdots \\ \mathrm{cv}_n^{\mathrm{BL}} \end{bmatrix}$, $\mathbf{Q} = \mathbf{I} - \frac{1}{n}\mathbf{e}\mathbf{e}^{\mathbf{T}} = \frac{1}{n}\begin{bmatrix} n-1 & \dots & -1 \\ \vdots & \ddots & \vdots \\ -1 & \dots & n-1 \end{bmatrix}$, and $\circ$ denotes the Hadamard product

3B.33. The CV for the forward linkage of industry *j* is:

$$\mathrm{cv}_j^{\mathrm{FL}} = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\Lambda_{ij} - \frac{1}{n}\sum_{i=1}^{n}\Lambda_{ij}\right)^2}}{\frac{1}{n}\sum_{i=1}^{n}\Lambda_{ij}} \qquad \text{(3B-20)}$$

or

$$\mathbf{CV_{FL}} = \frac{n}{\sqrt{n-1}}\left(\widehat{\boldsymbol{\Lambda}^{\mathbf{T}}\mathbf{e}}\right)^{-1}\left(\mathbf{I} \circ \left(\boldsymbol{\Lambda}^{\mathbf{T}}\mathbf{Q}\boldsymbol{\Lambda}\right)\right)^{\frac{1}{2}}$$

where $\mathbf{CV_{FL}} = \begin{bmatrix} \mathrm{cv}_1^{\mathrm{FL}} \\ \vdots \\ \mathrm{cv}_n^{\mathrm{FL}} \end{bmatrix}$

3B.34. Table 3B-5 presents the Backward and Forward Linkages table in matrix notation:

Table 3B-5: Backward and Forward Linkages Table

	Forward		Backward	
	Linkage	Coefficient of variation	Linkage	Coefficient of variation
Industries	$\frac{n}{\lvert\mathbf{e}^{\mathbf{T}}\boldsymbol{\Theta}\mathbf{e}\rvert}\boldsymbol{\Theta}^{\mathbf{T}}\mathbf{e}$	$\frac{n}{\sqrt{n-1}}\left(\widehat{\boldsymbol{\Theta}^{\mathbf{T}}\mathbf{e}}\right)^{-1}\left(\mathbf{I}\circ\left(\boldsymbol{\Theta}^{\mathbf{T}}\mathbf{Q}\boldsymbol{\Theta}\right)\right)^{\frac{1}{2}}$	$\frac{n}{\lvert\mathbf{e}^{\mathbf{T}}\boldsymbol{\Lambda}\mathbf{e}\rvert}\boldsymbol{\Lambda}^{\mathbf{T}}\mathbf{e}$	$\frac{n}{\sqrt{n-1}}\left(\widehat{\boldsymbol{\Lambda}^{\mathbf{T}}\mathbf{e}}\right)^{-1}\left(\mathbf{I}\circ\left(\boldsymbol{\Lambda}^{\mathbf{T}}\mathbf{Q}\boldsymbol{\Lambda}\right)\right)^{\frac{1}{2}}$

Annex C to Chapter 3: Derivation of impact of final demand tables

3C.1. This Annex presents the technical details to derive the impact of final demand tables from the Industry by Industry Input-Output Table (IOT).

Industrial Output by Final Demand

3C.2. The Industrial Output by Final Demand table measures the total production of output in response to the demand of final output by the various final demand categories. The output produced by industry i in response to the demand of final output by the various final demand category k can be represented by:

$$\begin{array}{rcl} g_{1k} & = & \theta_{11}f_{1k} + \ldots + \theta_{1j}f_{jk} + \ldots + \theta_{1n}f_{nk} \\ & \vdots & \\ g_{ik} & = & \theta_{i1}f_{1k} + \ldots + \theta_{ij}f_{jk} + \ldots + \theta_{in}f_{nk} \\ & \vdots & \\ g_{nk} & = & \theta_{n1}f_{1k} + \ldots + \theta_{nj}f_{jk} + \ldots + \theta_{nn}f_{nk} \end{array} \qquad (3C\text{-}1)$$

or

$$\mathbf{G} = \mathbf{\Theta F_d}$$

where g_{ik} is the total output produced by industry i in reponse to f_{jk} for all $j = 1, \ldots n$,
f_{jk} is the final output produced by industry j for final demand category k
$\mathbf{G} = \begin{bmatrix} g_{11} & \cdots & g_{1m} \\ \vdots & \ddots & \vdots \\ g_{n1} & \cdots & g_{nm} \end{bmatrix}$

3C.3. The total output produced by industry i in response to demand of final output produced by all industries can be represented by:

$$\begin{array}{rcl} g_{1} & = & g_{11} + \ldots + g_{1k} + \ldots + g_{1m} \\ & \vdots & \\ g_{i} & = & g_{i1} + \ldots + g_{ik} + \ldots + g_{im} \\ & \vdots & \\ g_{n} & = & g_{n1} + \ldots + g_{nk} + \ldots + g_{nm} \end{array} \qquad (3C\text{-}2)$$

or

$$\mathbf{g} = \mathbf{Ge}$$

3C.4. Table 3C-1 presents the Industrial Output by Final Demand table in matrix notation:

Table 3C-1: Industrial Output by Final Demand Table

	Final Demand	Total
Industries	$\boldsymbol{\Theta \mathbf{F}_d}$	$\mathbf{g}$
Total	$\mathbf{e}^{\mathbf{T}}\boldsymbol{\Theta \mathbf{F}_d}$	

3C.5. The same equations in (3C-1) can also be used to simulate the economic impact on output as a result of change in level of demand of final output by replacing f with Δf. The system of equations in (3C-1) is re-written as:

$$\begin{aligned}
\Delta g_1 &= \theta_{11}\Delta f_1 + \ldots + \theta_{1j}\Delta f_j + \ldots + \theta_{1n}\Delta f_n \\
&\vdots \\
\Delta g_i &= \theta_{i1}\Delta f_1 + \ldots + \theta_{ij}\Delta f_j + \ldots + \theta_{in}\Delta f_n \\
&\vdots \\
\Delta g_n &= \theta_{n1}\Delta f_1 + \ldots + \theta_{nj}\Delta f_j + \ldots + \theta_{nn}\Delta f_n
\end{aligned} \qquad \text{(3C-3)}$$

or

$$\boldsymbol{\Delta \mathbf{g} = \Theta \Delta \mathbf{f}}$$

where Δg_i is the change in output of industry i
Δf_j is the change in demand for final output of industry j

$$\boldsymbol{\Delta \mathbf{g}} = \begin{bmatrix} \Delta g_1 \\ \vdots \\ \Delta g_n \end{bmatrix}, \boldsymbol{\Delta \mathbf{f}} = \begin{bmatrix} \Delta f_1 \\ \vdots \\ \Delta f_n \end{bmatrix}$$

3C.6. Here, Δg_i shows the total change in output of industry i due to a change in the demand for the final output of all industries in the economy. Note that $\boldsymbol{\Delta \mathbf{g}} = \mathbf{g}$ when $\Delta \mathbf{f}$ is replaced by $\mathbf{f} = \mathbf{F_d e}$.

