Singapore Supply and Use, and Input - Output Tables 2010

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PREFACE

The supply and use tables (SUTs) provide a comprehensive and integrated framework for the reconciliation of key national accounts aggregates. The SUTs also describe the inter-relationship between producers and consumers of goods and services, and inter-dependence among the different industries. The input-output tables (IOTs) are derived from the SUTs and used for a variety of analytical purposes such as economic modelling and impact studies.

This publication, for the reference year 2010, is the tenth in the series of Singapore Supply and Use, and Input-Output Tables. The previous sets of benchmark SUTs for reference year 2005 and intermediate SUTs for reference year 2007 were published in June 2010 and March 2012 respectively.

The compilation of SUTs is a massive exercise which involves consolidating voluminous data and reconciling the transaction flows of products. Conceptual and methodological changes have been incorporated to improve the quality of estimates and ensure that they adhere to the latest international guidelines. The data compilation process of the SUTs has also been streamlined to improve the timeliness of the tables to better meet the needs of users in analysing the economic structure of Singapore.

The data used in the compilation of SUTs 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.

Wong Wee Kim
Chief Statistician
Singapore

July 2014

Our Vision

A National Statistical System of Quality, Integrity and Expertise.

Our Mission

We Provide Reliable, Relevant and Timely Statistics to Support Singapore's Social and Economic Development.

Our Guiding Principles

Professionalism & Expertise	*We adhere to professional ethics and proficiently produce quality statistics that comply with international concepts and best practices.*
Relevance	*We constantly innovate our processes and produce statistics that meet users' needs.*
Accessibility	*We make our statistics readily available.*
Confidentiality	*We protect the confidentiality of information provided to us.*
Timeliness & Reliability	*We produce statistics that users can depend on and disseminate them at the earliest possible date while maintaining data quality.*
Cost Effectiveness	*We use resources effectively, minimising respondent burden and leveraging on administrative data.*

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SINGAPORE SUPPLY AND USE, AND INPUT-OUTPUT TABLES 2010

1. INTRODUCTION

1.1 The Singapore Supply and Use, and Input-Output Tables are made up of the supply and use tables (SUTs) and the input-output tables (IOTs). The SUTs are product-by-industry tables, primarily related to the production account in the System of National Accounts[1] (SNA). The IOTs consist of a symmetric industry-by-industry table that is transformed from the SUTs, and its applications.

1.2 The SUTs provide systematic and 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 on flows of goods and services 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 To date, the Singapore Department of Statistics (DOS) has published eight sets of benchmark SUTs for reference years 1973, 1978, 1983, 1988, 1990, 1995, 2000 and 2005 and one set of intermediate SUTs for reference year 2007. Similar to earlier years, the 2010 SUTs have been used to reconcile the three GDP estimates in the recently completed rebasing of Singapore's national accounts to reference year 2010.

1.4 Chapter 2 of this publication provides information on the methodology and the main findings of the 2010 SUTs while Chapter 3 discusses the transformation of the SUTs to the symmetric industry-by-industry table and its applications. Chapter 4 concludes with key findings from the 2010 SUTs and IOTs. The theoretical basis and derivation of the symmetric industry-by-industry table and its applications are given in the Annex.

1.5 A summary report of this publication and the complete set of 2010 SUTs and IOTs at the detailed industry and product level in Excel format can be downloaded via the embedded links or from the SingStat website at www.singstat.gov.sg.

[1] The SNA is the conceptual framework that sets the international statistical standard for the compilation of macro-economic statistics for analysing the performance of an economy.

2. SUPPLY AND USE TABLES

2.1 The SUTs consist of three tables, namely the domestic supply table, domestic use table and import use table[2]. These tables bring together the production, expenditure and income measures of GDP. They are also used to derive the IOTs.

2.2 For reference year 2010, Singapore's SUTs are compiled at 127 Input-Output (IO) industries / products codes. The correspondence between the 127 IO codes and the industry / product classifications is given in Appendix 1. To facilitate analysis and easy understanding, the 127 IO codes are aggregated into 11 industrial sectors in this paper. The correspondence between the 11 industrial sectors and the detailed 127 IO codes is given in Appendix 2.

Methodology

2.3 The data used for compiling the SUTs come from surveys conducted by DOS and various government agencies as well as administrative data from a wide range of sources. The compilation of the Singapore's SUTs follows closely the concepts and principles recommended in the United Nations (UN) *System of National Accounts 2008* (2008 SNA).

A. Statistical Unit

2.4 An industry is formed by grouping together establishments that are engaged in similar kinds of activity. The establishment, as defined by the 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 homogenous qualities reduce the presence of secondary production in the SUTs. Product groups are formed by grouping the principal goods and services produced by the industries.

B. Classification

2.5 The industrial classification of IO codes is based on the *Singapore Standard Industrial Classification 2010* (SSIC 2010) while the product classification of IO codes follows the World Customs Organization (WCO) *Harmonised Product Description and Coding System Nomenclature 2007* (HS 2007). To link the industrial and product classifications together, the UN *Central Product Classification, Version 2* (CPC Ver.2) is used as a reference.

C. Valuation

2.6 The supply and use of products are valued at basic prices. The valuation at basic prices is defined as the amount receivable by the producer from the purchaser for a unit of good or service less any tax payable plus any subsidies receivable on the product. However, the actual observable transactions values for the supply of products are at basic prices, while

[2] These tables are known as the make matrix, absorption matrix and import matrix respectively in previous publications.

the values for the use of products are at purchasers' prices. Exhibit 1 gives an overview of the differences between basic, producers' and purchasers' prices.

Exhibit 1: Basic, Producers' and Purchasers' Prices

Basic prices
Plus
Taxes on products excluding invoiced value-added tax[3] (VAT)
Less
Subsidies on products
Equals
Producers' prices
Plus
VAT not deductible by purchaser
Plus
Separately invoiced transport charges
Plus
Wholesalers' and retailers' margins
Equals
Purchasers' prices

2.7 To ensure uniform valuation, the trade and transport margins as well as taxes and subsidies on products have to be excluded from the use of products. The trade and transport margins are removed from the use of products and reflected as the wholesale/retail or transport services consumed by the purchaser. Similarly, the taxes and subsidies on products are also removed from relevant products for each purchaser and shown separately as total taxes less subsidies on product of the purchaser.

D. Treatment of Imports and Exports

2.8 In Singapore's SUTs, only retained imports and domestic exports are recorded for goods. Re-exports, which are goods exported from Singapore in the same form as they have been imported, are not included in the compilation of the SUTs. Similarly, goods that are being transhipped are also excluded. For such goods, the differences between the re-exported and imported values are trade and transport margins, which are recorded as an export of trade and transport services.

2.9 Retained imports, which are goods imported and kept in the country for domestic use, are valued at cost, insurance, freight (c.i.f.) at the domestic customs frontier. This valuation basis has resulted in the inclusion of freight and insurance payments made to local carriers and insurance firms which need to be excluded. An adjustment is made on the exports of such services by domestic producers. Domestic exports, which are exported goods of Singapore origin, are valued free on board (f.o.b.), i.e. at the prices at the domestic customs frontier before being shipped out.

[3] In Singapore's context, VAT refers to Goods and Services Tax (GST).

E. Reconciliation

2.10 The compilation of the SUTs mainly involves reconciling the voluminous data from various sources, and fitting them together to obtain a single and coherent estimate of GDP. When the data are initially put together, it is inevitable that the tables are not balanced due to a variety of reasons, such as differences in coverage, definitions, estimation methods, classifications, recording periods and valuations across data sources.

2.11 The SUTs are balanced using an identity known as the product balance (see Exhibit 2). In an economy, the use of products has to be supplied from either domestic output or imports. This identity provides a framework where inconsistencies in data, coverage and methodologies are identified. 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.

2.12 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[4] is used to automatically distribute the residual imbalances to balance the tables.

F. Methodological Improvements

2.13 The SUTs form an integral part of the rebasing of Singapore's national accounts. Methodological improvements such as conceptual and classification changes are introduced and incorporated in the SUTs during rebasing[5].

2.14 The main conceptual change implemented in the 2010 SUTs is the capitalisation of research and development (R&D) expenditure. The 2008 SNA recommends that R&D expenditure be recognised as an investment and treated as gross fixed capital formation (GFCF) instead of intermediate consumption (IC). The new treatment recognises the contribution of R&D to future productive capacity.

2.15 In addition, the methodologies used to estimate the value-added (VA) of self-employed individuals have been reviewed and refined. New categories of self-employed individuals such as sports coaches are also included. The VA estimates are benchmarked against data from the Census of Population, General Household Survey, Labour Force Survey and relevant administrative sources.

2.16 There are two main classification refinements made to the 2010 SUTs as compared to the previous SUTs. Firstly, non-profit institutions are now classified according to their principal activity instead of being grouped together in a separate industry. This helps to improve the homogeneity of the SUTs as well as facilitate reconciliation with other components of national accounts. Secondly, government consumption expenditure has been disaggregated to show final expenditure on other types of non-market goods and services provided by the general government to individual households or the community. Examples of such goods and services include education, social services, museums and parks.

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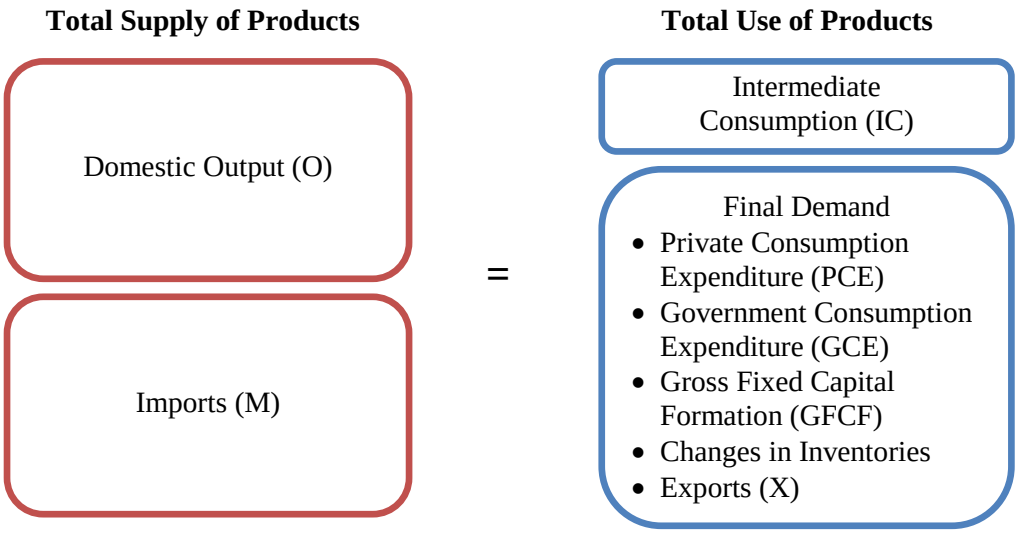
[4] The RAS method is an iterative proportional fitting procedure. For more details on this mathematical procedure, please refer to the Annex.

[5] Please refer to the Information Paper: *Rebasing of Singapore's national accounts to reference year 2010* for a more detailed discussion on the changes and improvements.

Exhibit 2: Product Balance



For Singapore's SUTs, the supply and use of products, together with trade and transport margins which are considered to be products produced by the wholesale/retail and transport industries, are balanced at basic prices. As supply must equal use, the following simplified identity on product balance at basic prices holds true for each of the products:

Supply = Use

$$O_{BP} + M_{cif} = IC_{BP} + PCE_{BP} + GCE_{BP} + GFCF_{BP} + \text{Changes in Inventories}_{BP} + X_{fob}$$

If the supply and use of a product are not balanced, investigations on possible discrepancies will then be carried out on components of this identity. In a balanced table, the total supply of products equals to the total use of products; GDP by expenditure approach equates to GDP by production approach.

To illustrate this relationship, taxes less subsidies on products are added to convert the total supply and use of the products from basic prices to purchasers' prices. The identity on product balance at purchasers' prices is rearranged from:

$$O_{BP} + M_{cif} + T = IC_{PP} + PCE_{PP} + GCE_{PP} + GFCF_{PP} + \text{Changes in Inventories}_{PP} + X_{fob}$$

to:

$$O_{BP} - IC_{PP} + T = PCE_{PP} + GCE_{PP} + GFCF_{PP} + \text{Changes in Inventories}_{PP} + (X_{fob} - M_{cif})$$

$$\Rightarrow VA_{BP} + T = PCE_{PP} + GCE_{PP} + GFCF_{PP} + \text{Changes in Inventories}_{PP} + (X_{fob} - M_{cif})$$

⇨ GDP by Output Approach = GDP by Expenditure Approach

where T = Taxes less Subsidies on Products
VA_{BP} = Gross Value-Added at Basic Prices = $O_{BP} - IC_{PP}$
BP = Basic Prices
PP = Purchasers' Prices

Domestic Supply Table

2.17 The domestic supply table records all domestic production, broken down by industries and products. Exhibit 3 provides a schematic representation of the domestic supply table. 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. All entries are valued at basic prices, i.e. exclusive of any taxes and subsidies on products, and trade and transport margins.

2.18 The diagonal entries of the domestic supply table 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 supply table refer to secondary products produced by the establishments.

Exhibit 3: Schematic Representation of Domestic Supply Table

<table>
<tr><td rowspan="2">Supply by Product</td><td colspan="6">Output by Industry</td><td rowspan="2">Total Domestic Supply</td></tr>
<tr><td>Industry 1</td><td>Industry 2</td><td>….</td><td>….</td><td>….</td><td>Industry n</td></tr>
<tr><td>Product 1
Product 2
….
….
….
Product n</td><td colspan="6">Domestic output by industry and product</td><td>Total Product Output</td></tr>
<tr><td>Total Output</td><td colspan="6">Total Industry Output</td><td></td></tr>
</table>

2.19 In 2010, the Singapore economy produced $836 billion worth of goods and services (Table 1). The services sector[6] accounted for 57 per cent of total domestic output while the goods sector contributed to the remaining 43 per cent. The manufacturing sector remained a major sector despite a decline in its share of domestic output from 40 per cent in 2005 to 35 per cent.

[6] The services sector comprises wholesale and retail trade, accommodation and food services, transportation and storage, information and communications, finance and insurance, business services, and other services. The goods sector comprises manufacturing, utilities, other goods and construction.

Table 1: Domestic Supply Table, 2010

Billion Dollars

Supply by Product	Output by Industry											
	Manufactur-ing	Utilities	Other Goods	Construct-ion	Wholesale & Retail Trade	Accommod-ation & Food Services	Transport-ation & Storage	Information & Communi-cations	Finance & Insurance	Business Services	Other Services	Total Domestic Supply
Manufacturing	279.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.3	0.0	280.0
Utilities	0.3	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	16.0
Other Goods	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Construction	0.0	0.0	0.0	50.4	0.0	0.0	0.0	0.0	0.0	1.1	0.0	51.5
Wholesale & Retail Trade	9.2	0.0	0.0	0.4	105.9	0.1	0.4	2.6	0.2	0.5	0.2	119.4
Accommodation & Food Services	0.0	0.0	0.0	0.0	0.0	13.3	0.0	0.0	0.0	0.2	0.1	13.7
Transportation & Storage	0.0	0.0	0.0	0.1	0.4	0.0	89.3	0.9	0.1	0.5	0.1	91.4
Information & Communications	0.3	0.0	0.0	0.0	0.4	0.1	0.2	28.6	0.7	0.4	0.4	31.1
Finance & Insurance	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.6	0.0	0.0	61.6
Business Services	2.9	0.1	0.0	1.3	2.9	0.4	1.6	1.6	1.1	90.6	2.6	105.2
Other Services	0.1	0.0	0.0	0.0	0.8	0.1	0.0	0.0	0.3	0.2	63.8	65.3
Total Output	291.8	15.6	0.3	52.1	111.1	13.9	91.6	33.8	64.0	93.8	67.5	835.5

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

Domestic Use Table

2.20 The domestic use table records the domestically produced products purchased or used for intermediate consumption and final demand. Value-added and imports are also included. A schematic representation of the domestic use table is shown in Exhibit 4.

Exhibit 4: Schematic Representation of Domestic Use Table

Sales by Product	Purchases by Industry						Total Intermediate Use	Final Demand						Total Use
	Industry 1	Industry 2	….	….	….	Industry n		Private Consumption Expenditure	Government Consumption Expenditure	Gross Fixed Capital Formation	Changes in Inventories	Exports of Goods & Services	Total Final Demand	
Product 1 Product 2 …. …. …. Product n	Quadrant 1 Intermediate consumption of domestically produced products by product and industry							Quadrant 2 Final demand for domestically produced products by product and category						
Imports of Goods and Services Taxes on Products Gross Value-Added at Basic Price Taxes less Subsidies on Production Compensation of Employees Gross Operating Surplus	Quadrant 3 Total imports, taxes on products and value-added (primary inputs) by industry							Quadrant 4 Final demand for total imports and taxes on products by category						
Total Inputs	Total Industry Inputs							Total Final Demand						

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

2.21 Quadrant 1 shows domestically produced products purchased by industries as intermediate inputs to current production while Quadrant 2 records the domestically produced products consumed by final demand. Quadrant 3 shows the rest of the inputs required by industries, namely retained imports, taxes on products and value-added while Quadrant 4 shows retained imports and taxes on products which are consumed by final demand. Collectively, Quadrants 1 and 2 show the total usage of each domestically produced product while Quadrants 1 and 3 show the inputs used to produce the total output of each industry. The four quadrants 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 Exhibit 5.

