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Economic Cooperation

Advancing Free Trade
for Asia-Pacific Prosperity

Methodologies of Constructing the APEC TiVA Database for Better Understanding Global Value Chains in the APEC Region

APEC Committee on Trade and Investment

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Preface

It is with a sense of pride and a bit of relief that we present this 2019 APEC Trade in Value Added (TiVA) Report. This is the first of the two reports that presents new data on the ways that goods and services travel throughout supply chains in the Asia-Pacific Economic Cooperation (APEC) region, as well as innovative analysis of that trade. It also clearly lays out the methods used to construct the APEC TiVA database. Together, the report, database, and associated website give the most accurate picture to date of the interconnectedness of APEC economies. They support the APEC Economic Leaders' goals, set out in 2014, of improving policy making and business decisions in the region.

This TiVA initiative has relied on both capacity building and collaboration with international experts to set new standards for accuracy and quality in global value chain analysis. The capacity-building efforts have allowed APEC economies to improve the economic statistics that underlie the analysis. Collaboration with international experts has ensured that the dataset employs the highest standards for transparency while advancing best practices in supply chain analysis. Care has been taken to ensure that these advances in data and methods can be integrated into future efforts by APEC and other organizations.

These accomplishments would not have been possible without the close cooperation of agencies in the two lead economies, China and the United States, along with the cooperation of statistical agencies throughout APEC. Leading international organizations such as the Asian Development Bank, the World Trade Organization, and the Organisation for Economic Co-operation and Development also played a key role. We truly appreciate the substantial time and efforts provided by these economies and organizations to help improve the initiative and ensure its success.

Technical Group Co-Chairs

19 August 2019

Introduction

APEC is home to some of the world's most integrated production networks. Recognizing the importance of global value chains (GVCs) in the APEC region, in 2013, APEC economic leaders agreed upon the GVC framework, *Global Value Chain (GVC) Development and Cooperation in the APEC region on the Basis of Previous Work on Connectivity*, encouraging APEC economies to work strategically and take action in creating an enabling environment for GVC development and cooperation.

In May 2014, the Meeting of APEC Ministers Responsible for Trade Qingdao Statement endorsed *the Strategic Framework on Measurement of Trade in Value Added (TiVA) under GVCs*, which called for the development of a TiVA database for the APEC region. In November 2014, APEC economic leaders and ministers approved *APEC Strategic Blueprint for Promoting Global Value Chains Development and Cooperation*, which identified improving statistics related to measuring GVCs as one of the action items among APEC economies. As a result, China and the United States kicked off the APEC TiVA Database Initiative in 2014, aiming to construct the APEC TiVA database by 2018 while also building APEC economies' capacity in TiVA statistics compilation and policy application of GVC analysis.

Although TiVA is a relatively new statistical approach to measure the interconnectivity and contribution in production of participating economies in global value chains (GVCs), its roots go back much further to at least Hummels et al. (2001) seminal paper looking at vertical specialization. Since then, as the availability of single-economy and inter-economy input-output tables (IOTs) has expanded, a number of other important efforts have been added to the field, including Chen Xikang et al., (2007); Koopman Robert et al. (2011); Degain and Maurer (2015); Wang Zhi et al. (2017).

In very simple terms, the advantage of the TiVA approach over traditional trade statistics is that it provides a view of the interconnected nature of global production, through the creation of an inter-economy or global input-output table (IEIOT) that connects goods and services trade as well as every economy's domestic input-output production structure. This in turn allows us to map and quantify the interdependencies between industries and economies by tracing value embodied in trade flows to the originating industries and economies. Therefore, TiVA statistics provide us with the ability to better estimate domestic and foreign contributions to an economy's gross exports or final demand, and thus more accurately assess the impact of international trade and GVC engagement.

It is important to recognize that although TiVA measures are derived from official statistics., the indicators themselves are estimated, typically derived via assumptions. In this sense therefore, the quality of TiVA statistics is subject to the availability of underlying input data, as well as the compilation methodologies and assumptions. TiVA statistics are not meant to replace official statistics. Instead, they supplement official statistics by providing additional information on trade and economic activities.

Although a number of TiVA databases, or rather IEIOTs have been produced in recent years, inducing WIOD, the WTO-OECD TiVA database and the European FIGARO dataset, the methodologies to construct TiVA databases are still being refined, and the underlying input data are still being improved, especially the single-economy supply use tables (SUTs)[1] and services trade statistics. This APEC TiVA Initiative report is designed in part to assist a convergence in approaches by sharing the methodologies and best

[1] Supply and use tables are in the form of matrices that record how supplies of different kinds of goods and services originate from domestic industries and imports and how those supplies are allocated between various intermediate or final uses, including exports. Source: UNSD, *System of National Accounts (SNA) 2008*.

practices developed during the five-year course of the APEC TiVA database project. The goal is to better understand the TiVA compilation process, encourage more statistical capacity building in APEC economies, and enhance the future global and regional TiVA collaboration effort.

This report consists of two major sections. Section one presents the methodologies of constructing the APEC TiVA database. Section two presents four single-economy extended supply-use tables (ESUTs), highlighting the importance of incorporating targeted granularity into the standard SUTs as well as the TiVA results reflecting firm heterogeneity.

SECTION I: METHODOLOGIES OF CONSTRUCTING THE APEC TIVA DATABASE

Chapter 1: The Conceptual Methodology of Compiling Inter-Economy Input-Output Tables

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This chapter describes the general concepts and overall methodology of compiling inter-economy input-output tables (IEIOTs), the underlying data for the APEC TiVA database. It identifies major technical issues that need to be addressed, and proposes a workflow as the general guideline for the APEC TiVA database initiative.

Inter-Economy Input-Output Tables (IEIOTs)

Inter-economy input-output tables (IEIOTs) are the underlying data for the TiVA-based GVC analytical approach. By applying the Leontief production function to IEIOTs, value embodied in products can be traced back to the originating industries and economies, and the resulting TiVA measures can be used for GVC-related analysis.

An IEIOT can be industry by industry (I-by-I), or product by product (P-by-P), though the former is much more commonly used in TiVA statistics, because value added data (e.g. labor compensation) are more available at the industry level than the product level, and the conversion of supply-use tables into symmetric input-output tables is considerably easier with I-by-I than P-by-P.

Standard IEIOTs consist of three matrix blocks: intermediate use (A), final use (F), and value added (V). For the intermediate use matrix, the rows show how the output of industries are used as inputs, and the columns show how those inputs are used by industries to generate output, with the residual between total output and inputs captured as value-added. For the final use matrix, the rows reflect consumption of the output of industries and the columns reflect the specific category of final demand.

They are symmetric and balanced tables, which means they must satisfy the following conditions.

- Total input equals total output at industry, economy, and global levels.
- Exports equals imports at global, bilateral, industry, and end use levels.
- Total input (supply) equals the sum of intermediate input use and final demand (demand).
- Total output equals the sum of intermediate input use and value added.

A standard IEIOT treats rest of world (RoW) as endogenous (table 1.1.1), which means RoW is treated as a single economy with its own input-output production structure, and exports from the APEC economies to RoW are differentiated for intermediate and final uses. As a result, domestic value that initially is embodied in intermediate goods/services exports to RoW but eventually returns home can be captured.

A simplified version of IEIOT treats RoW as exogenous (table 1.1.2). Differing from the standard IEIOT, this type of IEIOT assumes APEC economies' exports to RoW are for final use only. Therefore, it does not

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[2] This article is the result of the ongoing professional research by US International Trade Commission staff and is solely meant to represent the opinions and professional research of its author. It is not meant to represent in any way the views of the USITC, any of its individual Commissioners, or US Government.

differentiate exports to RoW between intermediate and final uses, and it does not require the estimation of RoW production structure. However, as a result, domestic value embodied in intermediate exports to RoW and eventually returned home cannot be estimated and captured.

The APEC TiVA Initiative adopted the standard IEIOTs, in which the RoW was treated as endogenous. Recognizing the size and importance of the European Union (EU) in global trade and GVCs, the APEC TiVA Initiative separated EU28 from RoW with its own production structure and bilateral trade flows.