Industrial Value Added by Final Demand

3C.7. The Industrial Value Added by Final Demand table measures the total value added generated from the production of output in response to the demand of final output by the various final demand categories. The value added generated by industry i in response to the demand of final output by the various final demand category k can be represented by:

$$\begin{aligned} v_{1k}^{\alpha} &= a_1^v(\theta_{11}f_{1k} + \dots + \theta_{1j}f_{jk} + \dots + \theta_{1n}f_{nk}) \\ &\vdots \\ v_{ik}^{\alpha} &= a_i^v(\theta_{i1}f_{1k} + \dots + \theta_{ij}f_{jk} + \dots + \theta_{in}f_{nk}) \\ &\vdots \\ v_{nk}^{\alpha} &= a_n^v(\theta_{n1}f_{1k} + \dots + \theta_{nj}f_{jk} + \dots + \theta_{nn}f_{nk}) \end{aligned} \qquad \text{(3C-4)}$$

or

$$\mathbf{V}^{\alpha} = \hat{\mathbf{a}}_{\mathbf{v}}\boldsymbol{\Theta}\mathbf{F}_{\mathbf{d}}$$

where v_{1k}^{α} is the value added generated from the production by industry i in reponse to f_{jk} for all $j = 1, \dots n$,

$$\mathbf{V}^{\alpha} = \begin{bmatrix} v_{11}^{\alpha} & \dots & v_{1m}^{\alpha} \\ \vdots & \ddots & \vdots \\ v_{n1}^{\alpha} & \dots & v_{nm}^{\alpha} \end{bmatrix}$$

3C.8. Table 3C-2 presents the Industrial Output by Final Demand table in matrix notation:

Table 3C-2: Industrial Value Added by Final Demand Table

	Final Demand	Total
Industries	$\hat{\mathbf{a}}_{\mathbf{v}}\boldsymbol{\Theta}\mathbf{F}_{\mathbf{d}}$	$\mathbf{V}^{\alpha}\mathbf{e}$
Total	$\mathbf{e}^{\mathbf{T}}\hat{\mathbf{a}}_{\mathbf{v}}\boldsymbol{\Theta}\mathbf{F}_{\mathbf{d}}$	

3C.9. Similar to (3C-3), (3C-4) can also be used to simulate the economic impact on value added as a result of change in level of demand of final output by replacing f with Δf:

$$\begin{aligned} \Delta v_1^{\alpha} &= a_1^v(\theta_{11}\Delta f_1 + \dots + \theta_{1j}\Delta f_j + \dots + \theta_{1n}\Delta f_n) \\ &\vdots \\ \Delta v_i^{\alpha} &= a_i^v(\theta_{i1}\Delta f_1 + \dots + \theta_{ij}\Delta f_j + \dots + \theta_{in}\Delta f_n) \\ &\vdots \\ \Delta v_n^{\alpha} &= a_n^v(\theta_{n1}\Delta f_1 + \dots + \theta_{nj}\Delta f_j + \dots + \theta_{nn}\Delta f_n) \end{aligned} \qquad \text{(3C-5)}$$

or

$$\Delta\mathbf{v}^{\alpha} = \hat{\mathbf{a}}_{\mathbf{v}}\boldsymbol{\Theta}\Delta\mathbf{f}$$

where Δv_i^{α} is the change in value added of industry i

$$\Delta\mathbf{v}^{\alpha} = \begin{bmatrix} \Delta v_1^{\alpha} \\ \vdots \\ \Delta v_n^{\alpha} \end{bmatrix}$$

Primary Inputs by Final Demand

3C.10. The Primary Inputs by Final Demand table measures the total primary inputs required to meet the level of demand of final output by the various final demand categories. The primary inputs, which include imports directly purchased by the final demand categories and the relevant taxes on the imported products, can be represented as follows:

$$
\begin{aligned}
\mathrm{m} &= \sum_{k=1}^{m}\sum_{j=1}^{n} \eta_j f_{jk} + \sum_{k=1}^{m} y_k^{\mathrm{m}} \\
\mathrm{t} &= \sum_{k=1}^{m}\sum_{j=1}^{n} \vartheta_j f_{jk} + \sum_{k=1}^{m} y_k^{\mathrm{t}} \\
v_1 &= \sum_{k=1}^{m}\sum_{j=1}^{n} \rho_j f_{jk} \\
v_2 &= \sum_{k=1}^{m}\sum_{j=1}^{n} \sigma_j f_{jk} \\
v_3 &= \sum_{k=1}^{m}\sum_{j=1}^{n} \varphi_j f_{jk}
\end{aligned}
\qquad \text{(3C-6)}
$$

or

$$
\mathrm{m} = \boldsymbol{\eta}^{\mathbf{T}}\mathbf{F_d}\mathbf{e} + \mathbf{y_m}\mathbf{e} \qquad \mathrm{t} = \boldsymbol{\vartheta}^{\mathbf{T}}\mathbf{F_d}\mathbf{e} + \mathbf{y_t}\mathbf{e} \qquad \mathbf{v} = \boldsymbol{\phi}^{\mathbf{T}}\mathbf{F_d}\mathbf{e} = \mathbf{A_v}\boldsymbol{\Theta}\mathbf{F_d}\mathbf{e}
$$

where y_k^{m} is the purchases of imported products by final demand category k
y_k^{t} is the taxes less subsidies on products paid by final demand category k
m is the total imports of goods and services
t is the total taxes less subsidies on products

3C.11. Table 3C-3 presents the Industrial Output by Final Demand table in matrix notation:

Table 3C-3: Primary Inputs by Final Demand Table

	Final Demand	Total
Imports	$\boldsymbol{\eta}^{\mathbf{T}}\mathbf{F_d} + \mathbf{y_m}$	m
Taxes on products	$\boldsymbol{\vartheta}^{\mathbf{T}}\mathbf{F_d} + \mathbf{y_t}$	t
Value added	$\boldsymbol{\phi}^{\mathbf{T}}\mathbf{F_d}$	$\mathbf{v}$
Total	$\mathbf{y}^{\mathbf{T}}$	

Net Foreign Exchange Earnings from Exports

3C.12. This section covers the derivation of the net foreign exchange earnings from the exports of goods and service. Exports are one of the components of the exogenous final demand, and foreign exchange earnings accrue as a direct result of this demand. However, in the process of producing goods and services for export, industries will use imports as inputs. Net foreign exchange earnings are computed as the foreign exchange earnings as a result of export demand, less the imports used to fulfil this demand.

3C.13. The import requirements for exports of industry j can be derived by multiplying the import multiplier of industry j and domestic exports of industry j:

$$\eta_j f_j^x \tag{3C-7}$$

or

$$\boldsymbol{\eta} \circ \mathbf{f_x}$$

where η_j is the import multiplier of industry j
f_j^x is the domestic exports of industry j
$\boldsymbol{\eta} = \begin{bmatrix} \eta_1 \\ \vdots \\ \eta_n \end{bmatrix}, \mathbf{f_x} = \begin{bmatrix} f_1^x \\ \vdots \\ f_n^x \end{bmatrix}$

3C.14. The net foreign exchange earnings from exports can be computed as:

$$f_j^x - \eta_j f_j^x \tag{3C-8}$$

or

$$\mathbf{f_x} - \boldsymbol{\eta} \circ \mathbf{f_x}$$

3C.15. The ratio of net foreign exchange earnings from exports to domestic exports can be computed as:

$$\frac{f_j^x - \eta_j f_j^x}{f_j^x} \tag{3C-9}$$

or

$$\mathbf{e} - \boldsymbol{\eta}$$

3C.16. Table 3C-4 summarises the derivation of coefficient tables in matrix notation presents the Net Foreign Exchange Earnings from Exports in matrix notation:

Table 3C-4: Net Foreign Exchange Earnings from Exports

	Domestic exports	Import requirements for exports	Net foreign exchange earnings	Net foreign exchange earnings as a proportion of domestic exports
Industries	$\mathbf{f_x}$	$\boldsymbol{\eta} \circ \mathbf{f_x}$	$\mathbf{f_x} - \boldsymbol{\eta} \circ \mathbf{f_x}$	$\mathbf{e} - \boldsymbol{\eta}$

Annex D to Chapter 3: Closed Input-Output model

3D.1. This Annex presents the technical details to derive the closed model for Input-Output analysis.