Exhibit 5: Derivation of GDP at Current Market Prices, 2010 (in billion dollars)

GDP ($322.4)	**Production Approach**
	Output – Intermediate consumption + Taxes on products (835.5 – 531.1 + 17.9)
	Expenditure Approach
	Final demand – Total imports (624.7 – 302.4)
	Income Approach
	Compensation of employees + Gross operating surplus + Taxes less subsidies on production + Taxes on products (126.1 + 173.9 + 4.5 +17.9)

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

2.22 In 2010, the total intermediate inputs supplied by domestic industries amounted to $272 billion representing 33 per cent of total domestic production (Table 2). The services sector continued to account for a larger consumption share of the intermediate inputs that were produced domestically at 55 per cent and the goods sector accounted for the remaining 45 per cent. The manufacturing sector consumed 31 per cent of the domestically produced intermediate inputs of which 64 per cent were manufacturing products. The amount of goods and services imported by domestic industries for use in their production process was $258 billion in 2010.

2.23 Final demand components, namely, PCE, GCE, gross capital formation (GCF)[7] and exports of goods and services absorbed $563 billion or 67 per cent of total domestic output in 2010. Exports of goods and services continued to account for the largest proportion of domestic output. Of the $836 billion of total domestic output in 2010, exports of goods and services accounted for $388 billion or 46 per cent of total domestic output, reflecting the economy's high dependence on external demand.

[7] Gross capital formation is made up of GFCF and changes in inventories.

Table 2: Domestic Use Table, 2010

Billion Dollars

Sales by Product	Purchases by Industry											Total Intermediate Use
	Manufactur-ing	Utilities	Other Goods	Construc-tion	Wholesale & Retail Trade	Accommod-ation & Food Services	Transporta-tion & Storage	Inform-ation & Communic ations	Finance & Insurance	Business Services	Other Services	
Total Intermediate Use at Purchasers' Prices	226.8	10.7	0.1	37.9	53.0	8.0	66.1	22.8	30.9	40.0	34.8	531.1
Domestic Production	85.7	5.5	0.1	30.6	29.4	5.4	27.6	10.7	18.5	32.9	26.0	272.4
Manufacturing	54.6	0.4	0.0	5.9	1.1	1.6	4.0	1.8	0.4	3.6	3.4	76.7
Utilities	4.2	3.5	0.0	0.1	0.6	0.6	0.5	0.2	0.2	0.8	1.5	12.3
Other Goods	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Construction	0.4	0.1	0.0	19.0	0.0	0.1	0.0	0.0	0.0	1.4	0.2	21.3
Wholesale & Retail Trade	11.4	0.2	0.0	1.5	1.5	0.4	1.0	0.1	0.0	0.3	0.7	17.3
Accommodation & Food Services	0.3	0.0	0.0	0.2	0.3	0.1	1.5	0.1	0.2	0.6	0.3	3.4
Transportation & Storage	3.6	0.1	0.0	0.7	9.9	0.1	14.2	0.5	0.5	1.6	0.4	31.5
Information & Communications	1.5	0.1	0.0	0.3	2.3	0.1	0.9	4.1	2.3	2.2	2.6	16.3
Finance & Insurance	1.5	0.2	0.0	0.4	3.5	0.2	0.9	0.5	11.4	6.5	4.2	29.2
Business Services	7.4	0.8	0.0	2.3	9.7	2.2	4.1	3.1	3.5	15.6	5.4	54.0
Other Services	0.7	0.0	0.0	0.2	0.5	0.1	0.6	0.3	0.1	0.4	7.2	10.3
Imports of Goods & Services	141.0	5.2	0.0	7.3	23.5	2.5	38.3	12.1	12.2	7.0	8.6	257.7
Taxes on Products	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.2	0.2	0.9
Gross Value-Added at Basic Prices	65.0	4.9	0.1	14.2	58.1	5.9	25.5	11.0	33.1	53.8	32.7	304.4
Taxes less Subsidies on Production	0.6	0.2	0.0	0.5	0.3	0.2	0.5	0.1	0.0	1.5	0.6	4.5
Compensation of Employees	20.6	1.0	0.1	7.8	19.5	3.2	8.7	6.2	16.5	18.3	24.0	126.1
Gross Operating Surplus	43.8	3.7	0.0	5.9	38.3	2.5	16.3	4.7	16.6	34.0	8.0	173.9
Total Inputs	291.8	15.6	0.3	52.1	111.1	13.9	91.6	33.8	64.0	93.8	67.5	835.5

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

Table 2: Domestic Use Table, 2010 (cont'd)

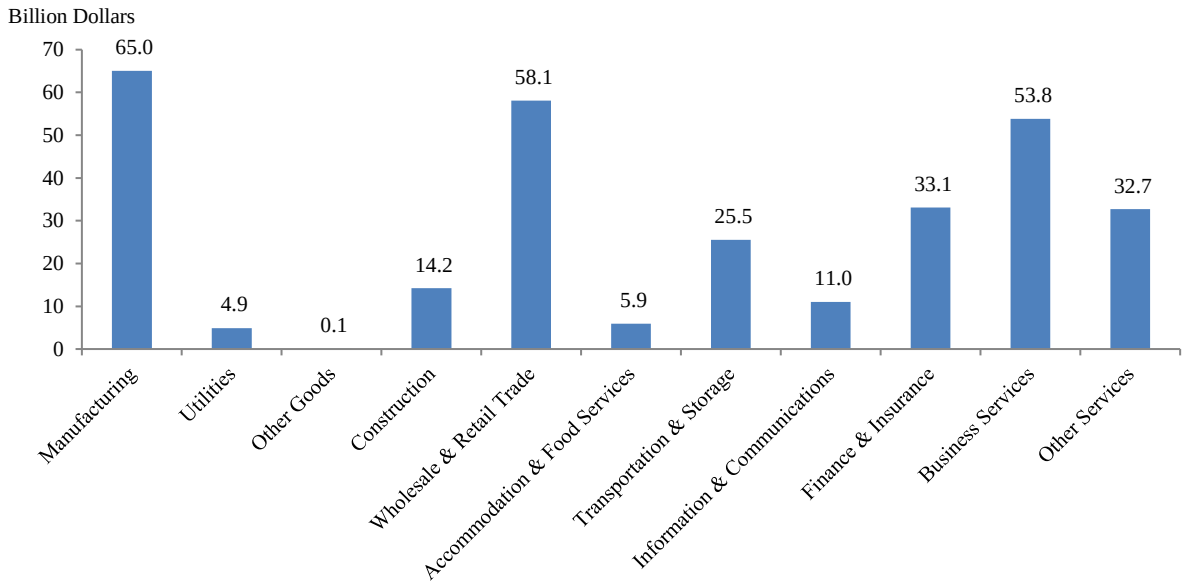
Billion Dollars

Sales by Product	Final Demand						Total Use
	Private Consumption Expenditure	Government Consumption Expenditure	Gross Fixed Capital Formation	Changes in Inventories	Exports of Goods & Services	Total Final Demand	
Total Final Use at Purchasers' Prices	114.5	32.8	84.2	5.6	387.5	624.7	1,155.8
Domestic Production	83.2	32.8	58.5	1.0	387.5	563.1	835.5
Manufacturing	4.0	0.0	7.0	1.0	191.2	203.3	280.0
Utilities	2.4	0.0	0.0	0.0	1.4	3.7	16.0
Other Goods	0.0	0.0	0.0	0.0	0.1	0.1	0.2
Construction	0.0	0.0	29.4	0.0	0.8	30.3	51.5
Wholesale & Retail Trade	10.9	0.0	3.6	0.0	87.6	102.1	119.4
Accommodation & Food Services	10.3	0.0	0.0	0.0	0.0	10.3	13.7
Transportation & Storage	6.1	0.0	0.0	0.0	53.8	59.9	91.4
Information & Communications	2.8	0.0	2.6	0.0	9.4	14.8	31.1
Finance & Insurance	7.2	0.0	0.0	0.0	25.2	32.4	61.6
Business Services	17.5	0.8	16.0	0.0	17.0	51.2	105.2
Other Services	22.0	32.1	0.0	0.0	1.0	55.0	65.3
Imports of Goods & Services	17.8	0.0	22.2	4.6	0.0	44.6	302.4
Taxes on Products	13.6	0.0	3.5	0.0	0.0	17.0	17.9
Gross Value-Added at Basic Prices	0.0	0.0	0.0	0.0	0.0	0.0	304.4
Taxes less Subsidies on Production	0.0	0.0	0.0	0.0	0.0	0.0	4.5
Compensation of Employees	0.0	0.0	0.0	0.0	0.0	0.0	126.1
Gross Operating Surplus	0.0	0.0	0.0	0.0	0.0	0.0	173.9
Total Inputs	114.5	32.8	84.2	5.6	387.5	624.7	1,460.2

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

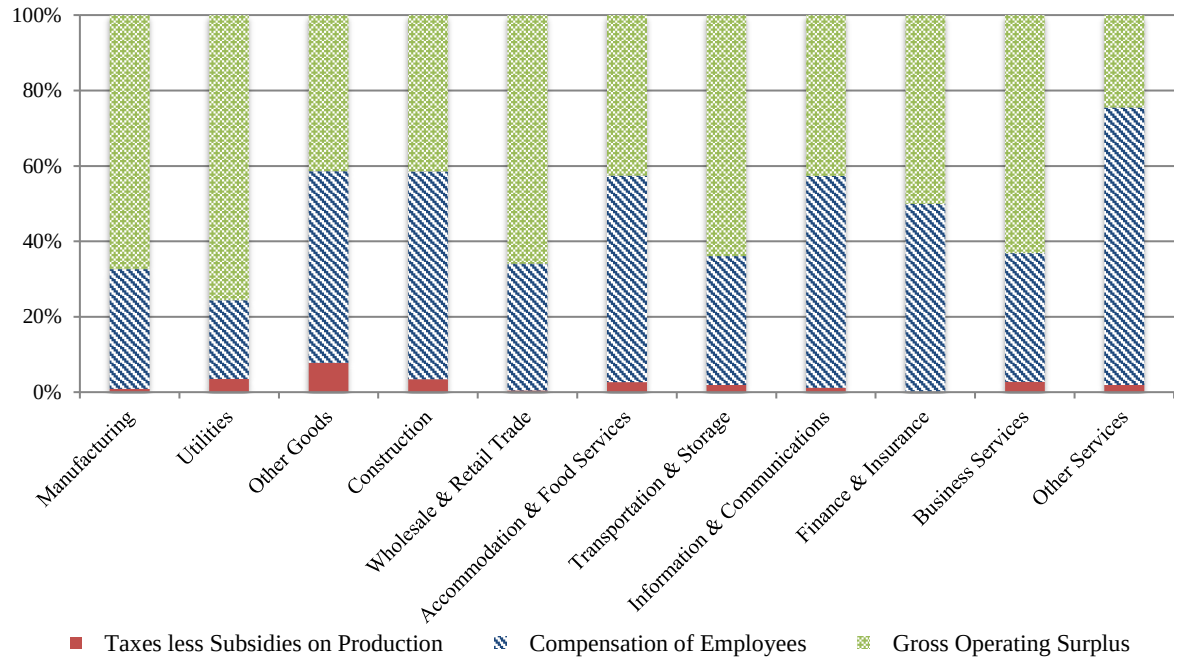
2.24 VA at basic prices in 2010 amounted to $304 billion which was about 36 per cent of total domestic output. Chart 1 below shows the VA at basic prices by industrial sectors. The manufacturing sector had the highest VA of $65 billion in 2010 followed by the wholesale and retail trade sector which generated VA of $58 billion. The other goods sector which includes agriculture had the lowest VA of $0.1 billion in 2010.

Chart 1: Gross Value-Added at Basic Prices, 2010



2.25 Compensation of employees in 2010 was $126 billion which was about 41 per cent of VA. Chart 2 below shows the percentage distribution of VA components by sectors, namely compensation of employees (or wages), gross operating surplus and taxes less subsidies on production by sectors. The other services sector's wage share of 74 per cent of VA was the highest in 2010 while the wage share of the utilities sector was the lowest at 21 per cent.

Chart 2: Percentage Distribution of Gross Value-Added, 2010



Import Use Table

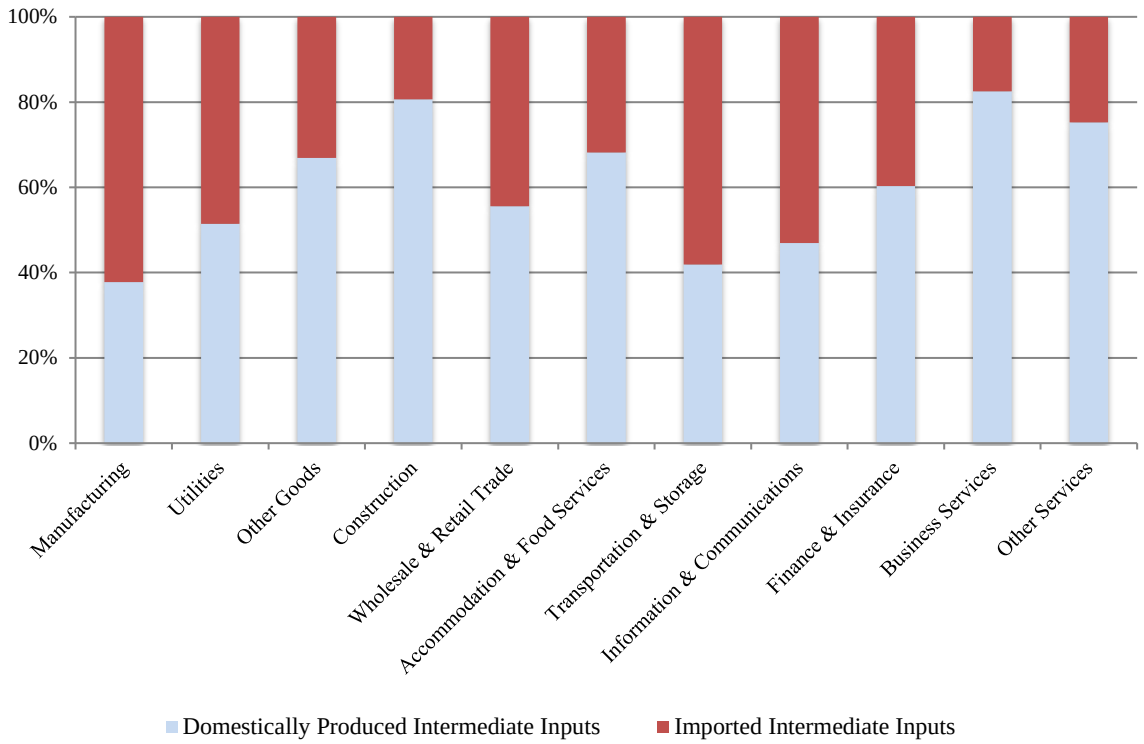
2.26 The import use table is an expansion of the row vector of retained imports in Table 2. Similar to the domestic use table, the import use table records the retained imports by product entering industries as intermediate inputs and the final demand sectors as consumption or capital formation. Exhibit 6 is a schematic representation of the import use table.

Exhibit 6: Schematic Representation of Import Use Table

Sales by Product	Purchases by Industry						Total Intermediate Use	Final Demand					Total Imports
	Industry 1	Industry 2	….	….	….	Industry n		Private Consumption Expenditure	Government Consumption Expenditure	Gross Fixed Capital Formation	Changes in Inventories	Total Final Demand	
Product 1 Product 2 …. …. …. Product n	Intermediate consumption of imported products by product and industry							Final demand for imported products by product and category					
	Total Intermediate Imports							Total Final Imports					

2.27 Total retained imports of goods and services in 2010 was $302 billion (Table 3) of which $258 billion was purchased by industrial sectors as intermediate inputs for their production, with only $45 billion retained for final demand. The bulk of the imported intermediate inputs were manufacturing products which made up 62 per cent of total retained imports. Chart 3 shows the distribution between domestically produced and imported intermediate inputs used by industrial sectors for production.

Chart 3: Percentage Distribution of Intermediate Inputs, 2010



Flows of Goods and Services

2.28 The transactions of goods and services recorded in the SUTs can be illustrated in a flow diagram (see Exhibit 7). In 2010, the total supply, which equals total use of goods and services, amounted to $1,156 billion. Retained imports made up 26 per cent ($302 billion) while domestic output accounted for 72 per cent ($836 billion) of total supply, with the remainder being taxes on products. $531 billion or 46 per cent of the total supply was used as intermediate inputs for the domestic output. The remaining $625 million or 54 per cent of total supply was consumed for final uses. Reflecting the export-oriented nature of the Singapore economy, domestic exports accounted for 62 per cent ($388 billion) of the supply for final demand.