Table 1.1.1 A three-economy IEIOT at basic price with the RoW treated as endogenous

		Intermediate Use				Final Use				Total output
		Econ 1	Econ 2	Econ 3	RoW	Econ 1	Econ 2	Econ 3	RoW	
		1……N	1……N	1……N	1……N	1…M	1…M	1…M	1…M	
Econ 1	1 . . . N	$ID^{1}_{i,j}$	$IM^{1,2}_{i,j}$	$IM^{1,3}_{i,j}$	$IM^{1,row}_{i,j}$	FD^{1}_{i}	$FM^{1,2}_{i}$	$FM^{1,3}_{i}$	$FM^{1,row}_{i}$	O^{1}_{i}
Econ 2	1 . . . N	$IM^{2,1}_{i,j}$	$ID^{2}_{i,j}$	$IM^{2,3}_{i,j}$	$IM^{2,row}_{i,j}$	$FM^{2,1,c}_{i}$	FD^{2}_{i}	$FM^{2,3}_{i}$	$FM^{2,row}_{i}$	O^{2}_{i0-}
Econ 3	1 . . . N	$IM^{3,1}_{i,j}$	$IM^{3,2}_{i,j}$	$ID^{3}_{i,j}$	$IM^{3,row}_{i,j}$	$FM^{3,1}_{i}$	$FM^{3,2}_{i}$	FD^{3}_{i}	$FM^{3,row}_{i}$	O^{3}_{i}
RoW	1 . . . N	$IM^{row,1}_{i,j}$	$IM^{row,2}_{i,j}$	$IM^{row,3}_{i,j}$	$ID^{row}_{i,j}$	$FM^{row,1}_{i}$	$FM^{row,2}_{i}$	$FM^{row,3}_{i}$	FD^{row}_{i}	O^{row}_{i}
Net taxes on products[3]		$Tax^{1}_{i,k}$	$Tax^{2}_{i,k}$	$Tax^{3}_{i,k}$	$Tax^{row}_{i,k}$	Tax^{1}_{i}	Tax^{2}_{i}	Tax^{3}_{i}	Tax^{row}_{i}	
Value-added		V^{1}_{j}	V^{2}_{j}	V^{3}_{j}	V^{row}_{j}	Source: modified from Nadim Ahmad's "Creating Global Input-output tables," 2017				
Total Input		O^{1}_{j}	O^{2}_{j}	O^{3}_{j}	O^{row}_{j}					

[3] To calculate TiVA indicators, it is a common practice to fold net taxes on products into value added.

Table 1.1.2 A three-economy IEIOT at basic price with the RoW treated as exogenous

		Intermediate use			Final use			Exports to RoW	Total output
		Econ 1	Econ 2	Econ 3	Econ 1	Econ 2	Econ 3		
		1……N	1……N	1……N	1…M	1…M	1…M	1…M	
Econ 1	1 . . . N	$ID^{1}_{i,j}$	$IM^{1,2}_{i,j}$	$IM^{1,3}_{i,j}$	FD^{1}_{i}	$FM^{1,2}_{i}$	$FM^{1,3}_{i}$	$FM^{1,row}_{i}$	O^{1}_{i}
Econ 2	1 . . . N	$IM^{2,1}_{i,j}$	$ID^{2}_{i,j}$	$IM^{2,3}_{i,j}$	$FM^{2,1,c}_{i}$	FD^{2}_{i}	$FM^{2,3}_{i}$	$FM^{2,row}_{i}$	O^{2}_{i0-}
Econ 3	1 . . . N	$IM^{3,1}_{i,j}$	$IM^{3,2}_{i,j}$	$ID^{3}_{i,j}$	$FM^{3,1}_{i}$	$FM^{3,2}_{i}$	FD^{3}_{i}	$FM^{3,row}_{i}$	O^{3}_{i}
Net taxes on products		$Tax^{1}_{i,k}$	$Tax^{2}_{i,k}$	$Tax^{3}_{i,k}$	Tax^{1}_{i}	Tax^{2}_{i}	Tax^{3}_{i}		
Imports from RoW		$IM^{row,1}_{i,j}$	$IM^{row,2}_{i,j}$	$IM^{row,3}_{i,j}$	$FM^{row,1}_{i}$	$FM^{row,2}_{i}$	$FM^{row,3}_{i}$		
Value-added		V^{1}_{j}	V^{2}_{j}	V^{3}_{j}	Source: modified from Nadim Ahmad's "Creating Global Input-output tables," 2017				
Total input		O^{1}_{j}	O^{2}_{j}	O^{3}_{j}					

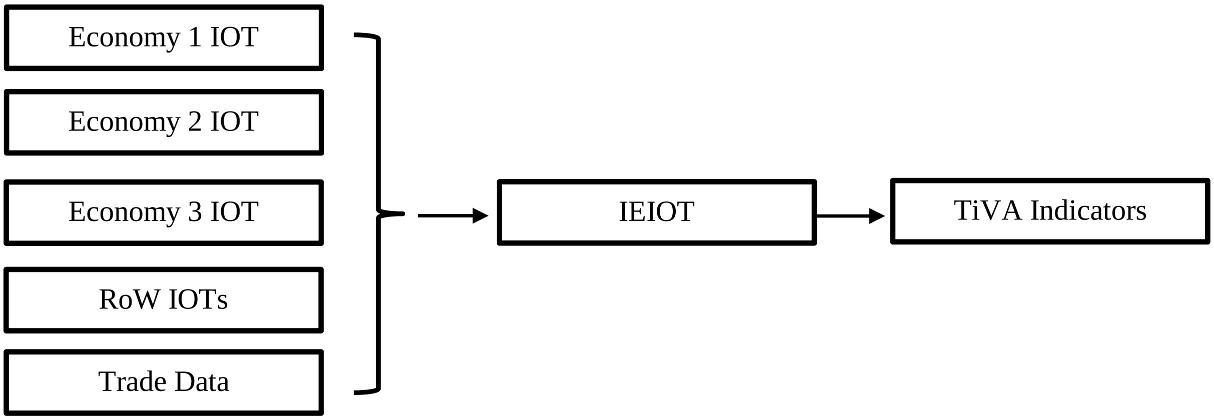
Note:

1. $ID^{k}_{i,j}$ shows the value of domestically produced intermediate use in basic prices for economy *k* used by domestic industry *j* of output produced by domestic industry *i*.
2. $IM^{s,r}_{i,j}$ shows the value of imported intermediate use at freight on board (FOB) price for receiving economy *r*, used by domestic industry *j* of output produced by foreign industry *i* in sourcing economy *s*.
3. FD^{k}_{i} shows the value at basic prices of domestic final use (by households, non-profit institutions serving households, and government) for economy *k*, as well as fixed capital (including investment and changes in inventories) of output produced by domestic industry *i.*
4. $FM^{s,r}_{i}$ shows the value at FOB price of imported final use (including by households, non-profit institutions serving households, and government) for receiving economy *r*, as well as fixed capital (including investment and changes in inventories) of output produced by foreign industry *i* in sourcing economy *s*.
5. V^{k}_{j}, showing value added by industry *j* in economy *k*.
6. O^{k}_{i} or O^{k}_{j}, showing output/input by industry *i* or *j* in economy *k*.

Overall IEIOT Compilation Processes

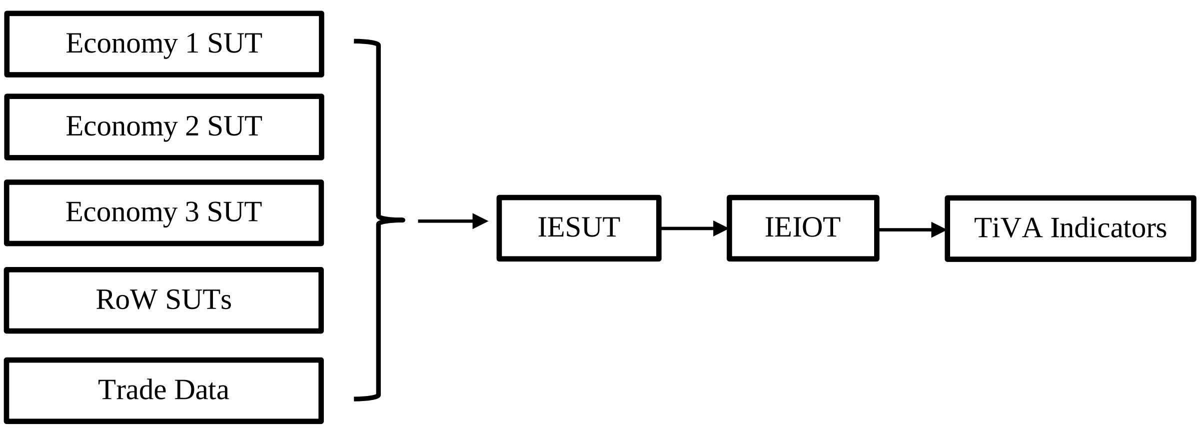
There have been two primary approaches of compiling the standard IEIOTs, which determine the underlying input data and the overall process. One approach is based on IOTs, and the other is based on SUTs.[4] Traditionally, many economies have compiled single-economy IOTs, either I-by-I or P-by-P. Therefore, the early TiVA effort adopted the IOT-based approach because the data were more readily available (diagram 1.1.1).