Closed Input-Output model

3D.2. In the closed model, one or more final demand categories are assumed to be endogenous in the production process. For the closed model used in this publication, only households are considered to be endogenous. Unlike the n industry economy in the open model, the closed model economy has n + 1 industries since households are considered to be an industry.

3D.3. For the closed model, the equations in (3B-1) can be re-expressed as below:

$$\begin{array}{rcccccccccccccc} g_1 & = & z_{11} & + & \ldots & + & z_{1j} & + & \ldots & + & z_{1n} & + & f_{11} & + & \ldots & + & f_{1m} \\ & \vdots & & & & & & & & & & & & & & & \\ g_i & = & z_{i1} & + & \ldots & + & z_{ij} & + & \ldots & + & z_{in} & + & f_{i1} & + & \ldots & + & f_{im} \\ & \vdots & & & & & & & & & & & & & & & \\ g_n & = & z_{n1} & + & \ldots & + & z_{nj} & + & \ldots & + & z_{nn} & + & f_{n1} & + & \ldots & + & f_{nm} \\ & & & & & & & & & & & & & & & & \\ v_1 & = & v_{11} & + & \ldots & + & v_{1j} & + & \ldots & + & v_{1n} & & & & & & \end{array} \qquad \text{(3D-1)}$$

or

$$\bar{\mathbf{g}} = \bar{\mathbf{Z}}_{\mathbf{d}}\mathbf{e} + \bar{\mathbf{F}}_{\mathbf{d}}\mathbf{e} \qquad \text{(3D-2)}$$

where v_{1j} is the costs of compensation of employees by industry j,
v_1 is the total costs of compensation of employees,

$$\bar{\mathbf{g}} = \begin{bmatrix} g_1 \\ \vdots \\ g_n \\ v_1 \end{bmatrix}, \bar{\mathbf{Z}}_{\mathbf{d}} = \begin{bmatrix} z_{11} & \cdots & z_{1n} & f_{11} \\ \vdots & \ddots & \vdots & \vdots \\ z_{n1} & \cdots & z_{nn} & f_{n1} \\ v_{11} & \cdots & v_{1n} & 0 \end{bmatrix}, \bar{\mathbf{F}}_{\mathbf{d}} = \begin{bmatrix} f_{12} & \cdots & f_{1m} \\ \vdots & \ddots & \vdots \\ f_{n2} & \cdots & f_{nm} \\ 0 & \cdots & 0 \end{bmatrix}.$$

3D.4. Similar to deriving input coefficients for the open model, a consumption coefficient, which is consumption per unit wage, is derived. The consumption share of industry i to total wages is $\alpha_i = f_{i1}/v_1$, where v_1 equals the total wages paid by all industries. The wage coefficient which is the wage per unit of output for industry j, is simply $a_{1j}^v = v_{1j}/g_j$.

3D.5. Substituting $f_{i1} = \alpha_i v_1$, $v_{1j} = a^v_{1j} g_j$ and $z_{ij} = a_{ij} g_j$ into the system of equations in (3D-1), the following is obtained:

$$\begin{array}{rcl}
g_1 & = & a_{11}g_1 + \ldots + a_{1j}g_j + \ldots + a_{1n}g_n + \alpha_1 v_1 + \bar{f}_1 \\
 & \vdots & \\
g_i & = & a_{i1}g_1 + \ldots + a_{ij}g_j + \ldots + a_{in}g_n + \alpha_i v_1 + \bar{f}_i \\
 & \vdots & \\
g_n & = & a_{n1}g_1 + \ldots + a_{nj}g_j + \ldots + a_{nn}g_n + \alpha_n v_1 + \bar{f}_n \\
 & & \\
v_1 & = & a^v_{11}g_1 + \ldots + a^v_{1j}g_j + \ldots + a^v_{1n}g_n
\end{array} \qquad \text{(3D-3)}$$

or

$$\bar{\mathbf{g}} = \bar{\mathbf{A}}\bar{\mathbf{g}} + \bar{\mathbf{f}}$$

3D.6. Different from the open model, the new matrix, $\bar{\mathbf{A}}$ has an additional column of consumption coefficients and an additional row of wage coefficients. Rearranging the equations in (3D-3), the equations are re-written as:

$$\begin{array}{ccccccccc}
(1-a_{11})g_1 & -\cdots- & a_{1i}g_i & -\cdots- & a_{1n}g_n & -\cdots- & \alpha_1 v_1 & = & \bar{f}_1 \\
 & & & & & & & \vdots & \\
-a_{i1}g_1 & -\cdots- & (1-a_{ii})g_i & -\cdots- & a_{in}g_n & -\cdots- & \alpha_i v_1 & = & \bar{f}_i \\
 & & & & & & & \vdots & \\
-a_{n1}g_1 & -\cdots- & a_{ni}g_i & -\cdots- & (1-a_{nn})g_n & -\cdots- & \alpha_n v_1 & = & \bar{f}_n \\
 & & & & & & & & \\
-a^v_{11}g_1 & -\cdots- & a^v_{1i}g_i & -\cdots- & a^v_{1n}g_n & -\cdots+ & v_1 & = & 0
\end{array} \qquad \text{(3D-4)}$$

or

$$(\mathbf{I} - \bar{\mathbf{A}})\bar{\mathbf{g}} = \bar{\mathbf{f}}$$

3D.7. Similar to the open model, if a positive solution exists for (3D-5), then the solution can be expressed as:

$$\begin{array}{rcccccccccccc} g_1 & = & \bar{\theta}_{11}\bar{f}_1 & + & \dots & + & \bar{\theta}_{1j}\bar{f}_j & + & \dots & + & \bar{\theta}_{1n}\bar{f}_n & + & \bar{\theta}_{1,n+1}\bar{f}_{n+1} \\ & \vdots & & & & & & & & & & & \\ g_i & = & \bar{\theta}_{i1}\bar{f}_1 & + & \dots & + & \bar{\theta}_{ij}\bar{f}_j & + & \dots & + & \bar{\theta}_{in}\bar{f}_n & + & \bar{\theta}_{i,n+1}\bar{f}_{n+1} \\ & \vdots & & & & & & & & & & & \\ g_n & = & \bar{\theta}_{n1}\bar{f}_1 & + & \dots & + & \bar{\theta}_{nj}\bar{f}_j & + & \dots & + & \bar{\theta}_{nn}\bar{f}_n & + & \bar{\theta}_{n,n+1}\bar{f}_{n+1} \\ v_1 & = & \bar{\theta}_{n+1,1}\bar{f}_1 & + & \dots & + & \bar{\theta}_{n+1,j}\bar{f}_j & + & \dots & + & \bar{\theta}_{n+1,n}\bar{f}_n & + & \bar{\theta}_{n+1,n+1}\bar{f}_{n+1} \end{array} \quad \text{(3D-5)}$$

or

$$\bar{\mathbf{g}} = (\mathbf{I} - \bar{\mathbf{A}})^{-1}\bar{\mathbf{f}} = \bar{\mathbf{\Theta}}\bar{\mathbf{f}}$$

where $\bar{f}_{n+1} = 0$,

$$\bar{\mathbf{\Theta}} = \begin{bmatrix} \bar{\theta}_{11} & \cdots & \bar{\theta}_{1,n+1} \\ \vdots & \ddots & \vdots \\ \bar{\theta}_{n+1,1} & \cdots & \bar{\theta}_{n+1,n+1} \end{bmatrix}$$