Table 3: Import Use Table, 2010

Billion Dollars

Imports by Product	Purchases by Industry											Total Intermediate Use
	Manufacturing	Utilities	Other Goods	Construction	Wholesale & Retail Trade	Accommodation & Food Services	Transportation & Storage	Information & Communications	Finance & Insurance	Business Services	Other Services	
Manufacturing	116.4	0.9	0.0	6.7	2.6	1.7	12.3	1.2	0.2	1.7	7.7	151.4
Utilities	1.0	4.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3
Other Goods	0.7	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	1.5
Construction	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
Wholesale & Retail Trade	0.4	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Accommodation & Food Services	0.8	0.0	0.0	0.1	0.8	0.1	0.9	0.4	0.8	1.2	0.4	5.5
Transportation & Storage	0.9	0.0	0.0	0.1	11.3	0.0	21.3	0.8	0.2	0.4	0.1	35.1
Information & Communications	0.2	0.0	0.0	0.0	2.9	0.0	0.1	7.9	0.8	0.4	0.1	12.3
Finance & Insurance	0.1	0.0	0.0	0.0	1.2	0.0	0.3	0.0	8.1	0.1	0.0	9.9
Business Services	20.4	0.0	0.0	0.1	4.0	0.0	3.4	1.6	2.1	3.0	0.2	34.9
Other Services	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.1	0.4
Imports of Goods & Services	141.0	5.2	0.0	7.3	23.5	2.5	38.3	12.1	12.2	7.0	8.6	257.7

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

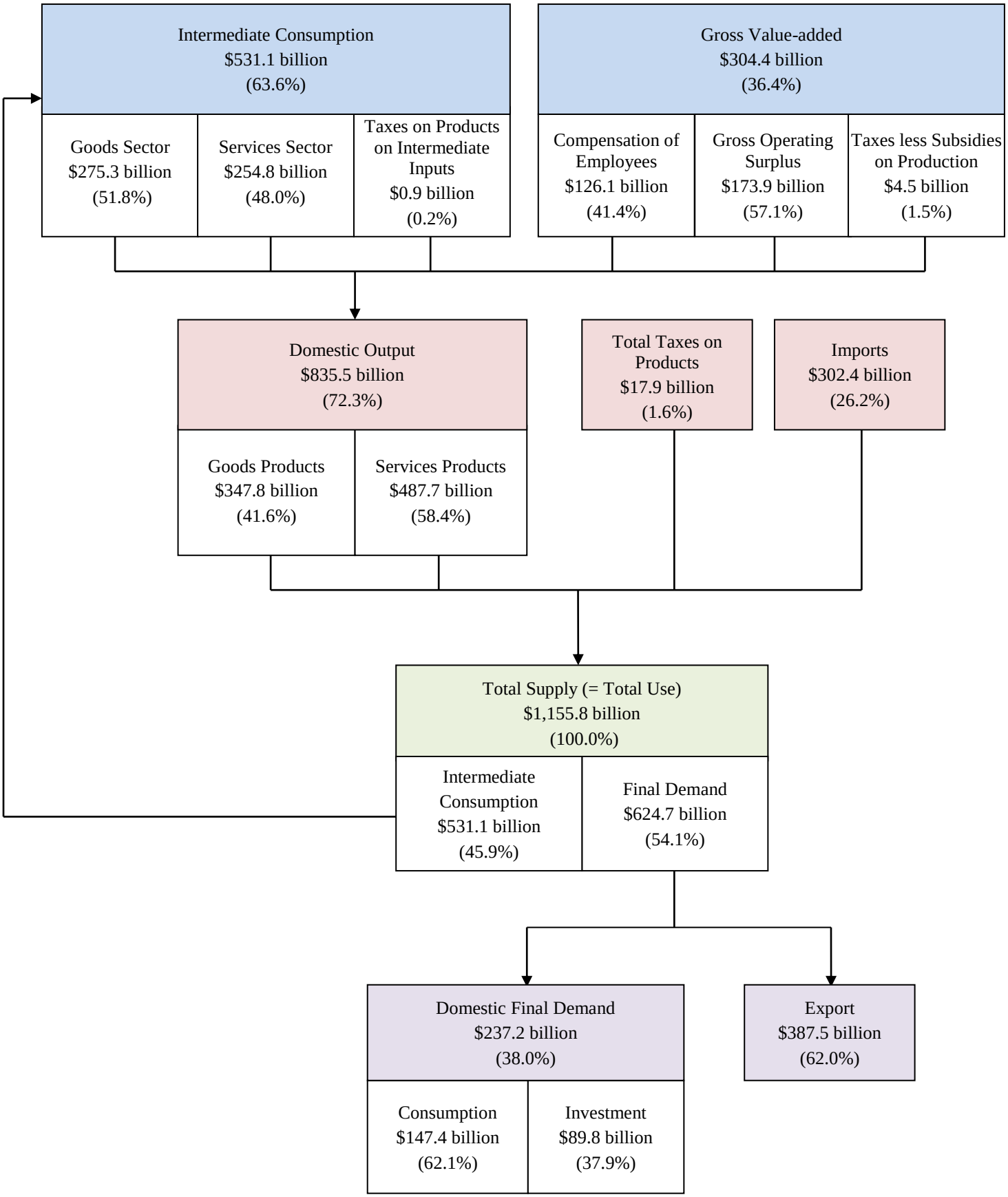
Table 3: Import Use Table, 2010 (cont'd)

Billion Dollars

Imports by Product	Final Demand					Total Imports
	Private Consumption Expenditure	Government Consumption Expenditure	Gross Fixed Capital Formation	Changes in Inventories	Total Final Demand	
Manufacturing	14.6	0.0	17.2	4.6	36.4	187.8
Utilities	0.0	0.0	0.0	0.0	0.0	5.3
Other Goods	1.3	0.0	0.0	0.0	1.4	2.8
Construction	0.0	0.0	0.0	0.0	0.0	0.4
Wholesale & Retail Trade	0.0	0.0	0.0	0.0	0.0	1.2
Accommodation & Food Services	0.0	0.0	0.0	0.0	0.0	5.5
Transportation & Storage	1.2	0.0	0.0	0.0	1.2	36.3
Information & Communications	0.1	0.0	0.3	0.0	0.3	12.6
Finance & Insurance	0.0	0.0	0.0	0.0	0.0	9.9
Business Services	0.0	0.0	4.7	0.0	4.7	39.6
Other Services	0.6	0.0	0.0	0.0	0.6	0.9
Imports of Goods & Services	17.8	0.0	22.2	4.6	44.6	302.4

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

Exhibit 7: Flows of Goods and Services



3. INPUT-OUTPUT TABLES

3.1 This chapter presents and explains how the SUTs are transformed into a symmetric IOT, as well as some of the applications of the symmetric IOT, i.e. multiplier analysis, linkage analysis and net foreign exchange earnings. A brief discussion on the impact of the various final demand components on the Singapore economy is also provided. The mathematical derivations of the IOTs are explained in the Annex. Similar to the SUTs, the IOTs are aggregated into 11 industrial sectors[8].

Derivation

3.2 The SUTs show the flows of products to and from industries and to final demand. In order to use these tables for analytical purposes, it is necessary that they be expressed in a symmetrical form, which shows either the purchases of industrial output by industries and final demand, or the purchases of products for production of products. These symmetric tables are known as industry-by-industry tables or product-by-product tables. The symmetric table used in the applications of the IOT in this publication is the industry-by-industry table.

3.3 To construct industry-by-industry table, product purchases by each industry is adjusted so that industries are shown as purchasing industrial output rather than products. To construct product-by-product tables, product purchases by each industry are adjusted so that products are shown as inputs to products, rather than inputs to industries.

3.4 In both cases, it is necessary to make assumptions for these adjustments. For industry-by-industry tables, assumptions are made on the structure of sales; for product-by-product tables, assumptions are made on the structure of technology. The assumptions, as defined in the 2008 SNA, are summarised in Exhibit 8.

Exhibit 8: Assumptions to Derive Symmetric Input-Output Table

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 from where it is sold	Users always demand the same mix of products from an industry

[8] Some of the figures in this paper 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.

3.5 For Singapore, the fixed product sales structure assumption[9] has been used to derive the industry-by-industry table.

Basic Assumptions

3.6 There are three basic assumptions that underlie the applications of the symmetric IOT and they are summarised in Exhibit 9.

Exhibit 9: Input-Output Tables' Assumptions

Homogeneity	There is no substitution between the inputs and outputs of different sectors.
Fixed proportion	The sector operates under constant returns to scale, which rules out the possibilities of economies and diseconomies of scale.
No supply constraints	The supply of inputs is unlimited and the economy can produce any amount of extra output without facing supply constraints or price adjustments to its inputs.

Multiplier Analysis

3.7 Multiplier analysis is one of the main applications of symmetric IOT. Multipliers provide a relative measure of the interdependence between one industry and the rest of the economy arising solely from the purchases and sales of industry output. A multiplier is a ratio that measures the impact on the total economy as a result of an initial exogenous change in any of the final demand components. The relationship between the initial autonomous change and the total effects on the entire economy generated by the change is known as the multiplier effect.

Exhibit 10: Two Models and Types of Multiplier Effects

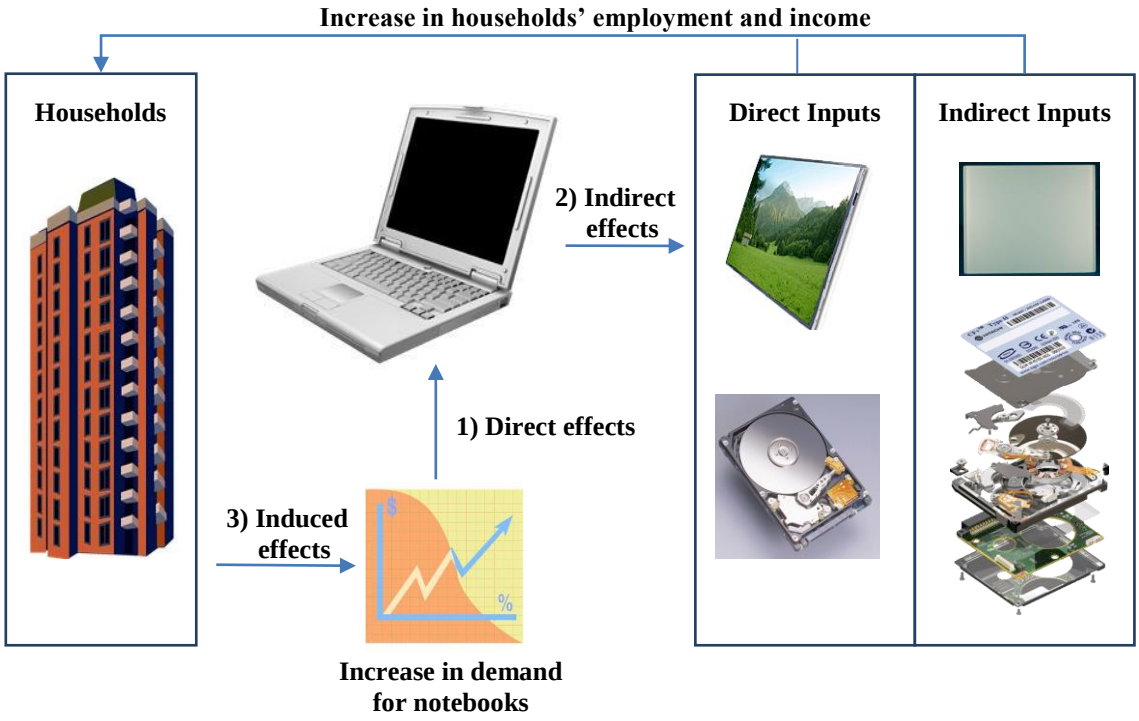
Type of Model	Multipliers Generated are Known as	Direct Effects	Indirect Effects	Consumption Induced Effects
Closed Model	Total	✔	✔	✔
Open Model	Simple	✔	✔	X

3.8 Two models can be distinguished when generating the multipliers: the *open model* which is used to generate simple multipliers, and the *closed model* which is used to generate total multipliers. The open model only measures the direct and indirect effects of a change in final demand while the closed model also takes into account the consumption induced effects in addition to these two effects. Therefore, total multipliers in the closed model are always higher than the simple multipliers in the open model. Exhibit 10 summarises the two models and their multiplier effects.

[9] The fixed product sales structure assumption is known as the industry technology assumption in previous publications.

3.9 The various multiplier effects arising from the sequence of events after an initial exogenous change, such as an increase in the demand of notebook, are illustrated in Exhibit 11.

Exhibit 11: Illustration of the Three Types of Multiplier Effects



1) Direct effects: An increase in the final demand for computer notebooks will lead to an increase in the production of notebooks.

2) Indirect effects: As producers of computer notebooks increase their output, there will also be an increase in demand for their suppliers' output and so on down the supply chain. For example, the manufacturers of computer notebooks will require more inputs such as liquid crystal display (LCD) screens and hard disks which will subsequently lead to manufacturers of LCD screens and hard disks requiring more inputs such as microelectronic chips to meet the increase in demand for computer notebooks.

3) Consumption induced effects: Household income will rise as a result of increased employment. The household sector will spend part of the increase in income on computer notebooks. This increase in the domestic consumption of notebooks will generate a new series of production events.

3.10 Different multipliers are generated for different analyses. The most commonly used multipliers are output, value-added, income, import and employment multipliers. For comparative purposes, multipliers are usually expressed with respect to a unit of exogenous change in final demand (Exhibit 12).

Exhibit 12: Explanation of Multipliers

Multiplier of Industry A	Per Million Dollar Change in Final Demand	Interpretation
		A $1m increase in the final demand of Industry A will generate in the whole economy, an additional:
Output	$1.28m	$1.28m of output
Value-Added	$0.36m	$0.36m of value-added
Income	$0.15m	$0.15m of income
Import	$0.64m	$0.64m of imports
Employment	5 persons	5 employment

A. Simple Multipliers (Open Model)

3.11 Table 4 shows the simple multipliers of the 11 industrial sectors generated from the 2010 IOTs[10]. The output multiplier for the construction sector is 2.080, the highest of all sectors. In other words, an increase in final demand for the construction sector's output will stimulate a relatively high level of domestic production in the whole economy. A decomposition of the output multiplier for the construction sector shows that the VA and import multipliers are 0.610 and 0.390 respectively, with the remaining 1.080 accruing to intermediates. This means that a $1 increase in the final demand of the construction sector will eventually generate an additional $0.61 of VA for the whole economy. A further breakdown of the VA multiplier shows that $0.30 will eventually be returned to workers as remuneration.

Table 4: Simple Multipliers by Industrial Sector Per Million Dollar Change in Final Demand, 2010

Industrial Sector	Output	Value-Added	Income	Import	Employ-ment[11]
	Million Dollars				Number
Manufacturing	1.423	0.358	0.118	0.641	2.876
Utilities	1.535	0.510	0.128	0.488	2.366
Other Goods	1.535	0.665	0.314	0.330	20.328
Construction	2.080	0.610	0.303	0.390	12.945
Wholesale & Retail Trade	1.390	0.683	0.239	0.316	5.183
Accommodation & Food Services	1.582	0.660	0.319	0.338	15.694
Transportation & Storage	1.441	0.434	0.155	0.564	3.624
Information & Communications	1.468	0.509	0.261	0.490	4.247
Finance & Insurance	1.420	0.717	0.349	0.280	3.817
Business Services	1.530	0.809	0.291	0.189	6.435
Other Services	1.580	0.734	0.477	0.261	12.009

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

[10] These are generated from Tables 6 and 8 (see pages 239 and 284).
[11] Administrative employment data compiled by the Ministry of Manpower are used to derive the employment multipliers in this publication.

3.12 While the output multiplier measures the amount of output generated in the whole economy, the VA multiplier provides a measurement of the corresponding VA created in the process. Services output is more dependent than goods output on domestic industries for its input requirements. As a result, more VA is generated in the economy by the consumption of services output than that of manufactured goods.

3.13 A $1 increase in the final demand of the business services sector will help to generate an additional $0.81 of VA in the whole economy, the highest among all sectors. In contrast, a $1 increase in final demand on the manufacturing sector will result only in an additional $0.36 of VA in the whole economy.

3.14 On the other hand, the business services sector has the lowest import multiplier of 0.189 while the manufacturing sector has the highest import multiplier of 0.641. This means that for every $1 of output produced, the business services sector will need $0.18 imports and the manufacturing sector will require $0.64 of imports. Comparing each sector's VA and import multipliers shows the inverse relationship between the VA and import multipliers.

3.15 The income and employment multipliers for the utilities and manufacturing sectors are lower than those for most other sectors, indicating that both sectors are relatively less labour intensive. Therefore, their contribution of remuneration to VA will also be relatively lower. The income and employment multipliers for the accommodation and food services, and other services sectors are among the highest, reflecting the highly labour intensive nature of these sectors.

3.16 As mentioned in the earlier section, the open model measures both the direct and indirect effects of a change in final demand. Table 5 illustrates these effects through the VA and import multipliers[12].

Table 5: Direct and Indirect Effects of Value-Added & Import Multipliers by Industrial Sector Per Million Dollar Change in Final Demand, 2010

Industrial Sector	Value-Added			Import		
	Multiplier	Direct	Indirect	Multiplier	Direct	Indirect
	Million Dollars					
Manufacturing	0.358	0.223	0.135	0.641	0.483	0.158
Utilities	0.510	0.315	0.195	0.488	0.332	0.155
Other Goods	0.665	0.462	0.204	0.330	0.177	0.153
Construction	0.610	0.273	0.337	0.390	0.141	0.249
Wholesale & Retail Trade	0.683	0.523	0.160	0.316	0.212	0.104
Accommodation & Food Services	0.660	0.426	0.233	0.338	0.182	0.156
Transportation & Storage	0.434	0.279	0.156	0.564	0.418	0.145
Information & Communications	0.509	0.325	0.184	0.490	0.358	0.132
Finance & Insurance	0.717	0.518	0.200	0.280	0.191	0.089
Business Services	0.809	0.574	0.235	0.189	0.074	0.114
Other Services	0.734	0.484	0.250	0.261	0.127	0.134

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

3.17 The VA multiplier of the finance and insurance sector is 0.717. Of the $0.72 of VA generated in the total economy from a $1 increase in final demand for finance and insurance services, the direct VA contribution to the finance and insurance sector is $0.52. The

[12] These are generated from Table 8 (see page 284).

remaining $0.20 is the indirect VA contribution generated in subsequent rounds by the industries (including the finance and insurance sector itself) supplying goods and services to the sector.