Diagram 1.1.1 The IOT-based TiVA compilation process



In recent years, recognizing the value of SUTs that have both the product and industry dimensions, which make them superior for linking to other product- (e.g. trade data) or industry-based economic data, more and more economies have begun to compile SUTs as their core efforts to improve and harmonize GDP statistics across the globe under the guidance of UNSD. As a result, the SUT-based TiVA compilation approach is preferred. Although the SUT-based approach improves the quality of the resulting TiVA measures, it also adds extra steps in the compilation process (diagram 1.1.2). Inter-economy SUTs (IESUTs) need to be compiled first before being converted into IEIOTs.

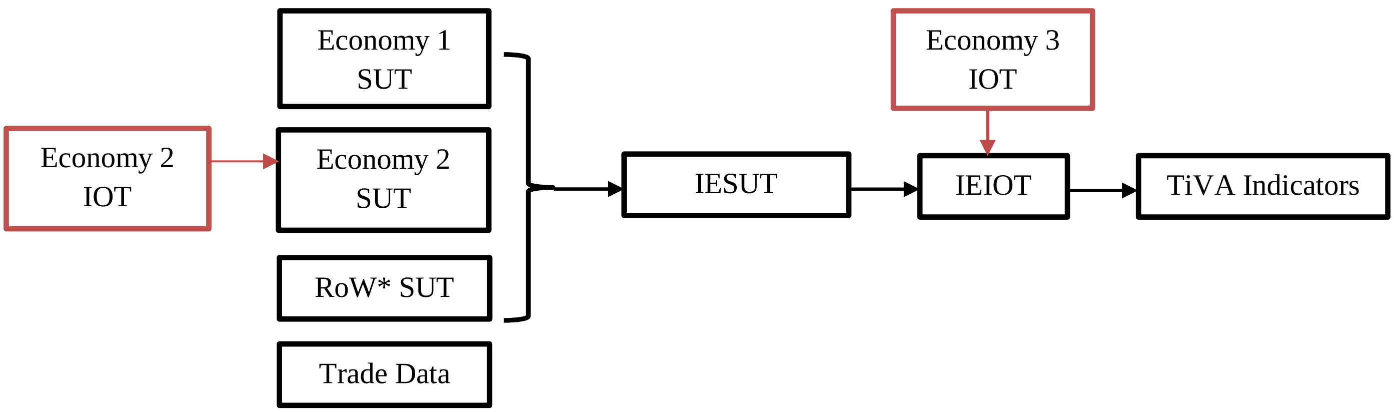
Diagram 1.1.2 The SUT-based TiVA compilation process



[4] Supply and use tables are in the form of matrices that record how supplies of different kinds of goods and services originate from domestic industries and imports and how those supplies are allocated between various intermediate or final uses, including exports. Source: UNSD, *SNA 2008*.

Since not every economy compiles SUTs, the limited availability of SUTs in some economies often forces statisticians to adopt hybrid approaches using available SUTs and IOTs which can be constructed independently of SUTs. With the SUT-based hybrid approach (diagram 1.1.3), for economies that only produce IOTs, such as Economy 2 in the diagram 1.1.3, at the initial stage, IOTs should ideally first be converted into SUTs. When this proves to be infeasible, as in the case of Economy 3, an implicit SUT for Economy 3 would be included in the SUT estimated for RoW[5]* and subsequently its IOT would be separated from the IOT for the RoW*. For the APEC TiVA initiative, we adopted this SUT-based hybrid approach, as a number of APEC economies, including Japan and Papua New Guinea, do not produce official SUTs.

Diagram 1.1.3 The SUT-based hybrid TiVA compilation process



The SUT-based Approach

Conceptually, the SUT-based approach is straightforward. The underlying idea is to link multiple single-economy SUTs through bilateral trade statistics to construct inter-economy supply use tables (IESUTs), which are then transformed into IEIOTs. Therefore, the major input data required are 1) single-economy SUTs (Table 1.1.3 and 1.1.4), 2) merchandise trade statistics, and 3) services trade statistics.

Table 1.1.3 A single-economy supply table at basic prices including a transformation into purchasers' prices

	Industry	Imports at CIF	Total supply at basic prices	Trade and transport margins	Taxes less subsidies on products	Total supply at purchaser's prices
Product	$DSUP^k_{i,j}$	IMP^k_i	SUP^k_i	MAG^k_i	Tax^k_i	SUP^k_i
Total output at basic prices	OUT^k_j	$TIMP^k$		0	Tax^k	

[5] The rest of world here (RoW)* includes RoW and Economy 3.

Table 1.1.4 A single-economy use table at basic prices

	Industry	Categories of Final use	Export at FOB	Total use at basic prices
Product	$ID^k_{i,j}$	FD^k_i	E^k_i	USE^k_i
Net taxes on Product	$ITax^k_j$	FTax		Tax^k
Import Use Matrix	$IM^k_{i,j}$	$FM^k{}_{I,j}$		$TIMP^k$
Value added at basic prices	VA^k_j			TVA^k
Total output at basic prices	OUT^k_j			

From SUTs, the following data are derived for economy k:[6]

- *A domestic intermediate use matrix*, ID^k_{ij};
- *An imported intermediate use matrix*, $IM^k_{i,j}$;
- *Domestic final use column(s)*, FD^k_i;
- *Imported final use column(s)*, FM^k_i;[7]
- *A vector of total use of product*, USE^k_i, at basic prices, where $USE^k_{i}= \sum_j ID^k_{i,j} + FD^k_i + E^k_i$;
- *A vector of value-added by industry*, VA^k_j, at basic price, where $OUT^k_j = VA^k_j + \sum_i (ID^k_{i,j} + IM^k_{i,j}) + ITax^k_j$.

From merchandise and services trade statistics, the following data are derived:

- *Bilateral trade matrices*, $X^{s,r}_i$, showing the value of exports of product *i* of sourcing economy *s* to receiving economy *r*; and $M^{s,r}_i$, showing the value of imports of product *i* from sourcing economy *s* to receiving economy *r*; and where $X^{s,r}_i = M^{s,r}_i$. For bilateral merchandise trade, $X^{s,r}_i$ and $M^{s,r}_i$ are both valued at 'free on board' (f.o.b.) prices.[8] They are also broken down into three end-use categories of intermediates (I), capital goods (K), and goods for final consumption (C).

With the data listed above, to produce an IESUT, $IM^k_{i,j}$ and FM^k_i from SUTs are further disaggregated into $IM^{s,r}_{i,j}$ and $FM^{s,r}_i$, using trading partners' shares derived from bilateral trade matrices as follows

$$IM^{s,r}_{i,j} = M^{s,r}_i(I) / (\sum_{world} M^{world,\,r}{}_i(I)) * IM^r_{i,j} \qquad \text{(I)}$$

$$FM^{s,r}_i = M^{s,r}_i(C,K) / (\sum_{world} M^{world,\,r}{}_i(C,K)) * FM^r_i \qquad \text{(II)}$$

$$\sum FM^{s,r}_i = M^{s,r}_i - \sum IM^{s,r}_{i,j} \qquad \text{(III)}$$

Note:

$IM^{s,r}_{i,j}$: imported intermediate by industry *j* of receiving economy *r* from industry *i* of sourcing economy *s*;

[6] Modified from Nadim Ahmad's "Creating Global Input-output tables," 2017.
[7] for both FD^k_i and FM^k_i, separate columns for each final demand category are in principle available
[8] Since many economies report merchandise imports at CIF price, bilateral CIF/FOB rates need to be estimated in order to convert imports from CIF to FOB price.