3D.8. In input-output analysis, the last column of the $\bar{\mathbf{\Theta}}$ is known as the consumption multiplier and the last row is the household income multiplier. The remaining rows and columns of the $\bar{\mathbf{\Theta}}$, which correspond to the rows and columns of the open inverse represent the industries. The consumption multiplier and household income multiplier are dropped when comparing the closed model inverse to the open model inverse. Equations (3D-5) can be further reduced to:

$$\begin{array}{rcccccccccc} g_1 & = & \bar{\theta}_{11}\bar{f}_1 & + & \dots & + & \bar{\theta}_{1j}\bar{f}_j & + & \dots & + & \bar{\theta}_{1n}\bar{f}_n \\ & \vdots & & & & & & & & & \\ g_i & = & \bar{\theta}_{i1}\bar{f}_1 & + & \dots & + & \bar{\theta}_{ij}\bar{f}_j & + & \dots & + & \bar{\theta}_{in}\bar{f}_n \\ & \vdots & & & & & & & & & \\ g_n & = & \bar{\theta}_{n1}\bar{f}_1 & + & \dots & + & \bar{\theta}_{nj}\bar{f}_j & + & \dots & + & \bar{\theta}_{nn}\bar{f}_n \end{array} \quad \text{(3D-6)}$$

or

$$\mathbf{g} = \bar{\bar{\mathbf{\Theta}}}\bar{\bar{\mathbf{f}}}$$

where $\bar{\bar{\mathbf{\Theta}}} = \begin{bmatrix} \bar{\theta}_{11} & \cdots & \bar{\theta}_{1n} \\ \vdots & \ddots & \vdots \\ \bar{\theta}_{n1} & \cdots & \bar{\theta}_{nn} \end{bmatrix}, \bar{\bar{\mathbf{f}}} = \begin{bmatrix} \bar{f}_1 \\ \vdots \\ \bar{f}_n \end{bmatrix}.$

3D.9. $\bar{\bar{\boldsymbol{\Theta}}}$ is the total requirements coefficients matrix for the closed model, which includes the consumption induced effects. The consumption induced effects can be computed as:

$$\varepsilon_{ij} = \bar{\theta}_{ij} - \theta_{ij} \qquad \text{(3D-7)}$$

or

$$\boldsymbol{\varepsilon} = \bar{\bar{\boldsymbol{\Theta}}} - \boldsymbol{\Theta}$$

where ε_{ij} measures the consumption induced effects on the production of output of industry j,

$$\boldsymbol{\varepsilon} = \begin{bmatrix} \varepsilon_{11} & \cdots & \varepsilon_{1n} \\ \vdots & \ddots & \vdots \\ \varepsilon_{n1} & \cdots & \varepsilon_{nn} \end{bmatrix}$$