B. Total Multipliers (Closed Model)

Table 6: Total Multipliers by Industrial Sector Per Million Dollar Change in Final Demand, 2010

Industrial Sector	Output	Value-Added	Income	Import	Employ-ment
	Million Dollars				Number
Manufacturing	1.572	0.425	0.149	0.673	3.673
Utilities	1.696	0.582	0.161	0.522	3.227
Other Goods	1.930	0.842	0.397	0.414	22.445
Construction	2.462	0.781	0.383	0.471	14.988
Wholesale & Retail Trade	1.692	0.818	0.303	0.380	6.797
Accommodation & Food Services	1.985	0.840	0.404	0.424	17.850
Transportation & Storage	1.637	0.522	0.196	0.605	4.670
Information & Communications	1.797	0.656	0.330	0.560	6.009
Finance & Insurance	1.861	0.914	0.442	0.373	6.175
Business Services	1.897	0.973	0.368	0.267	8.399
Other Services	2.181	1.004	0.603	0.389	15.225

3.18 Table 6 presents the total multipliers of the 11 industrial sectors[13]. The rankings of total multipliers are different from that of simple multipliers generated from the open model. For the simple VA multipliers, the top three sectors with the highest simple VA multipliers in descending order are business services, other services, and finance and insurance services, while the top three sectors with the highest total VA multipliers in order are other services, business services, and finance and insurance. Despite this, the rankings of simple and total multipliers are correlated because the direct and indirect effects reflected by the simple multipliers are also embedded within the total multipliers.

Table 7: Consumption-Induced Effects by Industrial Sector Per Million Dollar Change in Final Demand, 2010

Industrial Sector	Output	Value-Added	Income	Import	Employ-ment
	Million Dollars				Number
Manufacturing	0.149	0.067	0.031	0.032	0.797
Utilities	0.161	0.072	0.034	0.034	0.861
Other Goods	0.396	0.177	0.083	0.084	2.117
Construction	0.382	0.171	0.080	0.081	2.043
Wholesale & Retail Trade	0.302	0.135	0.064	0.064	1.615
Accommodation & Food Services	0.403	0.180	0.085	0.086	2.155
Transportation & Storage	0.196	0.088	0.041	0.042	1.046
Information & Communications	0.329	0.147	0.069	0.070	1.761
Finance & Insurance	0.441	0.197	0.093	0.094	2.357
Business Services	0.367	0.164	0.077	0.078	1.964
Other Services	0.601	0.269	0.127	0.128	3.216

[13] These are generated from Tables 6 and 8 (see pages 239 and 284).

3.19 The difference between the multipliers generated by the closed and open models is attributed to the consumption-induced effect. Table 7 shows the consumption-induced effect of the different industrial sectors[14]. It is observed that the more labour intensive sectors, such as the accommodation and food services sector, exhibit higher consumption induced effects as wage shares are generally higher in these sectors. An increase in income resulting from an increase in output will in turn lead to further spending by the wage earners, and consequently additional consumption-induced effects in the production process.

Linkage Analysis

3.20 Another application of the IOT is linkage analysis, which is typically carried out by examining the backward and forward linkages. These linkages are generally expressed in normalised form, providing a relative measure of the interdependency of supply and demand within the economy.

3.21 Backward linkages are demand-oriented and trace the changes in output that occur further back along the supply chain when there is a change in demand of a particular industry's output. For example, an increase in demand for the output of the manufacturing sector requires the manufacturing sector to source for more inputs. This in turn increases the output of the sectors from which the manufacturing sector purchases its inputs. This is the direction of causation from the demand side perspective and is known as backward linkage.

3.22 Forward linkages are supply-oriented and trace the changes in output that occur further forward along the supply chain when there is a change in demand of a particular industry's output. For example, an increase in the supply of the manufacturing sector's output implies additional amounts of manufacturing output are available to be used by other sectors for their production. This is the direction of causation from the supply-side perspective and is known as forward linkage.

3.23 The interpretation of linkages is shown in Exhibit 13. This is useful for identifying key sectors of the economy and for grouping sectors into spatial clusters[15]. However, high backward and forward linkages in any sector are not sufficient conditions for all producing and purchasing sectors in an economy to benefit when that sector expands.

Exhibit 13: Interpretation of Linkages

Type of Linkages	Interpretation	
Backward	Industry's dependency on domestic industries supply	< 1 Below average dependency
Forward	Domestic industries' dependency on the industry	> 1 Above average dependency

[14] These are generated from Tables 7 and 11 (see pages 281 and 332).

[15] It is important to note that linkages are affected by how the industries are grouped. If the industries are grouped in a way that they are self-sufficient, then the linkage with other industrial sectors will be small. This is because the source of inputs and the use of output occur within the industries of that industrial sector.

3.24 A coefficient of variation is computed to measure whether a linkage tends towards only a few sectors. A low coefficient of variation in a particular sector means that expansion of that particular sector will stimulate other sectors in an even manner. Conversely, a high coefficient of variation means that the benefits of an expansion of a particular sector are unevenly shared among all sectors. Table 8 shows the linkages and coefficients of variation for the 11 industrial sectors[16].

Table 8: Backward and Forward Linkages, 2010

Industrial Sector	Backward		Forward	
	Linkage	Coefficient of Variation	Linkage	Coefficient of Variation
Manufacturing	0.922	2.856	0.856	2.926
Utilities	0.994	2.712	1.400	1.818
Other Goods	0.994	2.079	1.126	1.822
Construction	1.347	2.466	1.062	3.009
Wholesale & Retail Trade	0.900	2.371	0.763	2.693
Accommodation & Food Services	1.025	2.039	0.854	2.339
Transportation & Storage	0.933	2.670	0.915	2.587
Information & Communications	0.951	2.521	1.102	2.013
Finance & Insurance	0.920	2.828	1.080	2.242
Business Services	0.991	2.520	1.093	2.131
Other Services	1.023	2.278	0.747	3.040

3.25 The utilities sector has the highest forward linkage with the lowest coefficient of variation, indicating that the services provided by the sector are essential to all other sectors in the economy. On the other hand, the other services sector has the lowest forward linkage with the highest coefficient of variation, indicating that it supplies a smaller proportion of its output as intermediate inputs to the domestic economy.

3.26 The construction sector has the highest backward linkage and also the highest output multiplier as backward linkage is directly proportional to output multiplier. A high backward linkage suggests that a sector is highly dependent upon other sectors for its input requirements. Conversely, the manufacturing sector has low backward linkage, indicative of its relatively high dependence on imported inputs.

Net Foreign Exchange Earnings

3.27 The IOT is used to generate net foreign exchange earnings by industrial sector. Net foreign exchange earnings are defined as total foreign exchange earnings from domestic exports minus the import requirements to produce these exports. The ratio of net foreign exchange earnings to total domestic exports gives an indication of the VA generated from domestic exports. Table 9 shows the net foreign exchange earnings of the 11 industrial sectors[17].

[16] These are generated from Table 13 (see page 336).
[17] These are generated from Table 14 (see page 339).

Table 9: Net Foreign Exchange Earnings from Exports, 2010

Industrial Sector	Exports	Import Requirements for Exports	Net Foreign Exchange Earnings		
	Billion Dollars		Billion Dollars	Percentage Distribution	As a Percentage of Exports
Manufacturing	199.045	127.586	71.459	38.0	35.9
Utilities	1.226	0.598	0.628	0.3	51.2
Other Goods	0.082	0.027	0.055	0.0	67.0
Construction	1.195	0.466	0.730	0.4	61.0
Wholesale & Retail Trade	79.098	24.986	54.112	28.8	68.4
Accommodation & Food Services	0.058	0.020	0.039	0.0	66.2
Transportation & Storage	53.736	30.282	23.454	12.5	43.6
Information & Communications	10.780	5.286	5.494	2.9	51.0
Finance & Insurance	25.571	7.155	18.415	9.8	72.0
Business Services	15.349	2.894	12.454	6.6	81.1
Other Services	1.386	0.362	1.024	0.5	73.9
TOTAL	387.525	199.662	187.863	100.0	48.5

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

3.28 Of the 11 sectors, the manufacturing sector contributes the most net foreign exchange earnings of $71 billion. However, its net foreign exchange earnings as a percentage of total domestic exports is lower than those of all other sectors, implying that the manufacturing sector has a relatively higher import requirement. Generally, sectors with relatively lower import requirements will have higher VA per unit of exports.

Impact of Final Demand

A. <u>On Output</u>

3.29 Different components of final demand have different impact on output. Output generated in the various industries as a result of a dollar change in each final demand component is presented in Table 10.

3.30 GCE has the greatest impact on the output of the economy followed by exports – every $1 increase in GCE and exports will generate $1.58 and $1.43 worth of additional output respectively. Every $1 increase in PCE will lead to $1.10 of additional output being generated, of which $0.10 are from the manufacturing sector, $0.04 from the utilities sector, and the rest of the $0.96 from the construction, wholesale and retail trade, and services sectors.

Table 10: Industrial Composition Per Dollar Change in Final Expenditure in terms of Gross Output, 2010

Dollars

Industrial Sector	Private Consumption Expenditure	Government Consumption Expenditure	Gross Capital Formation	Exports
Manufacturing	0.10	0.09	0.23	0.66
Utilities	0.04	0.03	0.01	0.02
Other Goods	0.00	0.00	0.00	0.00
Construction	0.02	0.01	0.51	0.01
Wholesale & Retail Trade	0.10	0.03	0.07	0.24
Accommodation & Food Services	0.09	0.01	0.01	0.01
Transportation & Storage	0.08	0.02	0.03	0.20
Information & Communications	0.06	0.05	0.04	0.05
Finance & Insurance	0.13	0.10	0.04	0.11
Business Services	0.24	0.13	0.22	0.11
Other Services	0.22	1.10	0.02	0.01
TOTAL	1.10	1.58	1.17	1.43

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

B. On Value-Added

3.31 Table 11 shows the VA generated in each industry by categories of final demand. VA generated by PCE is $56 billion, of which $2.6 billion is in the manufacturing sector, $1.6 billion in the utilities sector, $0.5 billion in the construction sector, $6.0 billion in the wholesale and retail trade sector, and $46 billion in the services sectors.

Table 11: Industrial Composition of Final Expenditure in terms of Value-Added at Basic Prices, 2010

Billion Dollars

Industrial Sector	Private Consumption Expenditure	Government Consumption Expenditure	Gross Capital Formation	Exports
Manufacturing	2.576	0.654	4.524	57.285
Utilities	1.591	0.359	0.298	2.651
Other Goods	0.029	0.002	0.007	0.080
Construction	0.484	0.115	12.411	1.211
Wholesale & Retail Trade	6.039	0.434	3.273	48.333
Accommodation & Food Services	4.590	0.104	0.232	0.995
Transportation & Storage	2.707	0.185	0.751	21.902
Information & Communications	2.355	0.569	1.306	6.760
Finance & Insurance	7.704	1.777	1.715	21.918
Business Services	15.990	2.538	11.121	24.163
Other Services	12.191	17.424	0.986	2.089
TOTAL	56.255	24.162	36.624	187.387

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

4. CONCLUSION

4.1 Similar to earlier sets of benchmark SUTs, the 2010 SUTs were used to derive and reconcile the three GDP estimates in the rebasing of Singapore's national accounts to reference year 2010. Conceptual changes and methodological improvements implemented in the 2010 SUTs include the capitalisation of R&D expenditure, improved estimation of self-employed workers, and revised classification of non-profit institutions and government consumption expenditure.

4.2 In 2010, the Singapore economy produced $836 billion worth of goods and services and consumed $272 billion worth of domestically produced intermediate inputs. Imports of goods and services totalled $302 billion, of which $258 billion were purchased by industrial sectors as inputs for production, with only $45 billion retained for final demand. Exports of goods and services accounted for $388 billion or 46 per cent of total domestic output in 2010, reflecting Singapore's high dependence on external demand. VA at basic prices amounted to $304 billion with the manufacturing sector contributing $65 billion or 21 per cent of total VA.

4.3 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 sectors of the economy and analyse structural changes.

4.4 Multiplier analysis shows that the construction sector has the highest simple output multiplier while the business services sector has the highest simple VA multiplier. Although the manufacturing sector has the highest output and VA in nominal terms, its VA multiplier is relatively lower due to its high import content. The accommodation and food services sector has one of the highest simple employment multipliers.

4.5 Similarly, while the manufacturing sector contributes to about one-third of the net foreign exchange earnings in Singapore, its VA per unit of export is relatively lower as compared to that of the services sector due to its higher import requirements for exports.

4.6 The utilities sector has the highest forward linkage with the lowest coefficients of variation as it provides essential services to all other sectors in the economy. The other services sector has the lowest forward linkage with the highest coefficient of variation, indicating that it supplies a smaller proportion of its output as intermediate inputs to the domestic economy.

APPENDICES

APPENDIX 1: CORRESPONDENCE BETWEEN THE 127 INPUT-OUTPUT CODES AND INDUSTRY / PRODUCT CLASSIFICATIONS

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
001	Agriculture (except nursery products)	0111x, 0112x, 0113x, 01149(part), 0119x, 01500(part), 0160x, 0200x	0601, 0602(part), 0604, 0701, 0702, 0703, 0704, 0705, 0706, 0707, 0708, 0709, 0713(part), 0714(part), 0801(part), 0802(part), 0803, 0804, 0805(part), 0806(part), 0807, 0808, 0809, 0810, 1001, 1002, 1003, 1004, 1005, 1006(part), 1007, 1008, 1201, 1202, 1203, 1204, 1205, 1206, 1207, 1209, 1210, 1211, 1212(part), 1301(part), 1401(part), 1404, 1801, 2401(part), 5201, 5301(part), 5302(part), 5303(part), 5305	01(part), 03(part), 34(part), 81(part), 86(part)
002	Nursery products	01141, 01142, 01149(part)	0602(part), 0603	01(part)
003	Livestock	0141x, 0142x, 0149x, 01500(part)	0101, 0102, 0103, 0104, 0105, 0106, 0307(part), 0407, 0408, 0409, 0410, 0511(part), 1521(part), 4101, 4102, 4103, 4301(part), 5001, 5101(part), 5102	02(part), 04(part), 34(part), 86(part)
004	Fisheries (except aquarium fish)	0310x, 03201, 03202, 03204, 03205, 03209, 0330x	0301(part), 0302, 0303, 0306(part), 0307(part), 0508, 1212(part)	04(part), 38(part), 86(part)
005	Aquarium fish	3203	0301(part)	04(part)
006	Food preparations	1010x, 1020x, 1030x	0201, 0202, 0203, 0204, 0205, 0206, 0207, 0208, 0209, 0210, 0304, 0305, 0306(part), 0307(part), 0504, 0710, 0711, 0712, 0713(part), 0714(part), 0801(part), 0802(part), 0805(part), 0806(part), 0811, 0812, 0813, 0814, 1601, 1602(part), 1603, 1604, 1605, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009	02(part), 21(part), 88(part)
007	Oils and fats	1040x	1501, 1502, 1503, 1504, 1505, 1506, 1507, 1508, 1509, 1510, 1511, 1512, 1513, 1514, 1515, 1516, 1517, 1518(part), 1521(part), 1522, 2304, 2305, 2306	02(part), 21(part), 88(part)
008	Dairy products	1050x	0401, 0402, 0403, 0404(part), 0405, 0406, 1901(part), 2105, 2202(part), 3501(part)	22(part), 23(part), 88(part)
009	Sugar, chocolate and related products	10622, 1072x, 1073x	1701, 1702, 1703, 1704, 1803, 1804, 1805, 1806	23(part), 88(part)
010	Bakery products	1071x	1905(part)	23(part), 88(part)
011	Coffee and tea	10761, 10762, 10763, 10764	0901, 0902, 0903, 2101, 2106(part)	21(part), 22(part), 23(part), 88(part)