$M^{s,r}_i(I)$: total intermediate imports by receiving economy *r* from industry *i* of sourcing economy *s*;

$\sum_{world} M^{world,\, r}_i(I)$: the total imports of economy *r* from the world;

$IM^r_{i,j}$: total imported intermediate use by industry *j* in receiving economy *r* of product *i*;

$FM^{s,r}_i$: total imported final use in receiving economy *r* of product *i* from sourcing economy *s*.

FM^r_i: total imported final use in receiving economy *r* of product *i*.

$M^{s,r}_i(C,K)$: total imported final consumption and gross capital formation in receiving economy *r* of product *i* from sourcing economy *s*;

$\sum_{world} M^{world,r}_i(C, K)$: total imported final consumption and gross capital formation in receiving economy *r* of product *i* from the world.

Key Price Concepts and Valuation Adjustment

During the process of constructing IESUTs, we must address different sets of prices presented in the SUT and trade data, not only for the purpose of harmonization and compatibility, but also for the purpose of truly reflecting value created in the process of international production and trade.

National Account (NA) and SUT data can be compiled at different price bases, most commonly, the basic price, the producer price, and the purchaser's price. According to the System of National Account (SNA) definition,

- *The basic price* is "the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer."
- *The producer's price* is "the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any VAT, or similar deductible tax, invoiced to the purchaser. It excludes any transport charges invoiced separately by the producer."
- *The purchaser's price* is "the amount paid by the purchaser, excluding any deductible VAT or similar deductible tax, in order to take delivery of a unit of a good or service at the time and place required by the purchaser. The purchaser's price of a good includes any transport charges paid separately by the purchaser to take delivery at the required time and place."

Basic prices
+
Taxes on products excluding invoiced VAT
-
Subsidies on products
=
Producer's prices
+
VAT not deductible by the purchaser
+
Separately invoiced transport charges
+
Wholesalers' and retailers' margins
=
Purchaser's prices

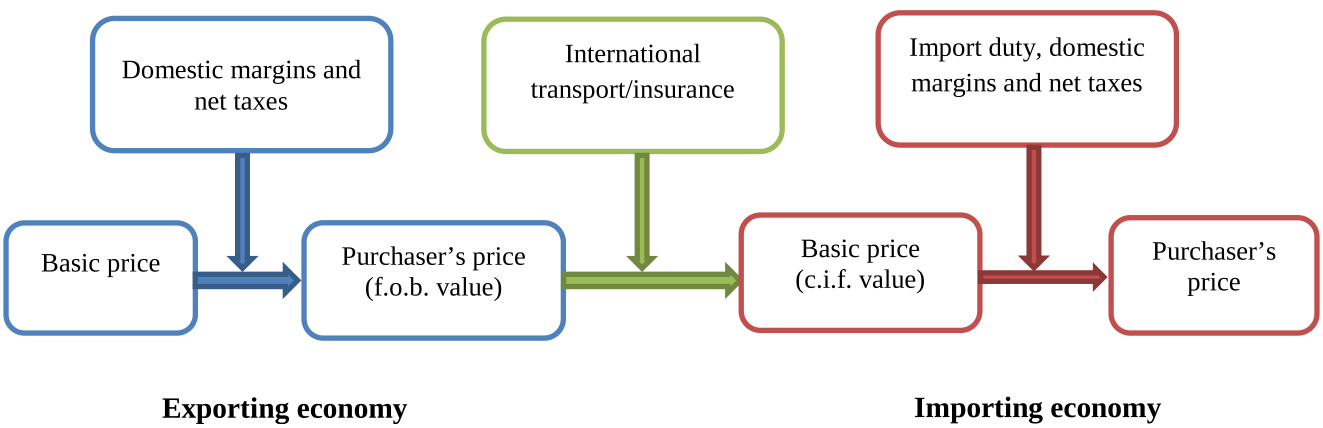
Source: UNSD, *2008 SNA* –chapter 6: the production account, 2008.

From a single-economy perspective, imported goods at c.i.f. (cost, insurance, and freight) value, which is the value at the border of the importing economy, is considered to be equivalent to the basic price. Exported goods at f.o.b (freight on board) value, is considered to be the purchaser's price, as f.o.b. value contains domestic transport and trade margins as well as net taxes.

For the purpose of TiVA measurement, all transactions need to be recorded on the same price base. The most relevant when looking from the perspective of industries is the basic price. However, whilst single-economy SUTs treat imports at CIF price as being equivalent to basic prices, this is not the case for IESUTs, because CIF values include international transport margins as well as exporting economies' domestic margins and net taxes. To arrive at a measure of imports in basic prices, international transport margins embodied in the c.i.f. value for a given import must be removed (typically re-allocated separately as an import of transportation and insurance services, if the services were provided by non-resident producers) so that we can derive, firstly, the f.o.b. value of imports. Then domestic trade and transport margins as well as net taxes incurred in the exporting economy that are embodied in f.o.b. value are removed so that we can eventually arrive at a value of traded goods in basic prices of the exporting economy (diagram 1.1.4).

Such valuation adjustments for international transactions add considerable complexity to the IEIOT compilation process. The use tables in purchaser's price first needs to be separated into domestic and import use tables, with each table requiring different basic-price valuation adjustment.

Diagram 1.1.4 Price valuations of international transactions from a single-economy perspective



Harmonization of Data

It is very common that input data from different sources use different product and/or industry classifications. International merchandise trade statistics adopt the Harmonized System (HS) of tariff nomenclature to classify traded goods. International trade statistics in services usually use major categories from the Balance of Payment Manual (BPM) as well as subcategories from the corresponding EBOPS classification. Single-economy SUTs or IOTs typically use a set of product and/or industry classifications that suit the producing economy's statistical needs but are often not directly compatible with each other. A TiVA project must first determine the common industry and product dimensions, and develop the concordance tables for the harmonization purpose. In the case of the APEC TiVA Initiative, the technical group chose 34 industries and 51 product as the APECSUT dimensions based on the optimal compatibility with input data (appendix tables A.1 and A.2).

In addition, APEC economies do not always produce SUTs/IOTs for the same benchmark years or at the same frequency. For instance, Canada produces SUTs annually; Mexico only began to produce SUTs since 2008 and produce them every five years; China has only two years' SUTs available (2005 and 2012). As a result, the SUTs/IOTs submitted from participating APEC economies vary a great deal in terms of the available years (appendix table B.1). A TiVA project thus must also choose the common benchmark years to harmonize these SUTs from different years, based on the time proximity of most SUT data but also taking into account the potential implication on TiVA measures from economic cycles. In the case of the APEC TiVA Initiative, the technical group chose 2005 and 2012 as the two benchmark years for the APECSUTs based on the available SUTs.

General Methodologies and Three-Stage Workflow

Other than valuation adjustment mentioned above, to link SUTs and trade statistics from different economies and different sources, we must overcome other statistical issues. The diagrams below illustrate the general methodologies of addressing key statistical issues at three different stages of the IEIOT construction process.[9]

The first stage of work mainly addresses harmonization issues in SUT data (diagram 1.1.5):

- *Harmonize different price valuations;*
- *Harmonize incompatible product and industry classification systems;*
- *Harmonize various industry/product detail levels and available years;*
- *Harmonize different currencies and unit values; and*
- *Benchmark to NA data.*

The second stage of work mainly addresses data issues in international trade statistics, such as data discrepancies, missing data points, and incompatibility (diagram 1.1.6):

- *Harmonize different price valuation for merchandise exports and imports;*
- *Reconcile discrepancies in bilateral merchandise trade statistics;*
- *Estimate missing bilateral services trade statistics;*
- *Reconcile discrepancies in bilateral services trade statistics; and*
- *Harmonize official international trade statistics and NA trade data.*