Appendices

Appendix 1: Classification of Input-Output (IO) Industry and Product

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
001	Agriculture and nursery products	0111A, 0112A, 0113A, 0114A, 0119A, 0150A, 0160A, 0200A	0601A, 0602A, 0603A, 0604A, 0701A, 0702A, 0703A, 0704A, 0705A, 0706A, 0707A, 0708A, 0709A, 0713P, 0714P, 0801P, 0802P, 0803A, 0804A, 0805P, 0806P, 0807A, 0808A, 0809A, 0810A, 1001A, 1002A, 1003A, 1004A, 1005A, 1006P, 1007A, 1008A, 1201A, 1202A, 1203A, 1204A, 1205A, 1206A, 1207A, 1209A, 1210A, 1211A, 1212A, 1301P, 1401P, 1404P, 1801A, 2401P, 5201A, 5301P, 5302P, 5303P, 5305P	01P, 03P, 04P, 21P, 23P, 38P, 39P, 86P
002	Livestock	0141A, 0142A, 0149A	0101A, 0102A, 0103A, 0104A, 0105A, 0106A, 0307P, 0407A, 0408A, 0409A, 0410A, 0511P, 1521P, 4101A, 4102A, 4103A, 4301P, 5001A, 5101P, 5102A	02P, 22P, 23P, 86P
003	Fishing and aquaculture	0310A, 0320A, 0330A	0301A, 0302A, 0303A, 0306P, 0307P, 0308P, 0508A, 7101P	04P, 21P, 86P
004	Food preparations	1010A, 1020A, 1030A	0201A, 0202A, 0203A, 0204A, 0205A, 0206A, 0207A, 0208A, 0209A, 0210A, 0304A, 0305P, 0306P, 0307P, 0308P, 0504A, 0710A, 0711A, 0712A, 0713P, 0714P, 0801P, 0802P, 0805P, 0806P, 0811A, 0812A, 0813A, 0814A, 1601A, 1602P, 1603A, 1604A, 1605A, 2001A, 2002A, 2003A, 2004A, 2005A, 2006A, 2007A, 2008A, 2009A, 2103P	01P, 21P, 88P
005	Oils and fats	1040A	1501A, 1502A, 1503A, 1504A, 1505A, 1506A, 1507A, 1508A, 1509A, 1510A, 1511A, 1512A, 1513A, 1514A, 1515P, 1516A, 1517A, 1518P, 1521P, 1522A, 2304P, 2305A, 2306A	21P, 34P, 88P
006	Dairy products	1050A	0401A, 0402A, 0403A, 0404A, 0405A, 0406A, 1901P, 2105A, 2202P, 3501P	02P, 22P, 88P
007	Other food products n.e.c	1061A, 1062A, 1071A, 1072A, 1073A, 1074A, 1075A, 1076A, 1079A, 1080A	0305P, 0511P, 0901A, 0902A, 0903A, 0904A, 0905A, 0906A, 0907A, 0908A, 0909A, 0910A, 1006P, 1101A, 1102A, 1103A, 1104A, 1105A, 1106A, 1107A, 1108A, 1109A, 1208A, 1213A, 1214A, 1302A, 1602P, 1701A, 1702A, 1703A, 1704A, 1802A, 1803A, 1804A, 1805A, 1806A, 1901P, 1902A, 1903A, 1904A, 1905A, 2101A, 2102A, 2103P, 2104A, 2106P, 2209A, 2301A, 2302P, 2304P, 2309A, 2501P, 3502P	01P, 16P, 21P, 23P, 24P, 39P, 88P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
008	Beverages and tobacco products	1101A, 1102A, 1103A, 1104A, 1200A	2106P, 2201A, 2202P, 2203A, 2204A, 2205A, 2206A, 2207P, 2208A, 2401P, 2402A, 2403A	17P, 24P, 25A, 88P
009	Textiles	1310A, 1391A, 1392A, 1393A, 1394A, 1399A	5002A, 5004A, 5005A, 5006A, 5007A, 5101P, 5103P, 5105A, 5106A, 5107A, 5108A, 5109A, 5110A, 5111A, 5112A, 5113A, 5203A, 5204A, 5205A, 5206A, 5207A, 5208A, 5209A, 5210A, 5211A, 5212A, 5301P, 5302P, 5303P, 5305P, 5306A, 5307A, 5308A, 5309A, 5310A, 5311A, 5401A, 5402P, 5403P, 5406A, 5407A, 5408A, 5506A, 5507A, 5508A, 5509A, 5510A, 5511A, 5512A, 5513A, 5514A, 5515A, 5516A, 5601A, 5602A, 5603A, 5604A, 5605A, 5606A, 5607A, 5608A, 5609A, 5701A, 5702A, 5703A, 5704A, 5705A, 5801A, 5802A, 5803A, 5804A, 5805A, 5806A, 5807A, 5808A, 5809A, 5810A, 5811A, 5901A, 5902A, 5903A, 5904A, 5905A, 5906A, 5907A, 5908A, 5909A, 5910A, 5911A, 6001A, 6002A, 6003A, 6004A, 6005A, 6006A, 6301P, 6302A, 6303A, 6304A, 6305A, 6306A, 6307A, 6308A, 7019P, 8804A, 9404P, 9619P	26A, 27A, 28P, 32P, 36P, 38P, 88P
010	Wearing apparel and fur products	1410A, 1420A, 1430A	3926P, 4301P, 4302A, 4303A, 4304A, 6101A, 6102A, 6103A, 6104A, 6105A, 6106A, 6107A, 6108A, 6109A, 6110A, 6111A, 6112A, 6113A, 6114A, 6115A, 6116A, 6117A, 6201A, 6202A, 6203A, 6204A, 6205A, 6206A, 6207A, 6208A, 6209A, 6210A, 6211A, 6212A, 6213A, 6214A, 6215A, 6216A, 6217A, 6501A, 6502A, 6504A, 6505A, 6506P, 6507A	28P, 88P
011	Footwear and leather products	1511A, 1512A, 1520A	4104A, 4105A, 4106A, 4107A, 4112A, 4113A, 4114A, 4115A, 4201A, 4202A, 4203A, 4205A, 6401A, 6402A, 6403A, 6404A, 6405A, 6406A, 9113P, 9605A	28P, 29A, 39P, 88P
012	Wood and wooden products (except furniture)	1610A, 1621A, 1622A, 1623A, 1629A	1401P, 1404P, 1515P, 4401P, 4403A, 4404A, 4405A, 4406A, 4407A, 4408A, 4409A, 4410A, 4411A, 4412A, 4413A, 4414A, 4415A, 4416A, 4417A, 4418A, 4419A, 4420A, 4421A, 4501A, 4502A, 4503A, 4504A, 4601A, 4602A, 9406P	03P, 31A, 88P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
013	Paper and paper products	1701A, 1702A, 1709A	3822P, 4701A, 4702A, 4703A, 4704A, 4705A, 4706A, 4801A, 4802A, 4803A, 4804A, 4805A, 4806A, 4807A, 4808A, 4809A, 4810A, 4811A, 4812A, 4813A, 4814A, 4816A, 4817A, 4818A, 4819A, 4822A, 4823A, 6812P, 9619P	32P, 88P
014	Printing and reproduction of recorded media	1811A, 1812A, 1820A	4820A, 4821A, 4901A, 4902A, 4903A, 4904A, 4905A, 4906A, 4907A, 4908A, 4909A, 4910A, 4911A, 8523P	32P, 47P, 89P
015	Petroleum products	09001, 1910A, 1920A	2701P, 2704A, 2706A, 2707P, 2709A, 2710P, 2711P, 2712A, 2713A, 2714P, 9893A	11P, 12P, 33P, 34P, 86P, 88P
016	Basic chemicals and chemical products	2011A, 2012A	1518P, 1520A, 2207P, 2503A, 2601P, 2707P, 2708A, 2801A, 2802A, 2803A, 2804A, 2805A, 2806A, 2807A, 2808A, 2809A, 2810A, 2811A, 2812A, 2813A, 2814A, 2815A, 2816A, 2817A, 2818P, 2819A, 2820A, 2821A, 2822A, 2823A, 2824A, 2825A, 2826A, 2827A, 2828A, 2829A, 2830A, 2831A, 2832A, 2833A, 2834A, 2835A, 2836P, 2837A, 2839A, 2840A, 2841A, 2842A, 2843A, 2844A, 2845A, 2846A, 2847A, 2849A, 2850A, 2852A, 2853A, 2901P, 2903P, 2904P, 2905P, 2906A, 2907P, 2908P, 2910P, 2911A, 2912P, 2914P, 2915P, 2916P, 2917P, 2918P, 2919A, 2920P, 2921P, 2922P, 2923P, 2924P, 2925P, 2926P, 2927A, 2928A, 2929A, 2930P, 2931P, 2932P, 2933P, 2934P, 2935P, 2940A, 3101A, 3102A, 3103A, 3104A, 3105A, 3402P, 3507P, 3823A	33P, 34P, 35P, 88P
017	Petrochemicals and petrochemical products	2013A	2707P, 2901P, 2902A, 2903P, 2904P, 2905P, 2907P, 2909A, 2910P, 2912P, 2913A, 2914P, 2915P, 2916P, 2917P, 2921P, 2926P, 2931P, 2933P, 3901A, 3902A, 3903A, 3904A, 3905A, 3906A, 3907P, 3908A, 3909P, 3910A, 3911A, 3912A, 3913A, 3914A, 4002A	34P, 88P
018	Paints and related products	2022A	2715P, 3202P, 3207A, 3208A, 3209A, 3210A, 3211A, 3212P, 3213A, 3214A, 3805A, 3814A, 3907P	35P, 88P
019	Detergents, perfumes, cleaning and toilet preparations	2023A	3301A, 3302P, 3303A, 3304A, 3305A, 3306A, 3307P, 3401A, 3402P, 3404A, 3405A, 3808P	34P, 35P, 88P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
020	Other chemical products	2021A, 2024A, 2029A, 2030A	2520P, 2903P, 2904P, 2908P, 2910P, 2914P, 2915P, 2916P, 2918P, 2920P, 2922P, 2924P, 2925P, 2930P, 2933P, 3201A, 3202P, 3203A, 3204A, 3205A, 3206A, 3212P, 3215A, 3302P, 3307P, 3403A, 3406A, 3407A, 3501P, 3502P, 3503A, 3504A, 3505A, 3506A, 3507P, 3601A, 3602A, 3603A, 3604A, 3802A, 3803A, 3806A, 3807A, 3808P, 3809A, 3810A, 3811A, 3812A, 3813A, 3815A, 3817A, 3818A, 3819A, 3820A, 3821P, 3822P, 3824P, 3826A, 3907P, 3909P, 4402A, 5402P, 5403P, 5404A, 5405A, 5501A, 5502A, 5503A, 5504A, 9602P	34P, 35P, 37P, 38P, 88P
021	Pharmaceuticals and biological products	2101A, 2102A, 2103A	2836P, 2903P, 2905P, 2914P, 2915P, 2916P, 2918P, 2921P, 2922P, 2923P, 2924P, 2925P, 2926P, 2930P, 2932P, 2933P, 2934P, 2935P, 2936A, 2937A, 2938A, 2939A, 2941A, 2942A, 3001A, 3002A, 3003A, 3004A, 3005A, 3006P, 3821P	35P, 88P