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
012	Other food products	1061x, 10621, 10629, 1074x, 1075x, 10765, 1079x, 1080x	0404(part), 0511(part), 0904, 0905, 0906, 0907, 0908, 0909, 0910, 1006(part), 1101, 1102, 1103, 1104, 1105, 1106, 1107, 1108, 1109, 1208, 1213, 1214, 1302, 1602(part), 1802, 1901(part), 1902, 1903, 1904, 1905(part), 2102, 2103, 2104, 2106(part), 2201(part), 2209, 2301, 2302(part), 2309, 2501(part), 3502(part)	17(part), 21(part), 23(part), 69(part), 86(part), 88(part)
013	Beverages (except alcoholic drinks)	1104x	2106(part), 2201(part), 2202(part)	24(part), 88(part)
014	Alcoholic drinks and tobacco products	1101x, 1102x, 1103x, 1200x	2106(part), 2203, 2204, 2205, 2206, 2207(part), 2208, 2401(part), 2402, 2403	24(part), 25, 88(part)
015	Textiles	1310x, 1391x, 1392x, 1393x, 1394x, 1399x	5002, 5004, 5005, 5006, 5007, 5101(part), 5103(part), 5105, 5106, 5107, 5108, 5109, 5110, 5111, 5112, 5113, 5203, 5204, 5205, 5206, 5207, 5208, 5209, 5210, 5211, 5212, 5301(part), 5302(part), 5303(part), 5306, 5307, 5308, 5309, 5310, 5311, 5401, 5402(part), 5406, 5407, 5408, 5503(part), 5504(part), 5506, 5507, 5508, 5509, 5510, 5511, 5512, 5513, 5514, 5515, 5516, 5601, 5602, 5603, 5604, 5605, 5606, 5607, 5608, 5609, 5701, 5702, 5703, 5704, 5705, 5801, 5802, 5803, 5804, 5805, 5806, 5807, 5808, 5809, 5810, 5811, 5901, 5902, 5903, 5904(part), 5907, 5908, 5909, 5910, 5911, 6001, 6002, 6003, 6004, 6005, 6006, 6301(part), 6302, 6303, 6304, 6305, 6306, 6307, 6308, 6310, 7019(part), 9404(part)	26(part), 27(part), 28, 88(part)
016	Wearing apparel and fur products	1410x, 1420x, 1430x	3926(part), 4301(part), 4302, 4303, 4304, 6101, 6102, 6103, 6104, 6105, 6106, 6107, 6108, 6109, 6110, 6111, 6112, 6113, 6114, 6115, 6116, 6117, 6201, 6202, 6203, 6204, 6205, 6206, 6207, 6208, 6209, 6210, 6211, 6212, 6213, 6214, 6215, 6216, 6217, 6501, 6502, 6504, 6505, 6506(part), 6507	28(part), 88(part)
017	Footwear and leather products	1511x, 1512x, 1520x	4104, 4105, 4106, 4107, 4112, 4113, 4114, 4115, 4201, 4202, 4203, 4205, 6401, 6402, 6403, 6404, 6405, 6406, 9113(part), 9605	28(part), 29(part), 38(part), 88(part)
018	Wood and wooden products (except furniture)	1610x, 1621x, 1622x, 1623x, 1629x	1401(part), 4401(part), 4402(part), 4403, 4404, 4405, 4406, 4407, 4408, 4409, 4410, 4411, 4412, 4413, 4414, 4415, 4416, 4417, 4418, 4419, 4420, 4421, 4501, 4502, 4503, 4504, 4601, 4602, 9406(part)	29(part), 31, 38(part), 88(part)

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
019	Paper and paper products	1701x, 1702x, 1709x	3822(part), 4701, 4702, 4703, 4704, 4705, 4706, 4801, 4802, 4803, 4804, 4805, 4806, 4807, 4808, 4809, 4810, 4811, 4812, 4813, 4814, 4816, 4817, 4818, 4819, 4822, 4823, 5905, 6812(part)	27(part), 32(part), 88(part)
020	Printing and reproduction of recorded media	1811x, 1812x, 1820x	4820, 4821, 4901, 4902, 4903, 4904, 4905, 4906, 4907, 4908, 4909, 4910, 4911, 8523(part)	32(part), 89(part)
021	Petroleum products	09001, 1910x, 1920x	2701(part), 2704, 2706, 2707(part), 2709, 2710(part), 2711(part), 2712, 2713, 2714(part), 9893(part)	11(part), 12, 33(part), 86(part), 88(part)
022	Industrial chemicals and gases	2011x	1518(part), 1520, 2207(part), 2503, 2601(part), 2707(part), 2708, 2801, 2802, 2803, 2804, 2805, 2806, 2807, 2808, 2809, 2810, 2811, 2812, 2813, 2814, 2815, 2816, 2817, 2818, 2819, 2820, 2821, 2822, 2823, 2824, 2825, 2826, 2827, 2828, 2829, 2830, 2831, 2832, 2833, 2834, 2835, 2836, 2837, 2839, 2840, 2841, 2842, 2843, 2844, 2845, 2846, 2847, 2848, 2849, 2850, 2852, 2853, 2901(part), 2903(part), 2905(part), 2906, 2907(part), 2908, 2910(part), 2911, 2912(part), 2914(part), 2915(part), 2916(part), 2917(part), 2918(part), 2919, 2920, 2921(part), 2922(part), 2923(part), 2924(part), 2925(part), 2926(part), 2927, 2928, 2929, 2930(part), 2931, 2932(part), 2933(part), 2934(part), 2940, 3402(part), 3507(part), 3823	24(part), 33(part), 34(part), 35(part), 88(part)
023	Petrochemicals and petrochemical products	2013x	2707(part), 2901(part), 2902, 2903(part), 2904, 2905(part), 2907(part), 2909, 2910(part), 2912(part), 2913, 2914(part), 2915(part), 2916(part), 2917(part), 2921(part), 2926(part), 2933(part), 3901, 3902, 3903, 3904, 3905, 3906, 3907(part), 3908, 3909(part), 3910, 3911, 3912, 3913, 3914	34(part), 88(part)
024	Paints and related products	2022x	3202(part), 3207, 3208, 3209, 3210, 3211, 3212(part), 3213, 3214, 3805, 3814, 3907(part)	35(part), 88(part)
025	Perfumes, cosmetics and related preparations	2023x	3301, 3302(part), 3303, 3304, 3305, 3306, 3307(part), 3401, 3402(part), 3404, 3405, 3808(part)	34(part), 35(part), 88(part)
026	Additives	2024x	2922(part), 2924(part), 2925(part), 3203(part), 3212(part), 3302(part), 3507(part), 3811(part), 3824(part)	34(part), 35(part), 38(part), 48(part), 88(part)

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
027	Other chemical products	2012x, 2021x, 2029x, 2030x	2520(part), 3101, 3102, 3103, 3104, 3105, 3201, 3202(part), 3203(part), 3204, 3205, 3206, 3212(part), 3215, 3307(part), 3403, 3407, 3501(part), 3502(part), 3503, 3504, 3505, 3506, 3601, 3602, 3603, 3604, 3605, 3701(part), 3702(part), 3703(part), 3704(part), 3707(part), 3801, 3802, 3803, 3804, 3806, 3807, 3808(part), 3809, 3810, 3811(part), 3812, 3813, 3815, 3817, 3818, 3819, 3820, 3821(part), 3822(part), 3824(part), 3907(part), 3909(part), 4402(part), 5402(part), 5403, 5404, 5405, 5501, 5502, 5503(part), 5504(part), 6809(part), 7104(part), 9602(part)	34(part), 35(part), 88(part)
028	Pharmaceuticals and biological products	2101x, 2102x	2903(part), 2905(part), 2915(part), 2916(part), 2918(part), 2921(part), 2922(part), 2923(part), 2924(part), 2925(part), 2926(part), 2930(part), 2932(part), 2933(part), 2934(part), 2935, 2936, 2937, 2938, 2939, 2941, 2942, 3001, 3002, 3003, 3004, 3005, 3006(part), 3821(part)	35(part), 88(part)
029	Rubber products	2211x, 2212x, 2219x	1301(part), 4001, 4002, 4003, 4005, 4006, 4007, 4008, 4009, 4010, 4011, 4012, 4013, 4014, 4015, 4016, 4017, 5906	29(part), 36(part), 88(part)
030	Plastic products	2221x, 2222x	3916, 3917, 3918, 3919, 3920, 3921, 3922, 3923, 3924, 3925, 3926(part), 6506(part), 8547(part)	28(part), 29(part), 36(part), 38(part), 88(part), 89(part)
031	Glass and glass products	2310x	7001, 7002, 7003, 7004, 7005, 7006, 7007, 7008, 7009, 7010, 7011, 7013, 7014, 7015, 7016, 7017, 7018, 7020, 8546(part)	37(part), 88(part)
032	Clay, cement, concrete and stone products	0810x, 0890x, 09002, 2391x, 2394x, 2395x, 2396x	2505, 2514, 2515, 2516, 2517, 2520(part), 2521, 2522, 2523, 2714(part), 3816, 3824(part), 6801, 6802, 6804, 6810, 6811(part), 6812(part), 6815, 6901, 6902, 6904, 6905, 6906, 6907, 6908	11(part), 13(part), 14, 15(part), 16(part), 34(part), 37(part), 38(part), 86(part), 88(part)
033	Non-metallic mineral products	2393x, 2399x	2501(part), 2504, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2518, 2519, 2524, 2525(part), 2526, 2528, 2529, 2530, 2701(part), 2702, 2703, 2715, 6803, 6805, 6806, 6807, 6808, 6809(part), 6811(part), 6812(part), 6813, 6814, 6903, 6909, 6910, 6911, 6912, 6913, 6914, 7019(part), 7102(part), 7103(part), 8546(part), 8547(part)	34(part), 37(part), 46(part), 88(part)

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
034	Basic metals	2410x, 2420x, 2431x, 2432x	2502, 2601(part), 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 7106, 7107, 7108, 7109, 7110, 7111, 7201, 7202, 7203, 7205, 7206, 7207, 7208, 7209, 7210, 7211, 7212, 7213, 7214, 7215, 7216, 7218, 7219, 7220, 7221, 7222, 7224, 7225, 7226, 7227, 7228, 7301, 7302, 7304(part), 7325(part), 7401, 7402, 7403, 7405, 7406, 7407, 7409, 7410, 7501, 7502, 7504, 7505(part), 7506, 7601, 7603, 7604(part), 7606, 7607, 7801, 7804, 7806(part), 7901, 7903, 7904, 7905, 8001, 8003, 8007(part), 8101(part), 8102(part), 8103(part), 8104(part), 8105(part), 8106(part), 8107(part), 8108(part), 8109(part), 8110(part), 8111, 8112(part), 8113, 8311(part)	41(part), 88(part), 89(part)
035	Structural metal products	2511x, 25994	7303, 7304(part), 7305, 7306, 7308, 7411, 7507(part), 7604(part), 7608, 7610, 7806(part), 7907(part), 8007(part), 9406(part)	38(part), 42(part), 88(part)
036	Metalworking (except treatment and coating of metals)	2591x		89(part)
037	Treatment and coating of metals	2592x		88(part)
038	Non-insulated cable products	2594x	7217, 7223, 7229, 7312, 7313, 7408, 7413, 7505(part), 7605, 7614, 8101(part), 8102(part), 8311(part)	42(part), 46(part), 49(part), 88(part)
039	Metal precision components	25993, 25995, 25997	7318, 7320	42(part)
040	Other metal products	2512x, 2513x, 2520x, 2593x, 2595x, 25991, 25992, 25996, 25998, 25999	6506(part), 7307, 7309, 7310, 7311, 7314, 7315, 7316, 7317, 7319, 7322, 7323, 7324, 7325(part), 7326, 7412, 7415, 7418, 7419, 7507(part), 7508, 7609, 7611, 7612, 7613, 7615, 7616, 7806(part), 7907(part), 8007(part), 8101(part), 8102(part), 8103(part), 8104(part), 8105(part), 8106(part), 8107(part), 8108(part), 8109(part), 8110(part), 8112(part), 8201, 8202, 8203, 8204, 8205, 8206, 8207, 8208, 8209, 8210, 8211, 8212, 8213, 8214, 8215, 8301, 8302, 8303, 8304, 8305, 8306, 8307, 8308, 8309, 8401(part), 8402, 8404, 8414(part), 8481(part), 8482, 8483(part), 8484, 9301, 9302, 9303, 9304, 9305, 9306, 9307	42(part), 44(part), 87(part)
041	Semiconductors	2611x, 28194	8541(part), 8542	43(part), 45(part), 46(part), 47(part), 48(part), 88(part)

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
042	Printed circuit boards	26123, 26124, 26125	8473(part), 8504(part), 8517(part), 8522(part), 8529(part), 8531(part), 8534, 8548(part)	45(part), 46(part), 47(part), 48(part), 88(part)
043	Electron tubes and electronic display devices	26127	8531(part), 8540, 9013(part)	47(part)
044	Computers and peripheral equipment	26201, 26204, 26209	8443(part), 8470(part), 8471(part), 8472(part), 8473(part), 8528(part)	45(part), 47(part), 88(part)
045	Data storage	26202, 26203, 2680x	8471(part), 8523(part)	45(part), 47(part), 88(part)
046	Communications equipment	2630x	8443(part), 8517(part), 8518(part), 8522(part), 8525(part), 8526, 8527(part), 8528(part), 8529(part), 8531(part), 8543(part)	46(part), 47(part), 88(part)
047	Consumer electronics	2640x	8517(part), 8518(part), 8519, 8521, 8522(part), 8525(part), 8527(part), 8528(part), 8529(part), 9504(part)	38(part), 47(part), 88(part)
048	Other electronic products	26121, 26122, 26126, 26128, 26129, 26205	8504(part), 8523(part), 8532, 8533, 8541(part), 8548(part)	45(part), 46(part), 47(part), 48(part), 88(part)
049	Scientific, photographic and optical products	2651x, 2652x, 2660x, 2670x	3701(part), 3702(part), 3703(part), 3704(part), 3705, 3706, 3707(part), 9001(part), 9002, 9005, 9006, 9007, 9008, 9010, 9011, 9012, 9013(part), 9014, 9015, 9016, 9017, 9018(part), 9021(part), 9022, 9024, 9025, 9026, 9027, 9028, 9029, 9030(part), 9031, 9032, 9033, 9101, 9102, 9103, 9104, 9105, 9106, 9107, 9108, 9109, 9110, 9111, 9112, 9114	47(part), 48(part), 87(part), 88(part)
050	Electrical industrial apparatus	2710x, 2733x, 2790x	8423(part), 8501, 8502, 8503, 8504(part), 8505, 8511(part), 8512(part), 8516(part), 8530, 8531(part), 8535, 8536, 8537, 8538, 8543(part), 8545, 8546(part), 8547(part), 8548(part)	44(part), 46(part), 47(part), 87(part), 88(part)
051	Batteries and accumulators	2720x	8506, 8507	46(part),88(part)
052	Electrical wires, cables and lighting equipment	2732x, 2740x	8512(part), 8513, 8539, 8544, 9405(part)	46(part), 88(part)
053	Domestic appliances	2750x	6301(part), 7321, 8413(part), 8414(part), 8418(part), 8419(part), 8420(part), 8421(part), 8422(part), 8450(part), 8451(part), 8452(part), 8508, 8509, 8510, 8516(part)	44(part), 88(part)
054	Lifting and handling machinery	2816x	8425, 8426, 8427, 8428, 8431(part), 8479(part)	43(part), 49(part)

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
055	Other machinery and equipment (including installation and engineering works)	2811x, 2812x, 2814x, 2815x, 2817x, 28192, 28193, 28195, 28196, 28199, 2821x, 2822x, 28243, 28249, 2825x, 2826x, 2829x, 2830x	8311(part), 8401(part), 8403, 8405, 8406, 8407(part), 8408(part), 8409(part), 8410, 8411(part), 8412, 8413(part), 8414(part), 8416, 8417, 8419(part), 8420(part), 8421(part), 8422(part), 8423(part), 8424, 8429, 8430(part), 8431(part), 8432, 8433, 8434, 8435, 8436, 8437, 8438, 8439, 8440, 8441, 8442, 8443(part), 8444, 8445, 8446, 8447, 8448, 8449, 8450(part), 8451(part), 8452(part), 8453, 8454, 8455, 8456, 8457, 8458, 8459, 8460, 8461, 8462, 8463, 8464, 8465, 8466, 8467, 8468, 8469(part), 8470(part), 8472(part), 8473(part), 8474, 8475, 8476, 8477, 8478, 8479(part), 8480, 8481(part), 8483(part), 8486(part), 8487(part), 8514(part), 8515, 8516(part), 8543(part), 8701(part), 8706(part), 8707(part), 8708(part), 8709, 8716(part)	38(part), 43(part), 44(part), 45(part), 48(part), 49(part), 54(part), 87(part), 88(part)
056	Refrigerators and air-conditioners	28191	8414(part), 8415, 8418(part), 8419(part)	43(part)
057	Oil rigs and oilfield machinery	28241, 28242	7304(part), 8421(part), 8430(part), 8431(part), 8905(part), 9892(part)	44(part)
058	Semiconductor related equipment	2827x	8486(part), 8514(part), 8541(part), 9030(part)	38(part), 43(part), 44(part), 88(part)
059	Land transport equipment	2910x, 2920x, 2930x, 3020x, 3040x, 3091x, 3092x, 3099x	8407(part), 8408(part), 8409(part), 8421(part), 8483(part), 8511(part), 8601, 8602, 8603, 8604, 8605, 8606, 8607, 8608, 8609, 8701(part), 8702, 8703, 8704, 8705, 8706(part), 8707(part), 8708(part), 8710, 8711, 8712, 8713, 8714, 8716(part)	38(part), 43(part), 44(part), 46(part), 49(part), 88(part)
060	Building and repairing of ships and boats	30111, 30112, 3012x	8901, 8902, 8903, 8904, 8905(part), 8906, 8907	49(part), 87(part), 88(part)
061	Marine engines and ship parts	30113	8407(part), 8408(part), 8409(part), 8483(part), 8487(part)	49(part)
062	Aircraft and related machinery	3030x	8407(part), 8409(part), 8411(part), 8511(part), 8801, 8802, 8803, 8804, 8805	38(part), 43(part), 49(part), 88(part)
063	Furniture (except of stone)	3100x	9401(part), 9402(part), 9403, 9404(part)	38(part), 88(part)
064	Jewellery and related articles	3211x, 3212x	7101, 7102(part), 7103(part), 7104(part), 7105, 7113, 7114, 7115, 7116, 7117, 7118, 9113(part)	38(part), 48(part), 88(part)
065	Medical and dental instruments and supplies	3250x	3006(part), 3926(part), 8419(part), 8421(part), 9001(part), 9003, 9004, 9018(part), 9019, 9020, 9021(part), 9402(part)	35(part), 43(part), 48(part), 88(part)