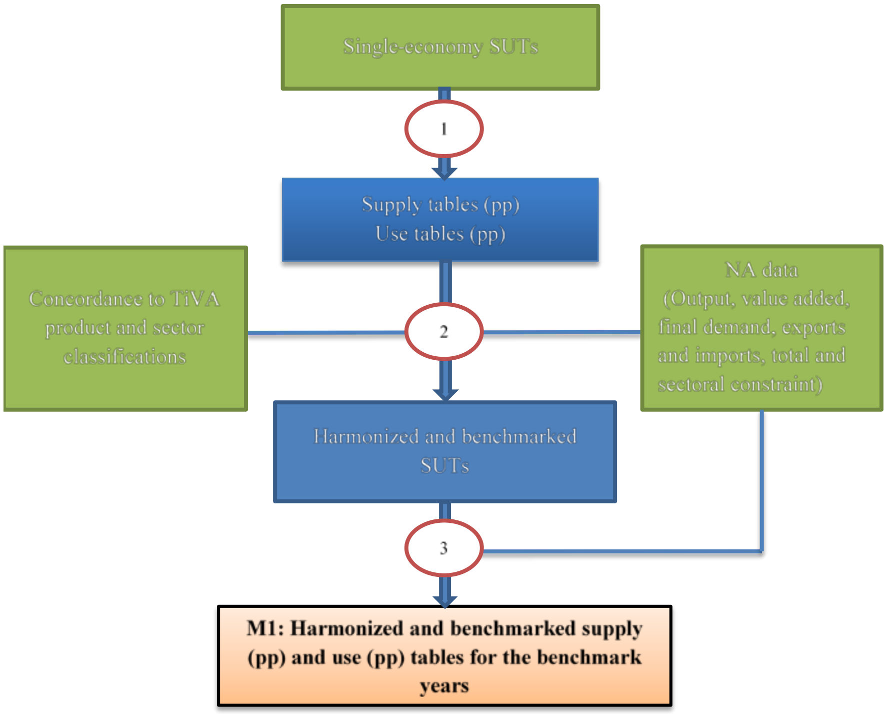
The last stage of work includes linking SUTs with trade statistics, adjusting price valuations, and achieving the final balancing at global, bilateral, and sectoral levels for the construction of IESUTs and IEIOTs (diagram 1.1.7).

- *Return values to the basic price from the international perspective;*
- *Balance exports and imports at global and bilateral levels;*
- *Balance exports and imports at product and sector levels; and*
- *Balance supply and demand at bilateral and global levels.*

[9] These three diagrams were developed by Lin Jones (USITC) and Jianqin Yuan (SIC) during their on-site collaboration with OECD in 2017, reflecting significant inputs from Nadim Ahmad and Fabienne Fortanier from OECD.

These three diagrams provide the general guideline for compiling the APECSUTs and APECIOTs. However, in practice, facing the limitation of available data and associated technical challenges, having the flexibility and allowance to deviate from this general process is necessary for the success of the APEC TiVA project. The APEC approach and methodologies will be discussed in details in the following chapters.

Diagram 1.1.5 Harmonize and benchmark single-economy SUTs



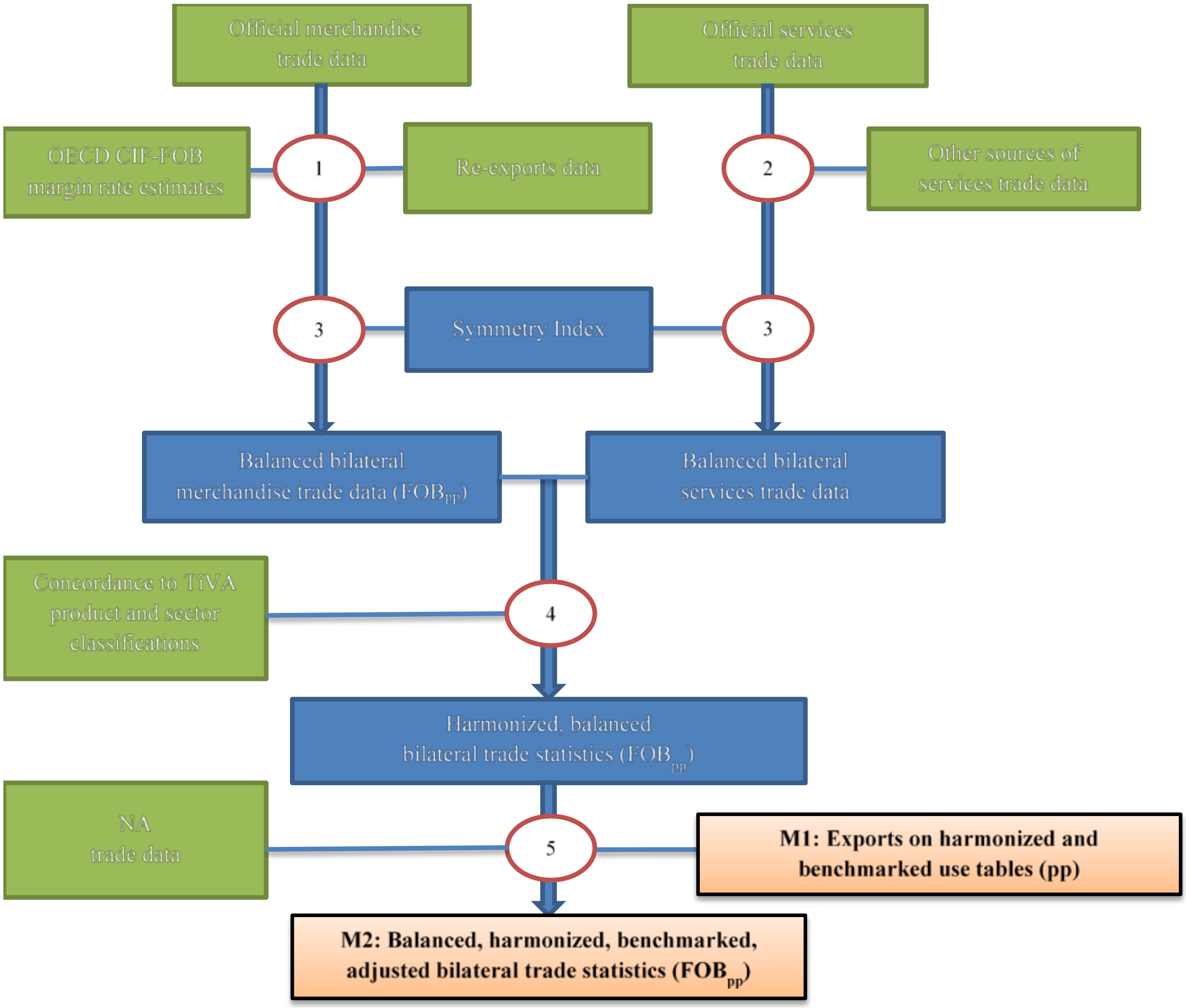
Description of each step:

1. Estimate supply and use tables (SUTs) at purchaser's price as the initial building blocks, for economies that such data are not readily available:
    a. Supply tables at basic price (bp) and the transformation to purchaser's price (pb);
    b. Use tables at purchasers' price (pb);

2. Harmonize single-economy SUTs to the TiVA product and sector classifications, benchmarking NA data (e.g. output, value added, exports, imports, final demand categories, margins, taxes) in the corresponding years;
    a. Estimate NA constraints at the TiVA standard industry/product level;
    b. Harmonize SUTs to the TiVA industry and product classifications with NA constraints;
    c. If feasible, evaluate the treatment of re-exports in SUT compilation. In principal, economies should include re-exports in imports and exports in SUTs;

3. For non-benchmark year SUTs, update them with the benchmark year NA data.

Diagram 1.1.6 Harmonize and balance trade statistics



1. Reconcile bilateral merchandise trade statistics discrepancies:
    a. Convert exports and imports to FOB$_{pp}$ price base;
    b. Adjust for re-exports and other contributing factors (e.g. geographical coverage difference);