022	Rubber and plastic products	2211A, 2212A, 2219A, 2221A, 2222A	1301P, 3916A, 3917A 3918A, 3919A, 3920A, 3921A, 3922A, 3923A, 3924A, 3925A, 3926P, 4001A, 4003A, 4005A, 4006A, 4007A, 4008A, 4009A, 4010A, 4011A, 4012A, 4013A, 4014A, 4015A, 4016A, 4017A, 6506P, 8547P, 9405P, 9406P	01P, 03P, 36P, 38P, 39P, 88P, 89P
023	Other non-metallic mineral products	0810A, 0890A, 09002, 2310A, 2391A, 2393A, 2394A, 2395A, 2396A, 2399A	2501P, 2504A, 2505A, 2506A, 2507A, 2508A, 2509A, 2510A, 2511A, 2512A, 2513A, 2514A, 2515A, 2516A, 2517A, 2518A, 2519A, 2520P, 2521A, 2522A, 2523A, 2524A, 2525P, 2526A, 2528A, 2529A, 2530A, 2701P, 2702A, 2703A, 2714P, 2715P, 2818P, 3801A, 3816A, 3824P, 6801A, 6802A, 6803A, 6804A, 6805A, 6806A, 6807A, 6808A, 6809A, 6810A, 6811A, 6812P, 6813A, 6814A, 6815A, 6901A, 6902A, 6903A, 6904A, 6905A, 6906A, 6907A, 6909A, 6910A, 6911A, 6912A, 6913A, 6914A, 7001A, 7002A, 7003A, 7004A, 7005A, 7006A, 7007A, 7008A, 7009A, 7010A, 7011A, 7013A, 7014A, 7015A, 7016A, 7017A, 7018A, 7019P, 7020A, 7102P, 7103P, 7104P, 8505P, 8546P, 8547P, 9405P, 9406P	11P, 15A, 16P, 34P, 37P 38P, 46P, 86P, 88P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
024	Basic metals	2410A, 2420A, 2431A, 2432A	2502A, 2601P, 2602A, 2603A, 2604A, 2605A, 2606A, 2607A, 2608A, 2609A, 2610A, 2611A, 2612A, 2613A, 2614A, 2615A, 2616A, 2617A, 2818P, 7106A, 7107A, 7108A, 7109A, 7110A, 7111A, 7112P, 7201A, 7202A, 7203A, 7205A, 7206A, 7207A, 7208A, 7209A, 7210A, 7211A, 7212A, 7213A, 7214A, 7215A, 7216A, 7218A, 7219A, 7220A, 7221A, 7222A, 7224A, 7225A, 7226A, 7227A, 7228A, 7301A, 7302A, 7401A, 7402A, 7403A, 7405A, 7406A, 7407A, 7409A, 7410A, 7501A, 7502A, 7504A, 7505P, 7506A, 7601A, 7603A, 7604P, 7606A, 7607A, 7801A, 7804A, 7806P, 7901A, 7903A, 7904A, 7905A, 8001A, 8003A, 8007P, 8101P, 8102P, 8103P, 8104P, 8105P, 8106P, 8107P, 8108P, 8109P, 8110P, 8111P, 8112P, 8113A, 8311P	13A, 14A, 16P, 39P, 41P, 88P, 89P
025	Fabricated metal products (except machinery and equipment)	2511A, 2512A, 2513A, 2520A, 2591A, 2592A, 2593A, 2594A, 2595A, 2599A	7217A, 7223A, 7229A, 7303A, 7304P, 7305A, 7306A, 7307A, 7308A, 7309A, 7310A, 7311A, 7312A, 7313A, 7314A, 7315A, 7316A, 7317A, 7318A, 7319A, 7320A, 7321P, 7322P, 7323A, 7324A, 7325A, 7326A, 7408A, 7411A, 7412A, 7413A, 7415A, 7418A, 7419A, 7505P, 7507A, 7508A, 7604P, 7605A, 7608A, 7609A, 7610A, 7611A, 7612A, 7613A, 7614A, 7615A, 7616A, 7806P, 7907A, 8007P, 8101P, 8102P, 8103P, 8104P, 8105P, 8106P, 8107P, 8108P, 8109P, 8110P, 8112P, 8201A, 8202A, 8203A, 8204A, 8205A, 8206A, 8207A, 8208A, 8209A, 8210A, 8211A, 8212A, 8213A, 8214A, 8215A, 8301A, 8302A, 8303A, 8304A, 8305A, 8306A, 8307A, 8308A, 8309A, 8311P, 8401P, 8402A, 8404A, 8484A, 8505P, 9301A, 9302A, 9303A, 9304A, 9305A, 9306A, 9307A, 9406P	38P, 41P, 42P, 43P, 44P, 46P, 87P, 88P, 89P
026	Semiconductor devices, electronic components and boards	2611A, 2612A	8473P, 8504P, 8517P, 8522P, 8523P, 8529P, 8531P, 8532A, 8533A, 8534A, 8540A, 8541A, 8542A, 8548P, 9013P	47P, 88P, 97P
027	Computers and peripheral equipment	2620A	8443P, 8471P, 8472P, 8473P, 8523P, 8528P	45P, 47P, 88P
028	Communications equipment	2630A	8443P, 8517P, 8518P, 8522P, 8525P, 8528P, 8529P, 8531P	44P, 46P, 47P, 88P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
029	Consumer electronics	2640A	8518P, 8519A, 8521A, 8522P, 8525P, 8527A, 8528P, 8529P, 9504P	38P, 47P, 88P
030	Scientific, photographic and optical products	2651A, 2652A, 2660A, 2670A, 2680A	3701A, 3702A, 3703A, 3704A, 3705A, 3706A, 3707A, 8523P, 8525P, 8526A, 9001P, 9002A, 9005A, 9006A, 9007A, 9008A, 9010A, 9011A, 9012A, 9013P, 9014A, 9015A, 9016A, 9017A, 9018P, 9021P, 9022A, 9024A, 9025A, 9026A, 9027A, 9028A, 9029A, 9030P, 9031A, 9032A, 9033A, 9101A, 9102A, 9103A, 9104A, 9105A, 9106A, 9107A, 9108A, 9109A, 9110A, 9111A, 9112A, 9114A	38P, 47P, 48P, 87P, 88P
031	Electrical industrial apparatus, batteries and accumulators	2710A, 2720A	8501A, 8502A, 8503A, 8504P, 8505P, 8506A, 8507A, 8511P, 8535A, 8536A, 8537A, 8538A, 8545A	46P, 87P, 88P
032	Electric wiring and lighting equipment	2732A, 2733A, 2740A	8512P, 8513A, 8539A, 8544A, 9001P, 9405P	46P, 48P, 88P
033	Domestic appliances	2750A	6301P, 7321P, 7322P, 8414P, 8418P, 8419P, 8420P, 8421P, 8422P, 8450P, 8451P, 8452P, 8508P, 8509A, 8510A, 8516P	43P, 44P, 88P
034	Other electrical equipment	2790A	8511P, 8512P, 8516P, 8530A, 8531P, 8543P, 8546P, 8547P, 8548P	44P, 46P, 88P
035	General and special purpose machinery (except oil rigs)	2811A, 2812A, 2814A, 2815A, 2816A, 2817A, 2818A, 2819A, 2821A, 2822A, 2825A, 2826A, 2829A	8401P, 8403A, 8405A, 8406A, 8407P, 8408P, 8409P, 8410A, 8411P, 8412A, 8413P, 8414P, 8415A, 8416A, 8417A, 8418P, 8419P, 8420P, 8421P, 8422P, 8423A, 8424A, 8425A, 8426A, 8427A, 8428A, 8429A, 8430P, 8431P, 8432A, 8433A, 8434A, 8435A, 8436A, 8437A, 8438A, 8439A, 8440A, 8441A, 8442A, 8443P, 8444A, 8445A, 8446A, 8447A, 8448A, 8449A, 8450P, 8451P, 8452P, 8453A, 8454A, 8455A, 8456A, 8457A, 8458A, 8459A, 8460A, 8461A, 8462A, 8463A, 8464A, 8465A, 8466A, 8467A, 8468A, 8470A, 8471P, 8472P, 8473P, 8474A, 8475A, 8476A, 8477A, 8478A, 8479A, 8480A, 8481A, 8482A, 8483P, 8486P, 8487A, 8508P, 8511P, 8514P, 8515A, 8516P, 8543P, 8701P, 8706P, 8707P, 8708P, 8709A, 8716P, 9508P	32P, 33P, 38P, 42P, 43P, 44P, 45P, 49P, 87P, 88P
036	Mining, quarrying and construction equipment	2824A	7304P, 8421P, 8430P, 8431P, 8701P, 8905P	41P, 44P, 49P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
037	Semiconductor related equipment	2827A	8486P, 8514P, 9030P	44P
038	Installation of industrial machinery and equipment	2830A		54P, 87P
039	Land transport equipment	2910A, 2920A, 2930A	8407P, 8408P, 8409P, 8413P, 8421P, 8483P, 8511P, 8512P, 8701P, 8702A, 8703P, 8704A, 8705A, 8706P, 8707P, 8708P, 8716P, 9401P	43P, 44P, 49P, 88P
040	Ships and boats	3011A, 3012A	8901A, 8902A, 8903A, 8904A, 8905P, 8906A, 8907A	49P, 88P
041	Aircraft and related parts	3030A	8407P, 8409P, 8411P, 8801A, 8802A, 8803A, 8805A, 9401P	38P, 43P, 49P, 88P
042	Transport equipment n.e.c	3020A, 3040A, 3091A, 3092A, 3099A	8407P, 8408P, 8409P, 8483P, 8601A, 8602A, 8603A, 8604A, 8605A, 8606A, 8607A, 8608A, 8609A, 8703P, 8707P, 8710A, 8711A, 8712A, 8713A, 8714A, 8715A, 8716P	38P, 44P, 49P, 88P
043	Furniture (except of stone)	3100A	9401P, 9402P, 9403P, 9404P	38P, 88P
044	Jewellery and related articles	3211A, 3212A	7101P, 7102P, 7103P, 7104P, 7105A, 7113A, 7114A, 7115A, 7116A, 7117A, 7118A, 9113P	38P, 88P
045	Medical and dental instruments and supplies	3250A	3006P, 3926P, 8419P, 8421P, 9001P, 9003A, 9004A, 9018P, 9019A, 9020A, 9021P, 9402P	36P, 48P, 87P, 88P
046	Other manufacturing	3220A, 3230A, 3240A, 3290A	0501A, 3605A, 3606A, 4206A, 6506P, 6601A, 6602A, 6603A, 6701A, 6702A, 6703A, 6704A, 8310A, 9023A, 9201A, 9202A, 9205A, 9206A, 9207A, 9208A, 9209A, 9403P, 9405P, 9406P, 9503A, 9504P, 9505A, 9506A, 9507A, 9508P, 9601A, 9602P, 9603A, 9604A, 9606A, 9607A, 9608A, 9609A, 9610A, 9611A, 9612A, 9613A, 9614A, 9615A, 9616A, 9617A, 9618A, 9620A, 9701A, 9702A, 9703A, 9704A, 9705A, 9706A	36P, 38P, 88P
047	Electricity	3510A	2716A	17P, 69P, 86P
048	Gas	3520A, 3530A	2705A, 2711P	12P, 17P, 69P, 86P
049	Water and sewerage	3600A, 3700A		18A, 69P, 86P, 94P