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
066	Other manufacturing	3220x, 3230x, 3240x, 3290x	0501, 3406, 3606, 4206, 5904(part), 6601, 6602, 6603, 6701, 6702, 6703, 6704, 8310, 8469(part), 8470(part), 8472(part), 8473(part), 8715, 9023, 9201, 9202, 9205, 9206, 9207, 9208, 9209, 9401(part), 9405(part), 9406(part), 9503, 9504(part), 9505, 9506, 9507, 9508, 9601, 9602(part), 9603, 9604, 9606, 9607, 9608, 9609, 9610, 9611, 9612, 9613, 9614, 9615, 9616, 9617, 9618, 9701, 9702, 9703, 9704, 9705, 9706	29(part), 32(part), 36(part), 38(part), 47(part), 88(part)
067	Electricity	3510x, 3530x	2716	17(part), 69(part), 86(part)
068	Gas	3520x	2705, 2711(part)	69(part), 86(part)
069	Water and sewerage	3600x, 3700x		69(part), 86(part)
070	Waste collection, treatment, disposal and material recovery services	3810x, 3820x, 3830x	0502, 0505, 0506, 0507, 0510, 2302(part), 2303, 2307, 2308, 2401(part), 2525(part), 2618, 2619, 2620, 2621, 2710(part), 3006(part), 3825, 3915, 4004, 4401(part), 4707, 5003, 5103(part), 5104, 5202, 5505, 6309, 7112, 7204, 7404, 7503, 7602, 7802, 7902, 8002, 8101(part), 8102(part), 8103(part), 8104(part), 8105(part), 8107(part), 8108(part), 8109(part), 8110(part), 8112(part), 8548(part), 8908, 9892(part)	94
071	Building construction	4100x		53(part), 54(part)
072	Civil engineering works	4210x, 4220x, 4290x		53(part), 54(part)
073	Specialised construction services	4311x, 4312x, 4321x, 4322x, 4329x, 4330x, 4390x		54(part)
074	Wholesale trade	4610x, 4621x, 4622x, 4630x, 4641x, 4642x, 4643x, 4644x, 4645x, 4646x, 4647x, 4649x, 4651x, 4652x, 4653x, 4654x, 4655x, 4656x, 4659x, 4661x, 4662x, 4663x, 4664x, 4665x, 4666x, 4669x, 4690x		61
075	Retail trade	4711x, 4719x, 4721x, 4722x, 4723x, 4731x, 4732x, 4741x, 4742x, 4751x, 4752x, 4753x, 4761x, 4762x, 4763x, 4764x, 4771x, 4772x, 4773x, 4774x, 4775x, 4776x, 4777x, 4780x, 4791x, 4799x		62

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
076	Passenger land transport (including cable cars)	4910x, 4921x, 4922x		64(part), 65(part)
077	Freight land transport	4923x, 4930x		65(part), 66(part)
078	Water transport	5001x, 5002x		64(part), 65(part), 66(part)
079	Air transport	5100x		64(part), 65(part), 66(part)
080	Warehousing and storage	5210x		67(part)
081	Supporting services to land transport	5221x		64(part), 67(part)
082	Supporting services to water transport	52221, 52222, 52225, 52226, 52227, 52229, 5225x		67(part)
083	Port operation services	52223, 52224		67(part)
084	Supporting services to air transport	5223x		67(part)
085	Cargo handling and other transportation support services	5224x, 5229x		67(part)
086	Postal and courier services	5310x, 5320x		68
087	Accommodation	5510x, 5590x		63(part)
088	Food and beverage services	5611x, 5612x, 5613x, 5614x, 5619x, 5620x		63(part)
089	Publishing	5811x, 5812x, 5813x, 5819x, 5820x		32, 38, 47, 73(part), 84(part), 89(part)
090	Media entertainment	5911x, 5912x, 5913x, 5914x, 5919x, 5920x, 6010x, 6020x		73(part), 84(part), 89(part), 96(part)
091	Telecommunications	6101x, 6109x		84(part)
092	Computer programming, consultancy and information services	6201x, 6202x, 6209x, 6311x, 6312x, 6390x		83(part), 84(part), 85(part)
093	Banking and finance	6411x, 6412x, 6413x, 6414x, 6415x, 6416x, 6419x, 6420x, 6430x, 6491x, 6492x, 64991, 64995, 64996, 64999		71(part)
094	Life insurance	6511x, 65201		71(part)
095	Non-life insurance and pension funds	6512x, 65202, 6530x		71(part)
096	Fund management	6630x		71(part)
097	Other auxiliary finance and insurance services	64992, 64993, 64994, 6611x, 6612x, 6619x, 6621x, 6622x, 6629x		71(part)
098	Real estate services	6810x, 6820x		72
099	Ownership of dwellings			

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
100	Legal services	6910x		82(part)
101	Accounting, auditing and tax consultancy services	6920x		82(part)
102	Head offices and business representative offices	7010x		83(part)
103	Consultancy services (including market research)	7020x, 7320x, 74904, 74905		82(part), 83(part)
104	Architectural and engineering services	7111x, 7112x, 7120x		83(part)
105	Research and development	7210x, 72200(part)		81
106	Advertising	7310x		83(part)
107	Industrial design	7411x		83(part)
108	Other professional, scientific and technical services	7419x, 7420x, 74901, 74902, 74903, 74906, 74909, 7500x		82(part), 83(part), 85(part)
109	Rental and leasing	7710x, 7721x, 7722x, 7729x, 7731x, 7732x, 7733x, 7734x, 7739x, 7740x		73(part)
110	Employment and labour contracting	7810x, 7830x		85(part)
111	Travel agencies, tour operators and reservation services	7910x, 7990x		85(part)
112	Security services	8000x		85(part)
113	Cleaning and landscape maintenance services	8121x, 8129x, 8130x		85(part)
114	Exhibitions, conventions and other events	8230x		73(part), 85(part), 96(part)
115	Office administrative and support services	8211x, 8219x, 8220x, 8291x, 8292x, 8299x		85(part)
116	Public administration and defence	72200(part), 8411x, 8412x, 8421x, 8422x, 8423x, 85102(part), 85211(part), 85212, 85221(part), 85303, 85499(part), 85502(part), 85509(part), 87021(part), 87022(part), 87029(part), 88911(part), 88919(part), 88921, 88992(part), 88999(part), 91029(part), 91030(part), 91040(part)		91

Input-Output (IO) Codes		Singapore Standard Industrial Classification 2010 (SSIC 2010)	Harmonised Product Description and Coding System Nomenclature 2007 (HS 2007)	Central Product Classification, Version 2 (CPC Ver.2)
117	Education	85101, 85102(part), 85103, 85104, 85211(part), 85213, 85214, 85221(part), 85222, 85223, 85301, 85302, 85304, 8541x, 8542x, 85491, 85492, 85493, 85494, 85499(part), 85501, 85502(part), 85509(part)		92
118	Health services	8610x, 8620x, 8690x, 8701x		93(part)
119	Social services	87021(part), 87022(part), 87029(part), 8810x, 88911(part), 88912, 88913, 88919(part), 88922, 88929, 88991, 88992(part), 88999(part)		93(part)
120	Museums, parks, arts and entertainment	9000x, 9101x, 91021, 91022, 91029(part), 91030(part), 91040(part)		73(part), 84(part), 96(part)
121	Recreation	9200x, 9320x		96(part)
122	Sports	9311x, 9312x		96(part)
123	Member organisations	9411x, 9412x, 9420x, 9491x, 9492x, 9499x		95
124	Repair of computers, personal and household goods	9511x, 9512x, 9521x, 9522x, 9523x, 9524x, 95292, 95293, 95299		87(part)
125	Repair of road transport equipment	95291, 9530x		83(part), 87(part)
126	Other personal services	9601x, 9602x, 9603x, 9604x, 9609x		86(part), 97
127	Domestic services	9700x		98

APPENDIX 2: CORRESPONDENCE BETWEEN THE 11 INDUSTRIAL SECTORS AND THE 127 INPUT-OUTPUT CODES

Industrial Sector	Input-Output (IO) Code	
1 Manufacturing	006	Food preparations
	007	Oils and fats
	008	Dairy products
	009	Sugar, chocolate and related products
	010	Bakery products
	011	Coffee and tea
	012	Other food products
	013	Beverages (except alcoholic drinks)
	014	Alcoholic drinks and tobacco products
	015	Textiles
	016	Wearing apparel and fur products
	017	Footwear and leather products
	018	Wood and wooden products (except furniture)
	019	Paper and paper products
	020	Printing and reproduction of recorded media
	021	Petroleum products
	022	Industrial chemicals and gases
	023	Petrochemicals and petrochemical products
	024	Paints and related products
	025	Perfumes, cosmetics and related preparations
	026	Additives
	027	Other chemical products
	028	Pharmaceuticals and biological products
	029	Rubber products
	030	Plastic products
	031	Glass and glass products
	032	Clay, cement, concrete and stone products
	033	Non-metallic mineral products
	034	Basic metals
	035	Structural metal products
	036	Metalworking (except treatment and coating of metals)
	037	Treatment and coating of metals
	038	Non-insulated cable products
	039	Metal precision components
	040	Other metal products
	041	Semiconductors
	042	Printed circuit boards
	043	Electron tubes and electronic display devices
	044	Computers and peripheral equipment
	045	Data storage
	046	Communications equipment
	047	Consumer electronics
	048	Other electronic products
	049	Scientific, photographic and optical products
	050	Electrical industrial apparatus
	051	Batteries and accumulators
	052	Electrical wires, cables and lighting equipment

Industrial Sector		Input-Output (IO) Code	
1	Manufacturing (cont'd)	053	Domestic appliances
		054	Lifting and handling machinery
		055	Other machinery and equipment (including installation and engineering works)
		056	Refrigerators and air-conditioners
		057	Oil rigs and oilfield machinery
		058	Semiconductor related equipment
		059	Land transport equipment
		060	Building and repairing of ships and boats
		061	Marine engines and ship parts
		062	Aircraft and related machinery
		063	Furniture (except of stone)
		064	Jewellery and related articles
		065	Medical and dental instruments and supplies
		066	Other manufacturing
2	Utilities	067	Electricity
		068	Gas
		069	Water and sewerage
		070	Waste collection, treatment, disposal and material recovery services
3	Other Goods	001	Agriculture (except nursery products)
		002	Nursery products
		003	Livestock
		004	Fisheries (except aquarium fish)
		005	Aquarium fish
4	Construction	071	Building construction
		072	Civil engineering works
		073	Specialised construction services
5	Wholesale & Retail Trade	074	Wholesale trade
		075	Retail trade
6	Accommodation & Food Services	087	Accommodation
		088	Food and beverage services
7	Transportation & Storage	076	Passenger land transport (including cable cars)
		077	Freight land transport
		078	Water transport
		079	Air transport
		080	Warehousing and storage
		081	Supporting services to land transport
		082	Supporting services to water transport
		083	Port operation services
		084	Supporting services to air transport
		085	Cargo handling and other transportation support services
		086	Postal and courier services
8	Information & Communications	089	Publishing
		090	Media entertainment
		091	Telecommunications
		092	Computer programming, consultancy and information services
9	Finance & Insurance	093	Banking and finance
		094	Life insurance
		095	Non-life insurance and pension funds
		096	Fund management

Industrial Sector		Input-Output (IO) Code	
9	Finance & Insurance (cont'd)	097	Other auxiliary finance and insurance services
10	Business Services	098	Real estate services
		099	Ownership of dwellings
		100	Legal services
		101	Accounting, auditing and tax consultancy services
		102	Head offices and business representative offices
		103	Consultancy services (including market research)
		104	Architectural and engineering services
		105	Research and development
		106	Advertising
		107	Industrial design
		108	Other professional, scientific and technical services
		109	Rental and leasing
		110	Employment and labour contracting
		111	Travel agencies, tour operators and reservation services
		112	Security services
		113	Cleaning and landscape maintenance services
		114	Exhibitions, conventions and other events
		115	Office administrative and support services
11	Other Services	116	Public administration and defence
		117	Education
		118	Health services
		119	Social services
		120	Museums, parks, arts and entertainment
		121	Recreation
		122	Sports
		123	Member organisations
		124	Repair of computers, personal and household goods
		125	Repair of road transport equipment
		126	Other personal services
		127	Domestic services

ANNEX

ANNEX: TECHNICAL NOTE

1. This annex presents a technical discussion of how the following are derived: (i) the symmetric IOT; (ii) the open and closed input-output models; (iii) other applications of the symmetric IOT (multiplier analysis, linkage analysis and net foreign exchange earnings); and (iv) the RAS method.

Derivation of Symmetric Input-Output Table

2. This section explains the method in deriving the industry-by-industry symmetric IOT from the SUTs based on the fixed product sales structure assumption. As seen in Exhibit 8, the industry or product technology assumption is used to derive the product-by-product table, whereas the fixed industry or product sales structure assumption is used to derive the industry-by-industry table. The technology assumption and fixed sales structure assumption can also be combined as a hybrid assumption to derive a symmetric table.

Notation

3. A letter in upper case denotes a matrix, while a letter in lower case denotes a vector. A letter italicised represents elements of the matrix or vector. Transposed matrices are written with an apostrophe ($'$) and diagonalisation of vectors is written with a circumflex ($\widehat{\ }$) attached to the letters. The following lists the various matrices and vectors used in this section. Other notations necessary for clarity are also explained.

$\mathbf{M}$	Domestic make matrix, transpose of Domestic supply matrix (industry by product)
$\mathbf{M}'$	Domestic supply matrix (product by industry)
$\mathbf{U}^{d}$	Domestic use matrix for intermediate use (product by industry)
$\mathbf{u}^{m}$	Row vector of total imports for intermediate use (by industry)
$\mathbf{f}^{d}$	Column vector of total final demand of domestic products
$\mathbf{f}^{m}$	Vector of total final demand of imported products
$\mathbf{i}$	Vector of total imports
$\mathbf{g}$	Column vector of industrial output
$\mathbf{q}$	Column vector of product output
$\mathbf{y}$	Row vector of value-added (by industry)
$\mathbf{e}$	Column vector of 1s
d	Index for domestic

^{m} Index for imports

^{x} Index for exports

Exhibit 14: Schematic Representation of an Integrated Supply and Use Table

	Industries	Domestic Products	Final Demand	Total
Industries	-	$\mathbf{M}$	-	$\mathbf{g}$
Domestic Products	$\mathbf{U}^{d}$	-	$\mathbf{f}^{d}$	$\mathbf{q}$
Imported Products	$\mathbf{u}^{m}$	-	$\mathbf{f}^{m}$	$\mathbf{i}$
Value-added	$\mathbf{y}$	-	-	
Total	$\mathbf{g}'$	$\mathbf{q}'$		

4. In Exhibit 14, row sums of the matrix $\mathbf{M}$ give the industry output $\mathbf{g}$ while the column sums of the matrix $\mathbf{M}$ give the domestic product output $\mathbf{q}'$.

5. The second row shows the use of each of the domestic products as intermediate inputs by industries $\mathbf{U}^{d}$ and for meeting final demand $\mathbf{f}^{d}$. The third row shows the total use of the imported products as intermediate inputs by industries $\mathbf{u}^{m}$ and for meeting the final demand $\mathbf{f}^{m}$.

6. The first column shows the total industry inputs, which are the sum of domestic and imported intermediate inputs $\mathbf{U}^{d}$, $\mathbf{u}^{m}$ and the value-added (primary inputs) $\mathbf{y}$.

7. From the above definitions and Exhibit 14, the total output of domestic products is obtained by adding up all products usage:

$$\mathbf{q} = \mathbf{U}^{d}\mathbf{e} + \mathbf{f}^{d} \tag{1.1}$$

or by adding up all the domestic products produced by industries:

$$\mathbf{q} = \mathbf{M}'\mathbf{e} \tag{1.2}$$

8. Similarly, the total output of the industries is obtained by adding up all the domestic products produced by industries:

$$\mathbf{g} = \mathbf{M}\mathbf{e} \tag{1.3}$$

9. To express $\mathbf{U^d}$ in equation (1.1) in terms of output, an intermediate input requirements matrix **H** is created:

$$\mathbf{H} = \mathbf{U}^{\boldsymbol{d}}\hat{\mathbf{g}}^{-\mathbf{1}} \tag{1.4}$$

where $\mathbf{H} = \{h_{ij}\}$, and h_{ij} specifies the purchases of inputs of each product *i* per unit output of industry *j*.

10. From equation (1.4), $\mathbf{U}^{\boldsymbol{d}} = \mathbf{H}\hat{\mathbf{g}}$ is obtained and substituted into (1.1), giving the following equation:

$$\mathbf{q} = \mathbf{Hg} + \mathbf{f}^{\boldsymbol{d}} \tag{1.5}$$

11. This equation describes the allocation of domestic products to industries based on their intermediate input requirements, and final demand.

A. Fixed Product Sales Structure Assumption

12. Under the fixed product sales structure assumption, it is assumed that the allocation of demand to users depends on the product and not the industry from where it is sold, i.e. the market share of a product is independent of the industry that produced the product.