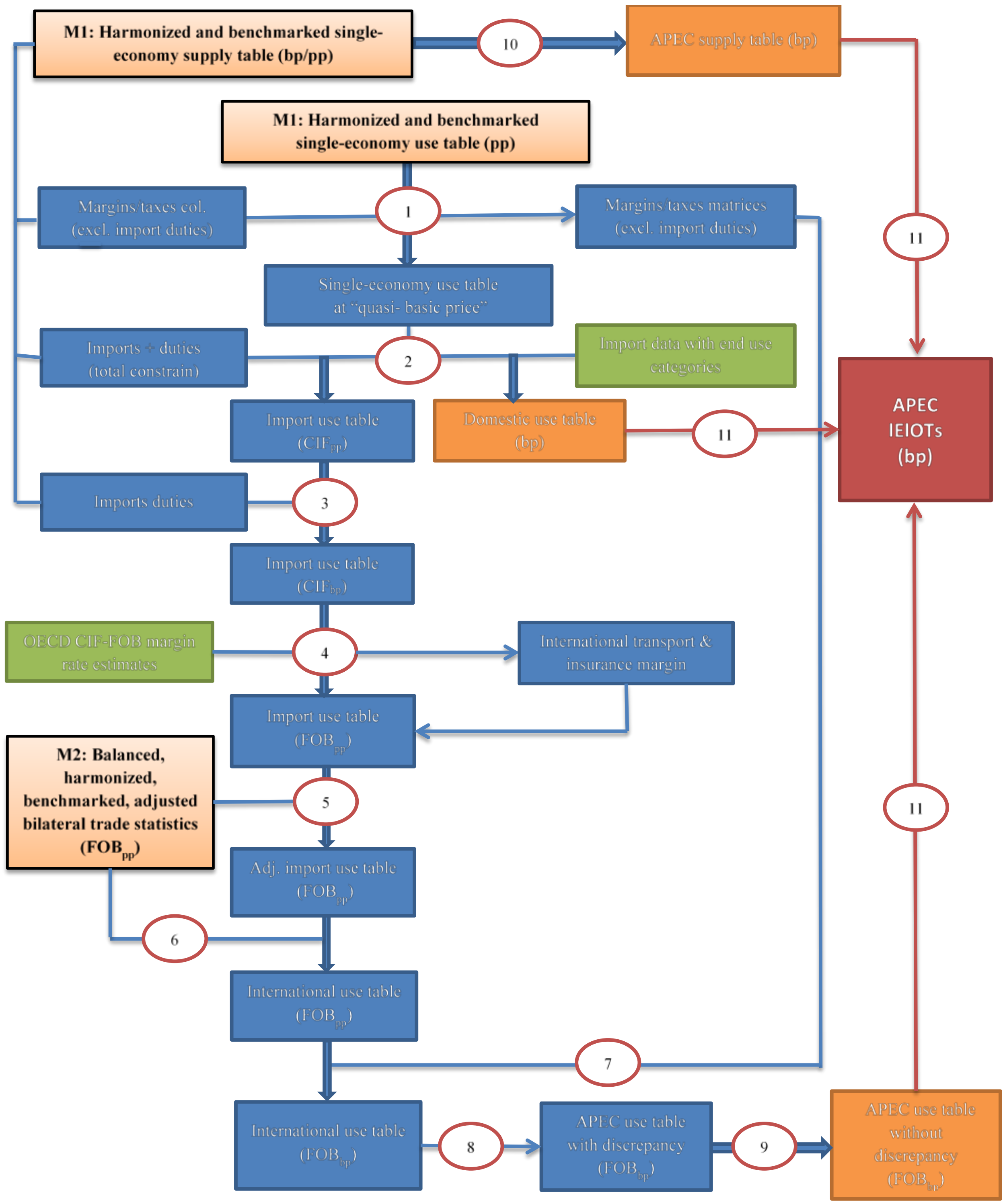
2. Use official services trade data, as well as other sources of services trade data to estimate the missing bilateral services trade data;

3. Estimate the Symmetric Indices for each reporting APEC economy as exporter and importer based on the reconciled trade statistics, and use them as the weight to generate balanced bilateral trade statistics (note: estimate the Symmetric Indices for merchandise and services trade separately);

4. Harmonize balanced trade statistics to the TiVA product classifications; align and benchmark to NA trade data;

5. Adjust product exports in balanced trade statistics to be aligned with product exports in use tables; then adjust product imports of corresponding trading partners' accordingly.

Diagram 1.1.7 Link SUTs and trade statistics to construct IEIOTs



1. Estimate use tables at "basic price" (including import duties and/or other import specific taxes) and generate margin/net tax matrices for later use in step 7;
    a. Combined with other available data, estimate domestic margin and net tax matrices (excluding import duties and other import specific taxes);

    b. Return domestic margins and net taxes embedded in intermediate and final uses to the corresponding margin sectors and tax rows;

2. Breakdown use tables into domestic use tables at basic price and import use tables at CIF purchaser's price (CIF_{pp}: CIF+ import duties or other import specific taxes);
    a. Convert import data to CIF_{pp} by adding import duties and/or other import specific taxes;
    b. Assign import with broad end use categories;
    c. Estimate import use tables at CIF_{pp} using the proportionality assumption;
    d. Derive domestic use tables at basic price;

3. Estimate import use tables at CIF basic price (CIF_{bp}) and return import related taxes to the corresponding tax rows;

4. Apply CIF-FOB margin rates to estimate import use tables at FOB purchaser's price (FOBpp); return international insurance and freight embedded in CIF price to a separate row in the import use table;

5. Adjust product imports in import use tables to be aligned with product imports in harmonized, benchmarked, adjusted, balanced trade statistics;

6. Apply the shares of trading partners by product and end use to generate international use tables at FOBpp;

7. Apply corresponding trading partners' domestic margin and net taxes rate to estimate international use tables at FOB basic price (FOB_{bp});

8. Compile global use tables with global trade discrepancies;

9. Adjust for global trade discrepancies to produce balanced global use tables;

10. Compile global supply tables at basic price;

11. Compile global SUTs and IEIOT at basic price.

Chapter 2: Balancing Trade Statistics at Sectoral and Bilateral Levels

Lin JONES, USITC[10]
Zhi WANG, George Mason University/UIBE

As the previous chapter discussed, one of the key steps in constructing IEIOTs, the underlying data for the APEC TiVA database, is to use trade statistics to disaggregate trade blocks in single-economy SUTs by trading partner. These expanded single-economy SUTs, or so-called international SUTs, then are linked together and re-balanced to produce the standard IESUTs and the symmetric I-by-I IEIOTs. Thus, trade statistics are a crucial input in this process. However, as the diagram 1.1.6 in chapter one illustrates, some inherent issues in trade statistics require additional actions before trade could be integrated. This chapter presents the APEC approach to address these major statistical issues and balance trade statistics at sectoral and bilateral levels.

Major Trade Statistical Issues

We identified the following trade statistical issues that required our attention.

- Filling in missing observations in international trade in services statistics (ITSS)
  Compiling ITSS is very challenging, in large part due to the intangible nature of services as well as the high capacity needed to record such data. This is particularly true for developing economies.[11] As a result, there is substantial variance across APEC economies in terms of data availability and the level of detail in submitted ITSS (appendix tables B.3 and B.4). Developing a methodology to fill in services trade data gaps is one of the top statistical issues we have to address.

- Reconciling the asymmetries in international merchandise trade statistics (IMTS)
  One economy's reported export values rarely equal its corresponding trading partner's reported import values and vice versa, at either the aggregate or detailed product level. A number of factors could contribute to the asymmetries in bilateral merchandise trade statistics, such as valuation differences for exports and imports, geographical coverage differences, re-exports, misclassifications, and under-reporting. Therefore, we need to address the asymmetries in IMTS at bilateral and sectoral levels.

- Reconciling the asymmetries in international trade in services statistics (ITSS)
  Although only ten APEC economies submitted any bilateral ITSS, the asymmetries in reported data are even more notable than IMTS, which requires additional reconciliation procedure.

International organizations, such as OECD, and statistical agencies in various economies have done considerable work on some of the statistical issues mentioned above. To avoid redundancy, we utilized the

[10] This article is the result of the ongoing professional research by US International Trade Commission staff and is solely meant to represent the opinions and professional research of its author. It is not meant to represent in any way the views of the USITC, any of its individual Commissioners, or US Government.
[11] World Bank, "Trade in Services Databases," https://datacatalog.worldbank.org/dataset/trade-services-database (accessed February 13, 2018).

existing work to the extent we could, and devoted our attention to issues related to services trade statistics and international margin services as our main contribution.

Input Data

In addition to trade data submitted directly by participating APEC economies through the APEC TiVA Initiative, this trade balancing exercise also used data from other available official sources such as the World Trade Organization (WTO), the Organisation for Economic Co-operation and Development (OECD), and the International Monetary Fund (IMF). After comparing and analyzing trade data from these different sources, we developed a systematic approach to using these data in a hierarchical yet complementary order. Moreover, we determined what additional adjustments were needed before we integrated trade data from different sources. This approach and the accompanied process is discussed in details below.