(Continued on next page)

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
050	Waste collection, treatment and disposal services	3810A, 3820A, 3830A	0502A, 0505A, 0506A, 0507A, 0510A, 2302P, 2303A, 2307A, 2308A, 2401P, 2525P, 2618A, 2619A, 2620A, 2621A, 2710P, 3006P, 3804A, 3825A, 3915A, 4004A, 4401P, 4707A, 5003A, 5103P, 5104A, 5202A, 5505A, 6309A, 6310A, 7112P, 7204A, 7404A, 7503A, 7602A, 7802A, 7902A, 8002A, 8101P, 8102P, 8103P, 8104P, 8105P, 8107P, 8108P, 8109P, 8110P, 8111P, 8112P, 8548P, 8908A, 9892P	39P, 89P, 94P
051	Building construction	4100A		53P, 54P
052	Civil engineering works	4210A, 4220A, 4290A		53P, 54P
053	Specialised construction services	4311A, 4312A, 4321A, 4322A, 4329A, 4330A, 4390A		54P, 87P
054	Wholesale trade	4610A, 4621A, 4622A, 4630A, 4641A, 4642A, 4643A, 4644A, 4645A, 4646A, 4647A, 4649A, 4651A, 4652A, 4653A, 4654A, 4655A, 4656A, 4659A, 4661A, 4662A, 4663A, 4664A, 4665A, 4666A, 4690A		61A
055	Retail trade	4711A, 4719A, 4721A, 4722A, 4723A, 4731A, 4732A, 4741A, 4742A, 4751A, 4752A, 4753A, 4761A, 4762A, 4763A, 4764A, 4771A, 4772A, 4773A, 4774A, 4775A, 4776A, 4777A, 4780A, 4791A, 4799A		62A
056	Land transport	4910A, 4921A, 4922A, 4923A, 4930A		64P, 65P, 66P
057	Water transport	5001A, 5002A		64P, 65P, 66P
058	Air transport	5100A		64P, 65P, 66P
059	Land transport supporting services	5221A		67P
060	Water transport supporting services	5222A, 5225A		67P
061	Air transport supporting services	5223A		67P
062	Cargo handling, warehousing and other support services	5210A, 5224A, 5229A		67P
063	Postal and courier services	5310A, 5320A		68A
064	Accommodation	5510A, 5590A		63P
065	Food and beverage services	5611A, 5612A, 5613A, 5614A, 5620A		63P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
066	Publishing	5811A, 5812A, 5813A, 5819A, 5820A		73P, 83P, 84P, 89P
067	Media entertainment	5911A, 5912A, 5913A, 5914A, 5920A, 6010A, 6020A		83P, 84P, 96P
068	Telecommunications	6101A, 6109A		84P
069	Computer programming, consultancy and information services	6201A, 6202A, 6209A, 6311A, 6312A, 6390A		47P, 83P, 84P, 85P, 87P
070	Banking and finance	6412A, 6413A, 6414A, 6415A, 6416A, 6411A, 6419A		71P
071	Financial services (except insurance and pension funding)	6420A, 6430A, 6491A, 6492A, 6499A		71P
072	Life insurance	6511A, 65201		71P
073	Non-life insurance	6512A, 65202, 6530A		71P
074	Other auxiliary financial and insurance services	6611A, 6612A, 6619A, 6621A, 6622A, 6629A		71P
075	Fund Management	6630A		71P
076	Real estate	6810A, 6820A		72A
077	Ownership of dwellings			
078	Legal services	6910A		82P
079	Accounting, auditing and tax consultancy services	6920A		82P
080	Head offices and business representative offices	7010A		83P
081	Consultancy services	7020A		82P, 83P
082	Architectural and engineering services	7111A, 7112A, 7120A		83P
083	Research and development	7210A, 7220A		81A
084	Advertising and market research	7310A, 7320A		83P
085	Specialised design services	7411A, 7419A		83P
086	Other professional, scientific and technical services	7420A, 7490A		83P, 85P
087	Veterinary services	7500A		83P
088	Rental and leasing of tangible assets	7710A, 7721A, 7722A, 7729A, 7731A, 7732A, 7733A, 7734A, 7739A		73P
089	Rental and leasing of intangible assets	7740A		73P, 83P
090	Employment and labour contracting	7810A, 7830A		85P