13. To transform equation (1.5) into a symmetrical form, a market shares matrix **D** is created:

$$\mathbf{D} = \mathbf{M}\,\hat{\mathbf{q}}^{-\mathbf{1}} \tag{2.1}$$

where $\mathbf{D} = \{d_{ij}\}$, and d_{ij} is the proportion of total product *j* output that is produced by industry *i*.

14. Equation (1.5) is transformed into a symmetrical form using the fixed product sales structure assumption as follows:

From equation (2.1), $\mathbf{M} = \mathbf{D}\hat{\mathbf{q}}$ is obtained and substituted into (1.3), giving the following equation:

$$\mathbf{g} = \mathbf{Dq} \tag{2.2}$$

substituting equation (1.5) into (2.2) gives the following equation:

$$\mathbf{g} = \mathbf{DHg} + \mathbf{Df}^{\boldsymbol{d}} \tag{2.3}$$

15. Equation (2.3) represents the symmetric industry-by-industry table and **DH** is the direct requirement coefficients matrix.

Derivation of Open and Closed Input-Output Models

16. This section explains the methodology used to construct the static open and closed input-output models from the symmetric table. In the symmetric table, total sales equal total purchases for each industry. Both the open and closed input-output models can be used to derive various multipliers, inter-industry linkages and net foreign exchange earnings.

17. For the purpose of this exposition, the formulae are illustrated for an economy with *n* industries using a symmetric industry-by-industry table.

A. Open Input-Output Model

18. In the open model, all final demand components, namely, PCE, GCE, GCF, and exports of goods and services are assumed to be exogenous.

19. A system of equations linking total output with intermediate consumption and final demand is expressed as follows:

$$\begin{aligned} x_1 &= z_{11} + \cdots + z_{1j} + \cdots + z_{1n} + f_1 \\ &\vdots \\ x_i &= z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + f_i \\ &\vdots \\ x_n &= z_{n1} + \cdots + z_{nj} + \cdots + z_{nn} + f_n \end{aligned} \tag{3.1}$$

where x_i is the sales of output by industry *i*,
z_{ij} is the purchases of industry *i*'s output for the production of output by industry *j*,
f_i is the final demand of output by industry *i*.

20. Each row in the system of equations in (3.1) 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.

21. A fundamental assumption in input-output analysis is that the direct requirement coefficients a_{ij} are assumed to be fixed, i.e. inputs are used in fixed proportions. a_{ij} is the direct requirement coefficient of output required by industry *j* from industry *i* and expressed as:

$$a_{ij} = \frac{z_{ij}}{x_j} \tag{3.2}$$

22. Substituting equation (3.2) into the system of equations in (3.1), the system of equations is re-written as:

$$\begin{aligned} x_1 &= a_{11}x_1 + \cdots + a_{1j}x_j + \cdots + a_{1n}x_n + f_1 \\ &\vdots \\ x_i &= a_{i1}x_1 + \cdots + a_{ij}x_j + \cdots + a_{in}x_n + f_i \\ &\vdots \\ x_n &= a_{n1}x_1 + \cdots + a_{nj}x_j + \cdots + a_{nn}x_n + f_n \end{aligned} \tag{3.3}$$

23. Rearranging the system of equations in (3.3), the system of equations is re-written as:

$$\begin{aligned}
&(1-a_{11})x_1 - \cdots - a_{1j}x_j - \cdots - a_{1n}x_n = f_1 \\
&\vdots \\
&-a_{i1}x_1 - \cdots + (1-a_{ij})x_j - \cdots - a_{in}x_n = f_i \\
&\vdots \\
&-a_{n1}x_1 - \cdots - a_{nj}x_j - \cdots + (1-a_{nn})x_n = f_n
\end{aligned} \tag{3.4}$$

24. In matrix notation, the system of equations in (3.3) is expressed as:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f} \tag{3.5}$$

and the system of equations in (3.4) is expressed as:

$$(\mathbf{I} - \mathbf{A})\mathbf{x} = \mathbf{f} \tag{3.6}$$

where

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, \mathbf{A} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix}, \mathbf{f} = \begin{bmatrix} f_1 \\ \vdots \\ f_n \end{bmatrix}, \mathbf{I} = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$$

25. For a given set of *f*'s, equation (3.6) is a set of *n* equations with *n* unknowns, namely, x_1 to x_n. If a positive solution[18] exists for equation (3.6), then the solution can be expressed as:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{f} = \mathbf{\Theta}\mathbf{f} \tag{3.7}$$

where

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

26. $\mathbf{\Theta}$ is the total requirements coefficients matrix which is also known as the Leontief inverse. Each θ_{ij} measures the dependency of industry *j* on the output of industry *i* when final demand for its output increases by a dollar.

27. In more detail, the system of equations summarised in (3.7) is expressed as:

$$\begin{aligned}
x_1 &= \theta_{11}f_1 + \cdots + \theta_{1j}f_j + \cdots + \theta_{1n}f_n \\
&\vdots \\
x_i &= \theta_{i1}f_1 + \cdots + \theta_{ij}f_j + \cdots + \theta_{in}f_n \\
&\vdots \\
x_n &= \theta_{n1}f_1 + \cdots + \theta_{nj}f_j + \cdots + \theta_{nn}f_n
\end{aligned} \tag{3.8}$$

where $x_i > 0$ for all *i = 1, 2,..., n.*

[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.*

B. Closed Input-Output Model

28. In the closed model, one or more final demand components 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.

29. To accommodate this modification, a vector of private consumption expenditure, $\mathbf{c} = \{c_1, c_2, \dots, c_n\}'$ is included in the *(n+1)*th column and a vector of wages, $\mathbf{w} = \{w_1, w_2, \dots, w_n\}$ in the *(n+1)*th row. The new final demand vector, after excluding private consumption expenditure, is $\tilde{\mathbf{f}} = \{\tilde{f}_1, \tilde{f}_2, \dots, \tilde{f}_n\}'$.

30. This modification leads to the system of equations below.

$$\begin{aligned} x_1 &= z_{11} + \cdots + z_{1j} + \cdots + z_{1n} + c_1 + \tilde{f}_1 \\ &\vdots \\ x_i &= z_{i1} + \cdots + z_{ij} + \cdots + z_{in} + c_i + \tilde{f}_i \\ &\vdots \\ x_n &= z_{n1} + \cdots + z_{nj} + \cdots + z_{nn} + c_n + \tilde{f}_n \end{aligned} \tag{4.1}$$

$$w = w_1 + \cdots + w_j + \cdots + w_n$$

31. 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 $\delta_i = c_i/w$, where w equals the total wages paid by all industries. The wage coefficient which is the wage per unit of output for industry *j*, is simply $\omega_j = w_j/x_j$.

32. Substituting $c_i = \delta_i w$ and $w_j = \omega_j x_j$ into the system of equations in (4.1), the following is obtained:

$$\begin{aligned} x_1 &= a_{11}x_1 + \cdots + a_{1j}x_j + \cdots + a_{1n}x_n + \delta_1 w + \tilde{f}_1 \\ &\vdots \\ x_i &= a_{i1}x_1 + \cdots + a_{ij}x_j + \cdots + a_{in}x_n + \delta_i w + \tilde{f}_i \\ &\vdots \\ x_n &= a_{n1}x_1 + \ldots + a_{nj}x_j + \cdots + a_{nn}x_n + \delta_n w + \tilde{f}_n \end{aligned} \tag{4.2}$$

$$w = \omega_1 x_1 + \cdots + \omega_j x_j + \cdots + \omega_n x_n$$

33. Similar to the open model, in matrix notation, the system of equations in (4.2) is expressed as:

$$\bar{\mathbf{x}} = \bar{\mathbf{A}}\bar{\mathbf{x}} + \bar{\mathbf{f}} \tag{4.3}$$

34. Similar to the open model, equation (4.3) is re-written as:

$$(\mathbf{I} - \bar{\mathbf{A}})\bar{\mathbf{x}} = \bar{\mathbf{f}} \tag{4.4}$$

where

$$\bar{\mathbf{x}} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \\ w \end{bmatrix}, \bar{\mathbf{A}} = \begin{bmatrix} a_{11} & \cdots & a_{1n} & \delta_1 \\ \vdots & \ddots & \vdots & \vdots \\ a_{n1} & \cdots & a_{nn} & \delta_n \\ \omega_1 & \cdots & \omega_n & 0 \end{bmatrix}, \bar{\mathbf{f}} = \begin{bmatrix} \tilde{f}_1 \\ \vdots \\ \tilde{f}_n \\ 0 \end{bmatrix}, \mathbf{I} = \begin{bmatrix} 1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 1 \end{bmatrix}$$

35. 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.

36. Similar to the open model, if a positive solution exists for equation (4.4), then the solution can be expressed as

$$\bar{\mathbf{x}} = (\mathbf{I} - \bar{\mathbf{A}})^{-1}\bar{\mathbf{f}} = \bar{\mathbf{\Psi}}\bar{\mathbf{f}} \tag{4.5}$$

where $\bar{\mathbf{\Psi}} = (\mathbf{I} - \bar{\mathbf{A}})^{-1}$, is the closed inverse matrix.

37. In input-output analysis, the last column of the closed inverse matrix is known as the consumption multiplier and the last row is the household income multiplier. The remaining rows and columns of the closed inverse, which correspond to the rows and columns of the open inverse represent the industries. The consumption multiplier and household income multiplier of the closed inverse are dropped when comparing the closed model inverse to the open model inverse. This gives us a truncated closed inverse $\mathbf{\Psi}$ which satisfies:

$$\mathbf{x} = \mathbf{\Psi}\tilde{\mathbf{f}} \tag{4.6}$$

where

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, \mathbf{\Psi} = \begin{bmatrix} \Psi_{11} & \cdots & \Psi_{1n} \\ \vdots & \ddots & \vdots \\ \Psi_{n1} & \cdots & \Psi_{nn} \end{bmatrix}, \tilde{\mathbf{f}} = \begin{bmatrix} \tilde{f}_1 \\ \vdots \\ \tilde{f}_n \end{bmatrix}$$

38. Each Ψ_{ij} measures the dependency of industry *j* on the output of industry *i* when exogenous final demand (excluding private consumption expenditure) for its good or service increases by a dollar.

Derivation of Applications of the Symmetric Input-Output Table

A. Multiplier Analysis

39. Multipliers estimate the effects on the entire economy as a result of an initial exogenous change in any of the final demand components. The multipliers generated using the open model are known as simple or Leontief multipliers and they measure both the direct and indirect effects of a change in final demand. The closed model captures the direct and indirect effects as well as the consumption induced effects due to a change in final demand. Closed model multipliers are known as total multipliers.

40. The frequently used multipliers are output, VA, income, imports and employment multipliers. This section presents the steps to derive the output and VA multipliers. The steps to derive the VA multiplier can also be used to derive income, imports and employment multipliers.

i) Output Multipliers

41. An output multiplier for industry *j* is defined as the additional output generated in the whole economy in order to satisfy an extra dollar's worth of final demand for industry *j*'s output.

42. In an open model, by replacing the final demand **f** with the changes in final demand, $\mathbf{\Delta f} = \{\Delta f_1, \Delta f_2, \dots, \Delta f_n\}'$**,** the system of equations in (3.8) is re-written as:

$$\begin{aligned} x_1{}^* &= \theta_{11}\Delta f_1 + \cdots + \theta_{1j}\Delta f_j + \cdots + \theta_{1n}\Delta f_n \\ &\vdots \\ x_i{}^* &= \theta_{i1}\Delta f_1 + \cdots + \theta_{ij}\Delta f_j + \cdots + \theta_{in}\Delta f_n \\ &\vdots \\ x_n{}^* &= \theta_{n1}\Delta f_1 + \cdots + \theta_{nj}\Delta f_j + \cdots + \theta_{nn}\Delta f_n \end{aligned} \tag{5.1}$$

where $x_i{}^*$ is the change in output of industry *i*,
Δf_j is the change in the final demand of the output by industry *j*.

43. Here, $x_i{}^*$ shows the total change in output of industry *i* due to a change in the final demand for the output of all industries in the economy. Note that $x_i{}^* = x_i$ for all *i* when **Δf** is replaced by **f.**

44. In matrix notation, the system of equations in (5.1) is represented as:

$$\mathbf{x}^* = \mathbf{\Theta}\Delta\mathbf{f} \tag{5.2}$$

where

$$\mathbf{x}^* = \begin{bmatrix} x_1{}^* \\ \vdots \\ x_n{}^* \end{bmatrix}, \Delta\mathbf{f} = \begin{bmatrix} \Delta f_1 \\ \vdots \\ \Delta f_n \end{bmatrix}$$

45. If $\Delta f_j = 1$ and $\Delta f_i = 0$ for all $i \neq j$, the system of equations in (5.1) is reduced to:

$$\begin{aligned} x_1{}^* &= \theta_{1j} \\ &\vdots \\ x_n{}^* &= \theta_{nj} \end{aligned} \tag{5.3}$$

46. The total output generated in the whole economy is $\sum_{i=1}^{n} \theta_{ij}$. Thus, the simple output multiplier for the industry *j* is $\sum_{i=1}^{n} \theta_{ij}$. This is equivalent to summing the elements in the j^{th} column of the Leontief inverse, $\mathbf{\Theta}$.

47. In matrix notation, the simple output multiplier in the open model is $\mathbf{e}'\mathbf{\Theta}$. Similarly, the corresponding closed model total output multiplier is $\mathbf{e}'\mathbf{\Psi}$.

ii) Value-Added Multipliers

48. A VA multiplier for industry *j* is defined as the additional VA generated in the whole economy in order to satisfy an extra dollar's worth of final demand for industry *j*'s output.

49. The VA coefficient for industry *j* is derived by dividing its VA by its industry output, that is $v_j = y_j/x_j$.

50. By multiplying each individual equation in (5.1) by the respective VA coefficients v_i, the following system of equations is derived:

$$\begin{aligned} {y_1}^* &= v_1(\theta_{11}\Delta f_1 + \cdots + \theta_{1j}\Delta f_j + \cdots + \theta_{1n}\Delta f_n) \\ &\vdots \\ {y_i}^* &= v_i(\theta_{i1}\Delta f_1 + \cdots + \theta_{ij}\Delta f_j + \cdots + \theta_{in}\Delta f_n) \\ &\vdots \\ {y_n}^* &= v_n(\theta_{n1}\Delta f_1 + \cdots + \theta_{nj}\Delta f_j + \cdots + \theta_{nn}\Delta f_n) \end{aligned} \tag{5.4}$$

where ${y_i}^*$ is the change in VA of industry *i.*

51. Here, ${y_i}^*$ shows the total change in VA of industry *i* due to a change in the final demand for the output of all industries in the economy.

52. In matrix notation, the system of equations in (5.4) is represented as:

$$\mathbf{y}^{*\prime} = \hat{\mathbf{v}}\boldsymbol{\Theta}\Delta\mathbf{f} \tag{5.5}$$

where

$$\mathbf{y}^{*\prime} = \begin{bmatrix} {y_1}^* \\ \vdots \\ {y_n}^* \end{bmatrix}, \mathbf{v} = \begin{bmatrix} v_1 \\ \vdots \\ v_n \end{bmatrix}$$

53. Similar to the output multipliers, if $\Delta f_j = 1$ and $\Delta f_i = 0$ for all $i \neq j$, the VA multiplier for the industry *j* is $\sum_{i=1}^{n} v_i\theta_{ij}$. This is equivalent to summing the elements in the *j*th column of the matrix $\hat{\mathbf{v}}\boldsymbol{\Theta}$.

54. $\hat{\mathbf{v}}\boldsymbol{\Theta}$ represents the matrix of direct and indirect requirements for VA and the open model VA multipliers for all *n* industries of the economy are simply the row vector: $\mathbf{e}'\hat{\mathbf{v}}\boldsymbol{\Theta} = \mathbf{v}'\boldsymbol{\Theta}$.

55. Similarly, $\hat{\mathbf{v}}\boldsymbol{\Psi}$ represents the matrix of total (direct, indirect and induced) requirements for VA and the closed model VA multipliers for all *n* industries of the economy are $\mathbf{v}'\boldsymbol{\Psi}$.

iii) Other Types of Multipliers

56. The steps to derive the income, import or employment multipliers are similar to the VA multipliers. The only new information required to generate each type of multiplier is each respective set of coefficients. The various coefficients for each industry are derived in the same way as the VA coefficients, by dividing the income, import or employment of industry *j* by the industry output of industry *j*.

B. Linkage Analysis[19]

57. Backward and forward linkages provide a relative measure of the interdependency of supply and demand within the economy.

i) Backward Linkages

58. 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 output of industry *j* will require industry *j* to source for more inputs. This in turn increases the 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.

59. An industry with a backward linkage greater (lower) than one indicates that its dependence on domestic industries for its inputs is higher (lower) than the average in the economy.

60. The 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:

$$\frac{\sum_{i=1}^{n} \theta_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \theta_{ij}} \tag{6.1}$$

61. In matrix notation, the vector of backward linkages is:

$$\frac{n}{|\mathbf{e}'\boldsymbol{\Theta}\mathbf{e}|}\boldsymbol{\Theta}'\mathbf{e} \tag{6.2}$$

ii) Forward Linkages[20]

62. 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 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.

63. An industry with a forward linkage greater (lower) than one indicates that the domestic industries' dependence on the industry for their inputs is higher (lower) than the average in the economy.

[19] The linkages presented in this publication are both normalized linkages. This is the 'Power of Dispersion Index' and the 'Sensitivity of Dispersion Index' suggested by Rasmussen, 1957. Interested readers can refer to *'Studies in Inter-sectoral Relations'* by *Rasmussen, P.N.*

[20] 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.*

64. 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.