- Detailed international merchandise trade statistics (IMTS)
  For detailed IMTS, we relied primarily on OECD *Balanced International Merchandise Trade Statistics* (BIMTS*)*,[12] and supplemented it with the World Bank's *World Integrated Trade Solution (WITS).*[13]

- Detailed services trade statistics
  One of the biggest challenges in preparing trade statistics for the APEC TiVA work is the limited availability of services trade statistics at the detailed product and bilateral level. To address this issue, we pulled available data from different sources, and developed a systematic approach to piece them together. Five major sources were used for constructing detailed bilateral services trade data for APEC economies: participating APEC economies' direct submission; OECD *Trade in Services Data*; WTO *Services Trade Data*; IMF *Services Trade Statistics*; and the WTO-OECD *Balanced Service Database*.

- International margin services data
  Based on the CIF-FOB ratios provided in the OECD *International Transport and Insurance Costs of Merchandise Trade* (ITIC),[14] together with other available explicit CIF-FOB margin data (.e.g. US trade statistics),[15] we estimated international transport and insurance costs of merchandise trade at the

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[12] BIMTS is a product of OECD's recent effort on reconciling IMTS, which is based on a three-step reconciliation approach. In the first step, data are collected and organized, and imports are converted to f.o.b. prices to match the valuation of exports. In the second step, data are adjusted for several specific problems known to drive asymmetries, including unallocated and confidential trade; re-exports by Hong Kong, China; Swiss non-monetary gold; and clear-cut cases of product misclassifications. In the third step, adjusted data are balanced using a "Symmetry Index" that weights exports and corresponding imports. OECD, OECDstat. Balanced International Merchandise Trade Statistics (by CPA) https://stats.oecd.org/Index.aspx?DataSetCode=BIMTS_CPA.

[13] WITS is a software platform developed by the World Bank, which allows users to access and retrieve information on trade and tariffs. Its merchandise trade statistics is based on the UNSD Commodity Trade database (UN COMTRADE), covering over 170 economies, providing annual international trade statistics data detailed with commodities categories and trading partners in US dollar. Source: World Bank, "About WITS;" UNSD, "What is UN Comtrade?"

[14] OECD International Transport and Insurance Costs of Merchandise Trade (ITIC) is a dataset that provides international margin estimations using a gravity model for more than 180 economies and over 1,000 individual products (4 digit HS) at the bilateral level.

[15] CIF-FOB ratios for the United States and Canada with their 20 APEC and 6 other major trading partner are computed directly from US trade statistic at 6-digit HS.

product, bilateral and global levels. The total international transport and insurance costs of merchandise trade equals the global demand of international margin services. We used services trade statistics, mainly the categories of "SCB: freight transport" and "SF12: freight insurance," as a part of statistics estimating the global supply of international margin services.[16]

- USITC Broad Economic Categories (BEC) Concordance data
  In 2015–2016, to meet the specific need of constructing the APEC TiVA database, US International Trade Commission (USITC) staff combined BEC concordance data from UNSD, WIOD, and OECD; compared and reconciled the differences between them; recalibrated some weights for dual-use goods based on USITC industry analysts' expertise; and developed a comprehensive set of concordance data mapping 6-digit HS codes (including four revisions of HS codes) to BEC, ISIC 3, ISIC 4, GTAP, and CPC sectors, with specific weights on three major end use categories: capital goods, consumer goods, and intermediate goods. We used this dataset to break down IMTS by end use to be consistent with the SUT structure.

Multi-level Trade Statistics Reconciliation Models

We developed the multi-level reconciliation models to balance goods and services trade statistics at the bilateral and sectoral levels. The technical details of the models are described as follows.

- Economy and time coverage
  The models estimate and reconcile trade data covering all 21 APEC economies for years 2005 and 2012. Non-APEC economies are divided into six major trading blocs: (1) the 28 member of European Union (EU28); (2) Africa (AFR); (3) Rest of Asia (ASIA); (4) Rest of Latin America (LatAm); (5) OPEC countries (OPEC); (6) the Rest of the world (ROW).

- Balancing merchandise trade statistics
  Since OECD has done considerable work on balancing bilateral merchandise trade statistics, and the resulting dataset–*OECD BIMTS*–covers all 21 APEC economies, we deemed it unnecessary to duplicate the effort. Instead, we directly applied *USITC BEC Concordance data* to *OECD BIMTS* to compute the sectoral and geographical structure by end use for merchandise trade between the 21 APEC economies and with EU28. For merchandise trade with the other five trading blocks, we used *WITS* data with a similar balancing approach, as it has a broader economy coverage.

- Balancing services trade statistics
  During this reconciliation exercise, our special attention was focused on creating a set of balanced bilateral services trade statistics at the most detailed product level possible. We accomplished this with a two-step approach. In the first step, we employed a top-down method to fill in missing data points from different official sources and generated a set of initial services trade data. In the second step, we used an optimization model with internal consistency constraints to generate a complete matrix of balanced bilateral services trade flows by 49 EBOPS categories (appendix table A.3) between the 21 APEC economies and their six major trading partners.

[16] For more information on estimating the global demand and supply of international margin services, please see text box 1.2.1.

- The first step: filling in missing observations

  As discussed earlier, the availability of services trade statistics is far from perfect, with a lot of data points missing even for an economy's total trade with the world. Therefore, we constructed the initial services dataset using data from four major official sources: participating APEC economies' direct submission, IMF, WTO, and OECD. We treated every piece of trade statistics as useful information but with various degrees of conformability with other data sources. To combine initial services trade data from various sources, we applied the following orders. First, we used data submitted by participating APEC economies as the first priority, after making adjustment for outliers based on the comparison results with other data sources. To fill in any missing observations in this initial dataset, we pulled in data from OECD for the 10 APEC economies and EU28, and from WTO for the remaining 11 APEC economies and the rest of the world. We used IMF data as the last resort after exhausting all data from the previous three sources.

  We applied the following rules to fill in the initial values for missing observations:

  1. In a top-down process, we first filled in missing observations at major EBOPS categories using an economy's total services trade as the control; then we filled in missing observations at the next EBOPS subcategory using the value from the corresponding major EBOPS category as the control; we repeated a similar process to the most detailed product level we need.
  2. At each level, the missing observations were filled by either subtraction from the total or by their shares in the total.
  3. After all missing observations are filled, if any statistical discrepancies remained between the higher aggregate category and the sum of lower level sub-categories, we distributed the discrepancies by share.
  4. The category of "SN- Services not allocated" was distributed by proportion.

  We applied these rules to both services trade with the world and bilateral services trade. But for bilateral services trade, one additional set of data, *the WTO-OECD Balanced Service Database*, was used to compute the shares of an economy's trading partners. Since the database is based on the 2002 major EBOPS categories, we first mapped and converted the data to 2010 major EBOPS categories; then we calculated the shares for each major EBOPS category and applied the same shares to any subcategories under each major EBOPS category. Using the derived shares, we distributed an economy's services exports to and imports from the world to its trading partners and filled in any missing observations at the bilateral level after exhausting all reported official bilateral trade data.

- The second step: reconciling asymmetries

  Even after we applied the most systematic approach to fill in the missing observations, some data coherency issues remained, requiring an additional process to achieve the final balancing. The inconsistency could lie in the sectoral or geographical trade flows.

  One common issue is that the sum of trade flows at disaggregated subcategories is not equal to trade value in the parent category. In general, the sum of disaggregated trade flows is often smaller than trade value in the corresponding parent category. Another common issue is that the sum of all bilateral trade flows for an economy is not equal to the economy's reported total services trade value with the world, especially for those economies for which we relied on various rules to fill in the missing bilateral trade flow observations. To create a coherent set of services trade statistics at both the global and bilateral levels, an optimization model with quadratic penalty function was constructed to carry out the final balancing procedure.

In general, economies report service trade data with the world at more detailed EBOPS categories than bilateral service trade data. Therefore, we started the reconciliation process at the aggregate level with the world, using the following pair of mirror data: on one side, we used an economy's reported total services exports to and imports from the world; and on the other side, we aggregated services imports from and exports to this particular economy reported by all its trading partners (the partner "world"). An economy's reported exports to and import from the world, and its trading partner's– "world's"–reported exports to and imports from this economy, constituted a pair of mirrored service trade statistics. The discrepancies between the mirror data were used to compute the asymmetry index, and specified the interval of the model for generating an internally consistent and externally balanced set of service trade data in the later optimization process.