IO Industries/ Products		Singapore Standard Industrial Classification 2015 (SSIC 2015)	Harmonised Product Description and Coding System Nomenclature 2017 (HS 2017)	Central Product Classification, Version 2.1 (CPC Ver. 2.1)
091	Travel agency, tour operator and reservation services	7910A, 7990A		85P
092	Security and investigation services	8000A		85P
093	Cleaning and landscape maintenance services	8121A, 8129A, 8130A		85P, 94P
094	Office administrative and support services	8211A, 8219A, 8220A, 8291A, 8292A, 8299A		85P
095	Exhibitions, conventions and other events	8230A		85P
096	Public administration and defence	8411A, 8412A, 8421A, 8422A, 8423A		91A
097	Education	8510A, 8521A, 8522A, 8530A, 8541A, 8542A, 8549A, 8550A		92A
098	Health services	8610A, 8620A, 8690A		93P
099	Social services	8701A, 8702A, 8810A, 8891A, 8892A, 8899A		93P
100	Arts and entertainment	9000A, 9101A, 9102A, 9103A		84P, 96P
101	Recreation and sports	9200A, 9311A, 9312A, 9320A		96P
102	Member organisations	9411A, 9412A, 9420A, 9491A, 9492A, 9499A		95A
103	Repair of computers, personal and household goods and vehicles	9511A, 9512A, 9521A, 9522A, 9523A, 9524A, 9529A, 9530A		87P
104	Other personal services	9601A, 9602A, 9603A, 9604A, 9609A		86P, 97P
105	Domestic services	9700A		98A

Note:
For SSIC 2015 codes at class level, HS 2017 codes at 4-digits level and CPC Ver. 2.1 codes at 2-digits level that are mapped to more than one IO industry/product code, they are indicated with a suffix “P”. Else, they are indicated with a suffix “A”.

Appendix 2: Correspondence between the 11 broad industries and the detailed 105 IO industries

IO Industries		Broad industries
001	Agriculture and nursery products	Other goods Industries
002	Livestock	
003	Fishing and aquaculture	
004	Food preparations	Manufacturing
005	Oils and fats	
006	Dairy products	
007	Other food products n.e.c	
008	Beverages and tobacco products	
009	Textiles	
010	Wearing apparel and fur products	
011	Footwear and leather products	
012	Wood and wooden products (except furniture)	
013	Paper and paper products	
014	Printing and reproduction of recorded media	
015	Petroleum products	
016	Basic chemicals and chemical products	
017	Petrochemicals and petrochemical products	
018	Paints and related products	
019	Detergents, perfumes, cleaning and toilet preparations	
020	Other chemical products	
021	Pharmaceuticals and biological products	
022	Rubber and plastic products	
023	Other non-metallic mineral products	
024	Basic metals	
025	Fabricated metal products (except machinery and equipment)	
026	Semiconductor devices, electronic components and boards	
027	Computers and peripheral equipment	
028	Communications equipment	
029	Consumer electronics	
030	Scientific, photographic and optical products	
031	Electrical industrial apparatus, batteries and accumulators	
032	Electric wiring and lighting equipment	
033	Domestic appliances	
034	Other electrical equipment	
035	General and special purpose machinery (except oil rigs)	

2015 IO Industries		Broad industries
036	Mining, quarrying and construction equipment	Manufacturing
037	Semiconductor related equipment	
038	Installation of industrial machinery and equipment	
039	Land transport equipment	
040	Ships and boats	
041	Aircraft and related parts	
042	Transport equipment n.e.c	
043	Furniture (except of stone)	
044	Jewellery and related articles	
045	Medical and dental instruments and supplies	
046	Other manufacturing	
047	Electricity	Utilities
048	Gas	
049	Water and sewerage	
050	Waste collection, treatment and disposal services	
051	Building construction	Construction
052	Civil engineering works	
053	Specialised construction services	
054	Wholesale trade	Wholesale & retail trade
055	Retail trade	
056	Land transport	Transport & storage
057	Water transport	
058	Air transport	
059	Land transport supporting services	
060	Water transport supporting services	
061	Air transport supporting services	
062	Cargo handling, warehousing and other support services	
063	Postal and courier services	
064	Accommodation	Accommodation & food services
065	Food and beverage services	
066	Publishing	Information & communications
067	Media entertainment	
068	Telecommunications	
069	Computer programming, consultancy and information services	
070	Banking and finance	Financial & insurance
071	Financial services (except insurance and pension funding)	
072	Life insurance	

2015 IO Industries		Broad industries
073	Non-life insurance	Financial & insurance
074	Other auxiliary financial and insurance services	
075	Fund Management	
076	Real estate	Business services
077	Ownership of dwellings	
078	Legal services	
079	Accounting, auditing and tax consultancy services	
080	Head offices and business representative offices	
081	Consultancy services	
082	Architectural and engineering services	
083	Research and development	
084	Advertising and market research	
085	Specialised design services	
086	Other professional, scientific and technical services	
087	Veterinary services	
088	Rental and leasing of tangible assets	
089	Rental and leasing of intangible assets	
090	Employment and labour contracting	
091	Travel agency, tour operator and reservation services	
092	Security and investigation services	
093	Cleaning and landscape maintenance services	
094	Office administrative and support services	
095	Exhibitions, conventions and other events	
096	Public administration and defence	Other services industries
097	Education	
098	Health services	
099	Social services	
100	Arts and entertainment	
101	Recreation and sports	
102	Member organisations	
103	Repair of computers, personal and household goods and vehicles	
104	Other personal services	
105	Domestic services	

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