65. 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.

66. This can be understood by the equations below which relate industry *j*'s purchases of industry *i*'s output to purchases of primary inputs. Let $\mathbf{p} = \{p_1, p_2, \dots, p_n\}'$ be the vector of the sum of primary inputs and imports. Then:

$$\begin{aligned} x_1 &= z_{11} + \cdots + z_{j1} + \cdots + z_{n1} + p_1 \\ &\vdots \\ x_i &= z_{1i} + \cdots + z_{ji} + \cdots + z_{ni} + p_i \\ &\vdots \\ x_n &= z_{1n} + \cdots + z_{jn} + \cdots + z_{nn} + p_n \end{aligned} \tag{6.3}$$

67. The output coefficient, b_{ij} measures the amount of output from industry *j* required by industry *i* as a ratio of industry *i*'s gross output. b_{ij} is different from the direct requirements coefficient a_{ij} in that z_{ij} is divided by the output of industry *i* and not the output of industry *j*. b_{ij} is expressed as:

$$b_{ij} = \frac{z_{ij}}{x_i} \tag{6.4}$$

68. Substituting equation (6.4) into the system of equations in (6.3), the system of equations is re-written as:

$$\begin{aligned} x_1 &= b_{11}x_1 + \cdots + b_{j1}x_j + \cdots + b_{n1}x_n + p_1 \\ &\vdots \\ x_i &= b_{1i}x_1 + \cdots + b_{ji}x_j + \cdots + b_{ni}x_n + p_i \\ &\vdots \\ x_n &= b_{1n}x_1 + \cdots + b_{jn}x_j + \cdots + b_{nn}x_n + p_n \end{aligned} \tag{6.5}$$

69. Rearranging the system of equations in (6.5), the system of equations is re-written as:

$$\begin{aligned} &(1 - b_{11})x_1 - \cdots - b_{j1}x_j - \cdots - b_{n1}x_n = p_1 \\ &\vdots \\ &-b_{1i}x_1 - \cdots + (1 - b_{ji})x_j - \cdots - b_{ni}x_n = p_i \\ &\vdots \\ &-b_{1n}x_1 - \cdots - b_{jn}x_j - \cdots + (1 - b_{nn})x_n = p_n \end{aligned} \tag{6.6}$$

70. In matrix notation, the system of equations in (6.5) is expressed as

$$\mathbf{x} = \mathbf{B}'\mathbf{x} + \mathbf{p} \tag{6.7}$$

and the system of equations in (6.6) is expressed as:

$$(\mathbf{I} - \mathbf{B}')\mathbf{x} = \mathbf{p} \tag{6.8}$$

where

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \vdots \\ x_n \end{bmatrix}, \mathbf{B} = \begin{bmatrix} b_{11} & \dots & b_{1n} \\ \vdots & \ddots & \vdots \\ b_{n1} & \dots & b_{nn} \end{bmatrix}, \mathbf{p} = \begin{bmatrix} p_1 \\ \vdots \\ p_n \end{bmatrix}, \mathbf{I} = \begin{bmatrix} 1 & \dots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \dots & 1 \end{bmatrix}$$

71. For a given set of *p*'s, equation (6.8) 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 (6.8), then the solution can be expressed as:

$$\mathbf{x} = (\mathbf{I} - \mathbf{B}')^{-1}\mathbf{p} = \boldsymbol{\lambda}\mathbf{p} \tag{6.9}$$

where

$$\boldsymbol{\lambda} = \begin{bmatrix} \lambda_{11} & \dots & \lambda_{1n} \\ \vdots & \ddots & \vdots \\ \lambda_{n1} & \dots & \lambda_{nn} \end{bmatrix} = (\mathbf{I} - \mathbf{B}')^{-1} = \begin{bmatrix} (1 - b_{11}) & \dots & -b_{1n} \\ \vdots & \ddots & \vdots \\ -b_{n1} & \dots & (1 - b_{nn}) \end{bmatrix}^{-1}$$

72. Each λ_{ij} represents the change in total output of industry *j* in response to a dollar change in value-added available to industry *i* 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.

73. In more detail, the system of equations summarised in (6.9) is expressed as:

$$\begin{aligned} x_1 &= \lambda_{11}p_1 + \cdots + \lambda_{1j}p_j + \cdots + \lambda_{1n}p_n \\ &\vdots \\ x_i &= \lambda_{i1}p_1 + \cdots + \lambda_{ij}p_j + \cdots + \lambda_{in}p_n \\ &\vdots \\ x_n &= \lambda_{n1}p_1 + \cdots + \lambda_{nj}p_j + \cdots + \lambda_{nn}p_n \end{aligned} \tag{6.10}$$

where $x_i > 0$ for all *i = 1, 2,..., n*.

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

$$\frac{\sum_{j=1}^{n} \lambda_{ij}}{\frac{1}{n}\sum_{i=1}^{n}\sum_{j=1}^{n} \lambda_{ij}} \tag{6.11}$$

75. In more compact form, the vector of forward linkages is:

$$\frac{n}{|\mathbf{e}'\boldsymbol{\lambda}\mathbf{e}|}\boldsymbol{\lambda}'\mathbf{e} \tag{6.12}$$

iii) Coefficients of Variation (CVs)

76. The coefficients of variation (CVs) for a sample of observations is 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.

77. An industry with high CVs indicates that its dependencies are concentrated on a few industries. An industry with low CVs indicates that its dependencies are spread across many industries.

78. For an *n*-industry economy, the CV for the backward linkage of industry *j* is defined as:

$$\frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(\theta_{ij}-\frac{1}{n}\sum_{i=1}^{n}\theta_{ij}\right)^2}}{\frac{1}{n}\sum_{i=1}^{n}\theta_{ij}} \tag{6.13}$$

79. Let $\circ$ denote the Hadamard product, then in matrix notation, the vector of CV for backward linkages is expressed as:

$$n\left(\left(\widehat{\boldsymbol{\Theta}'\mathbf{e}}\right)^{-\mathbf{1}}\sqrt{\frac{1}{n-1}\mathbf{I}\circ(\boldsymbol{\Theta}'\mathbf{Q}\boldsymbol{\Theta})}\right) \tag{6.14}$$

where

$$\mathbf{Q}=\mathbf{I}-\frac{1}{n}\mathbf{e}\mathbf{e}'=\frac{1}{n}\begin{bmatrix} n-1 & \dots & -1 \\ \vdots & \ddots & \vdots \\ -1 & \dots & n-1 \end{bmatrix}$$

80. The CV for the forward linkage of industry *j* is:

$$\frac{\sqrt{\frac{1}{n-1}\sum_{j=1}^{n}\left(\lambda_{ij}-\frac{1}{n}\sum_{j=1}^{n}\lambda_{ij}\right)^2}}{\frac{1}{n}\sum_{j=1}^{n}\lambda_{ij}} \tag{6.15}$$

81. In matrix notation, the vector of CV for forward linkages is expressed as:

$$n\left(\left(\widehat{\boldsymbol{\Lambda}'\mathbf{e}}\right)^{-\mathbf{1}}\sqrt{\frac{1}{n-1}\mathbf{I}\circ(\boldsymbol{\Lambda}'\mathbf{Q}\boldsymbol{\Lambda})}\right) \tag{6.16}$$

where

$$\mathbf{Q}=\mathbf{I}-\frac{1}{n}\mathbf{e}\mathbf{e}'=\frac{1}{n}\begin{bmatrix} n-1 & \dots & -1 \\ \vdots & \ddots & \vdots \\ -1 & \dots & n-1 \end{bmatrix}$$

C. Net Foreign Exchange Earnings

82. This section covers the derivation of the net foreign exchange earnings from the exports of goods and services for the various industries. 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.

83. The import coefficient for industry *i* is derived by dividing the imports purchased by industry *i* by the industry output of industry *i*. This gives $\eta_i = u_i^m / x_i$. By multiplying the equations in (5.1) by the import coefficients η_i and replacing changes in final demand **Δf** with the final demand **f,** the following system of equations is derived:

$$\begin{aligned} u_1^m &= \eta_1(\theta_{11}f_1 + \cdots + \theta_{1j}f_j + \cdots + \theta_{1n}f_n) \\ &\vdots \\ u_i^m &= \eta_i(\theta_{i1}f_1 + \cdots + \theta_{ij}f_j + \cdots + \theta_{in}f_n) \\ &\vdots \\ u_n^m &= \eta_n(\theta_{n1}f_1 + \cdots + \theta_{nj}f_j + \cdots + \theta_{nn}f_n) \end{aligned} \tag{7.1}$$

where u_i^m is the imports of industry *i*.

84. In matrix notation, equation (7.1) is represented as:

$$\mathbf{u^{m\prime}} = \hat{\boldsymbol{\eta}}\boldsymbol{\Theta}\mathbf{f} \tag{7.2}$$

where

$$\mathbf{u^{m\prime}} = \begin{bmatrix} u_1^m \\ \vdots \\ u_n^m \end{bmatrix}, \boldsymbol{\eta} = \begin{bmatrix} \eta_1 \\ \vdots \\ \eta_n \end{bmatrix}$$

85. The final demand f_i for the output of industry *i* are divided into a domestic component f_i^d and an export component f_i^x or in matrix form, $\mathbf{f} = \mathbf{f^d} + \mathbf{f^x}$. The imports u_i^m of industry *i* are divided into import requirement for domestic component σ_i^d and import requirement for export component σ_i^x or in matrix form, $\mathbf{u^{m\prime}} = \boldsymbol{\sigma}^{\mathbf{d}} + \boldsymbol{\sigma}^{\mathbf{x}}$. Substituting these into the system of equations in (7.1) gives the following system of equations:

$$\begin{aligned} \sigma_1^d + \sigma_1^x &= \eta_1(\theta_{11}(f_1^d + f_1^x) + \cdots + \theta_{1j}(f_j^d + f_j^x) + \cdots + \theta_{1n}(f_n^d + f_n^x)) \\ &\vdots \\ \sigma_i^d + \sigma_i^x &= \eta_i(\theta_{i1}(f_1^d + f_1^x) + \cdots + \theta_{ij}(f_j^d + f_j^x) + \cdots + \theta_{in}(f_n^d + f_n^x)) \\ &\vdots \\ \sigma_n^d + \sigma_n^x &= \eta_n(\theta_{n1}(f_1^d + f_1^x) + \cdots + \theta_{nj}(f_j^d + f_j^x) + \cdots + \theta_{nn}(f_n^d + f_n^x)) \end{aligned} \tag{7.3}$$

86. In matrix notation, the system of equations in (7.3) is expressed as:

$$\boldsymbol{\sigma}^{\mathbf{d}} + \boldsymbol{\sigma}^{\mathbf{x}} = \hat{\boldsymbol{\eta}}\boldsymbol{\Theta}\left(\mathbf{f^d} + \mathbf{f^x}\right) \tag{7.4}$$

87. If $f_j^d = 0$, $\sigma_i^d = 0$ and $\sum_{j=1}^{n} f_j^x = 1$, the system of equations in (7.3) is expressed as:

$$\begin{aligned}
\sigma_1^x &= \eta_1\theta_{11}f_1^x + \cdots + \eta_1\theta_{1j}f_j^x + \cdots + \eta_1\theta_{1n}f_n^x \\
&\vdots \\
\sigma_i^x &= \eta_i\theta_{i1}f_1^x + \cdots + \eta_i\theta_{ij}f_j^x + \cdots + \eta_i\theta_{2n}f_n^x \\
&\vdots \\
\sigma_n^x &= \eta_n\theta_{n1}f_1^x + \cdots + \eta_n\theta_{nj}f_j^x + \cdots + \eta_n\theta_{nn}f_n^x
\end{aligned} \tag{7.5}$$

where σ_i^x is the import requirement of industry *i* for a dollar of exports from industry *j*.

88. The total imports required by all industries in order to produce f_j^x of exports in industry j is $f_j^x \times \sum_{i=1}^{n} \eta_i\theta_{ij}$. The net foreign exchange earnings from the export of f_j^x is $f_j^x \times \left(1 - \sum_{i=1}^{n} \eta_i\theta_{ij}\right)$.

89. In matrix terms, the system of equations in (7.5) is expressed as:

$$\boldsymbol{\sigma}^{\mathbf{x}} = \hat{\boldsymbol{\eta}}\boldsymbol{\Theta}\mathbf{f}^{\boldsymbol{x}} \tag{7.6}$$

90. $\boldsymbol{\sigma}^{\mathbf{x}} = \hat{\boldsymbol{\eta}}\boldsymbol{\Theta}\mathbf{f}^{\boldsymbol{x}}$ is the formula for the import requirements due to exogenous final demand. The import requirements to fulfil exports $\mathbf{f}^{\boldsymbol{x}}$ are thus equal to $\boldsymbol{\sigma}^{\mathbf{x}}$. Accordingly, the net foreign exchange earnings are given by subtracting these import requirements from the export value, and are given by $\mathbf{f}^{\boldsymbol{x}} - \boldsymbol{\sigma}^{\mathbf{x}}$.

RAS Method

91. 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, **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 **A** for year 0.

Notation

x	Column vector of total sales (or output) by industry for year 1. **x** = $\{x_i\}$ where *i=1,2,...,n*. **x** is also equal to the vector of total purchases (or inputs) 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
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 $k = 0,1,2,\mathrm{K}$

A. RAS Method

92. The RAS method is used to estimate the technical coefficients for year 1, $a_{ij}{}^{*}$, by adjusting the coefficients for year 0, a_{ij}, to fit the known total inter-industry sales and purchases $\mathbf{u}^{*}$ and $\mathbf{v}^{*}$. Note that $\mathbf{u}^{*}$ and $\mathbf{v}^{*}$ are the known row totals and column totals respectively of the as yet unknown matrix $\mathbf{A}^{*}\hat{\mathbf{x}}$.

93. The initial estimate $\mathbf{A^0}$ is simply equal to the matrix for the previous year $\mathbf{A}$. 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 $\mathbf{A}$, $\mathbf{A^1}$, 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

$$\mathbf{u^1 = A^0\hat{x}e} \tag{8.1}$$

and

$$\mathbf{r^1 = (\hat{u}^1)^{-1}u}^{*} \tag{8.2}$$

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

$$\mathbf{A^1 = \hat{r}^1A^0} \tag{8.3}$$

94. 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

$$\mathbf{v^2 = e'A^1\hat{x}} \tag{8.4}$$

and

$$\mathbf{s^2 = v}^{*}\mathbf{(\hat{v}^2)^{-1}} \tag{8.5}$$

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

$$\mathbf{A^2 = A^1\,\hat{s}^2} \tag{8.6}$$

or in a more recognisable form

$$\mathbf{A^2 = \hat{r}^1A^0\hat{s}^2} \tag{8.7}$$

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

95. 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:

$$\mathbf{u}^{k+1} = \mathbf{A}^{k}\hat{\mathbf{x}}\mathbf{e} \tag{8.8}$$

$$\mathbf{r}^{k+1} = (\hat{\mathbf{u}}^{k+1})^{-1}\mathbf{u}^{*} \tag{8.9}$$

$$\mathbf{A}^{k+1} = \hat{\mathbf{r}}^{k+1}\mathbf{A}^{k} \tag{8.10}$$

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:

$$\mathbf{v}^{k+1} = \mathbf{e}'\mathbf{A}^{k}\hat{\mathbf{x}} \tag{8.11}$$

$$\mathbf{s}^{k+1} = \mathbf{v}^{*}(\hat{\mathbf{v}}^{k+1})^{-1} \tag{8.12}$$

$$\mathbf{A}^{k+1} = \mathbf{A}^{k}\,\hat{\mathbf{s}}^{k+1} \tag{8.13}$$

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

96. The sequence of estimates $\mathbf{A^0}, \mathbf{A^1}, \ldots$ converges[21] and the resulting limit matrix is the estimate of $\mathbf{A}^{*}$, the intermediate transactions matrix in coefficient form for year 1.

$$\mathbf{A}^{*} = \lim_{\mathbf{k}\to\infty} \mathbf{A}^{k} = \ldots \hat{\mathbf{r}}^{5}\hat{\mathbf{r}}^{3}\hat{\mathbf{r}}^{1}\mathbf{A}^{0}\,\hat{\mathbf{s}}^{2}\hat{\mathbf{s}}^{4}\hat{\mathbf{s}}^{6} \ldots \tag{8.14}$$

B. Incorporating Exogenous Information

97. The RAS method can also be modified to estimate $\mathbf{A}^{*}$ in the case where some of the $a_{ij}{}^{*}$ 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.

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

$$\tilde{\mathbf{u}} = \mathbf{u}^{*} - \mathbf{\Omega}^{*}\hat{\mathbf{x}}\mathbf{e} \tag{9.1}$$

$$\tilde{\mathbf{v}} = \mathbf{v}^{*} - \mathbf{e}'\mathbf{\Omega}^{*}\hat{\mathbf{x}} \tag{9.2}$$

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:

$$\mathbf{A}^{*} = \mathbf{\Omega}^{*} + \mathbf{\Phi}^{*} = \mathbf{\Omega}^{*} + \cdots \hat{\mathbf{r}}^{5}\hat{\mathbf{r}}^{3}\hat{\mathbf{r}}^{1}\mathbf{\Phi}\hat{\mathbf{s}}^{2}\hat{\mathbf{s}}^{4}\hat{\mathbf{s}}^{6} \ldots \tag{9.3}$$

[21] 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).

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