A set of pre-defined constraints is an important component of the services trade reconciliation models, governing the data consistency during the optimization process. At the major EBOPs category and sub-category levels, the reconciled data held true to the following constraints for both services trade with the world and bilateral services trade:

Total services trade=$\sum$ major EBOPS categories
Each major EBOPS category =$\sum$ subcategories

Outputs

After this trade statistics balancing exercise at the bilateral and sectoral levels, we produced two sets of balanced bilateral merchandise and services trade statistics for years 2005 and 2012, by the APEC TiVA product classification and end use, covering 21 APEC economies and their six major trading partners.

Based on these two sets of balanced trade statistics, we derived each economy's total trade with the world by product composition, and each economy's trade by product and geographical compositions. These datasets, both were in shares, would be used in the next stage when we expanded single-economy SUTs by trading partner, which are described in chapter 4.

In addition, we also produced two sets of bilateral CIF-FOB margin estimates for years 2005 and 2012 by four APEC TiVA products (air, sea and other transport for freight; and freight insurance) and end use for all 21 APEC economies and their major trading partners.

Text Box. 1.2.1 Global demand and supply of international margin services

Global Demand and Supply of International Margin Services

To truly trace values embodied in a final product to their original sources, APECSUTs and APECIOTs need to be compiled at the basic price from the international perspective.[1] Thus, we needed not only to estimate international margin services, but also to balance the global demand, which is embedded in merchandise trade statistics, with the global supply, which is only partially reflected in services trade statistics.

We made the attempt, for the first time in any TiVA database construction, to balance global supply and demand of international transport margin services. From the demand side, we combined the official statistics on explicit CIF-FOB margins (e.g. the United States) with OECD gravity-model based *ITIC* estimations to derive the global demand of international margin services. From the supply side, we combined two categories of services trade statistics, freight transport (SCB), and freight insurance (SF12), as a part of the global supply of international margin services that are reflected in service trade statistics.

To understand why services trade statistics only capture the partial global supply of international margin services, we need to take into consideration the unique nature of how international transport and insurance services are recorded in trade statistics, that they are recorded only when they are carried out by domestic residents of one economy for foreign residents in other economies. A key assumption is that the transport and insurance services performed on an economy's goods exports beyond its borders are paid for by the importing economy. Thus, freight and insurance charges for transporting one economy's goods exports are included in the economy's international accounts as transport and insurance services exports if the carriers/providers are domestic residents; if the carriers/providers are foreign residents, the charges are excluded because the transactions are deemed to be between foreign residents. Similarly, freight and insurance charges for transporting one economy's goods imports are included in the economy's international accounts as transport and insurance services imports if the carriers/providers are foreign residents; if the carriers/providers are domestic residents, the charges are excluded because the transactions are deemed to be between domestic residents.

Given the unique nature of how international freight and insurance service trade statistics are recorded, the balance between global supply and demand of international margin services can only be achieved by linking trade statistics with SUTs, which is described in Chapter 4.

Note:

1. See "Chapter 1- The Concepts and Methodology of Compiling Inter-Economy Input-Output Tables" for more information on the basic price from the international perspective.

Chapter 3: Compiling APEC Supply Use Tables with Discrepancies[17]

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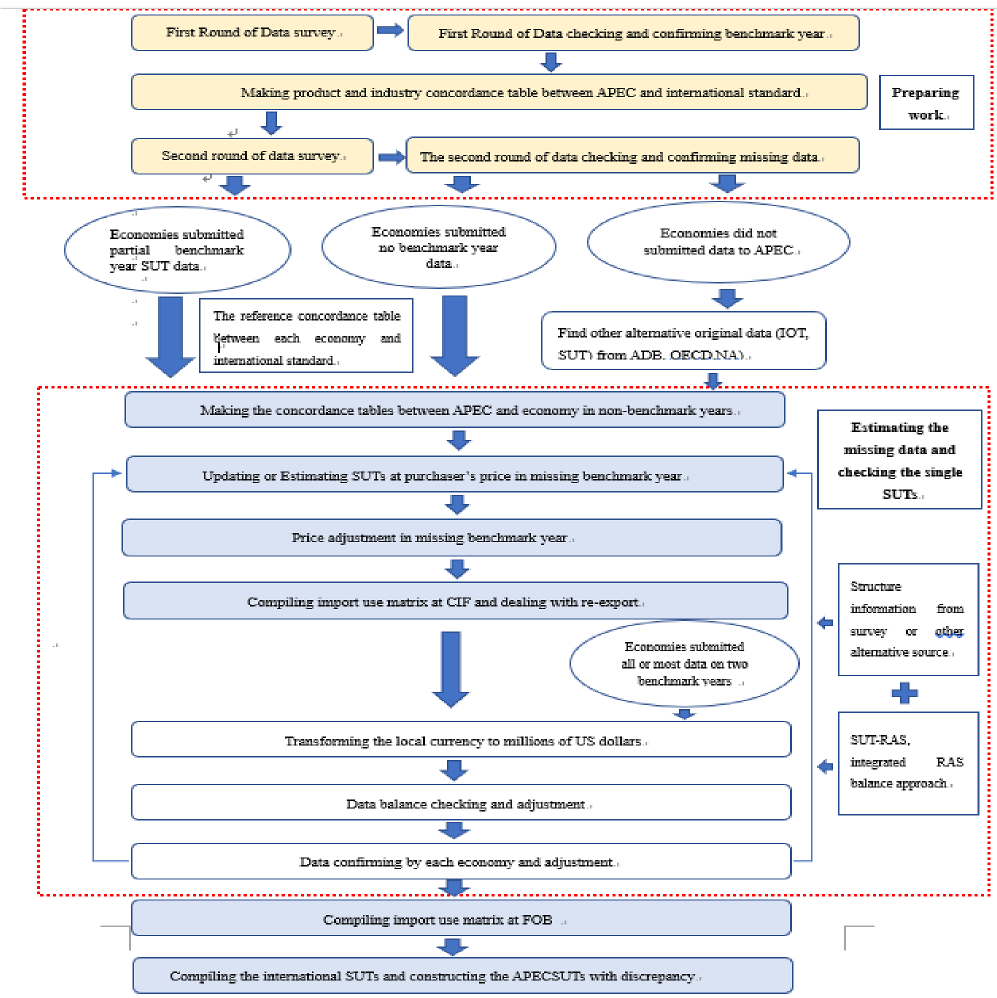
This chapter summarizes the methodologies of estimating missing SUTs and technical details on linking SUTs to compile the imbalanced APECSUTs with discrepancy for the two-benchmark years of 2005 and 2012 (diagram 1.3.1).

It consists three sections: section one presents the general methodologies of estimating missing SUTs for the APEC economies; section two presents the SUT linking process for compiling the imbalanced APECSUTs with discrepancies; and section three summaries the data characteristics as well as the estimation methods.

Diagram 1.3.1 The process of compiling the APECSUTs with discrepancy



[17] The authors would like to thank the valuable inputs from all SUT working teams (BEA, CAS, SIC, and UIBE) on the methodologies summarized in this chapter.

Methodologies of Estimating Missing SUTs

After two rounds of data submissions, 19 APEC economies submitted the required SUTs or IOTs (except the Philippines and Papua New Guinea). Of them, ten economies submitted the complete eight sets of SUT data, including the supply table at basic price, the use table at basic price, the use table at purchaser's prices, and the import use table at c.i.f. valuation for years 2005 and 2012. The remaining economies submitted at least partial SUTs for one year (appendix table B.2). The limited availability of SUTs from APEC economies required additional work to estimate missing SUTs, before APECSUTs can be compiled.

The process of estimating missing SUTs at basic price can be summarized into the following main steps:

Step 1: Estimating and benchmarking SUTs at purchaser's price

For economies that did not provide the complete set of required SUT data, they provided at least a use table at purchaser's price, and a supply table at basic price with or without the valuation adjustment matrix that transforms supply by product from basic price to purchaser's price. Some of these SUTs were in one benchmark year; and some of them were in non-benchmark years. For economies that did not submit any SUTs, we obtained SUTs or IOTs data from international organizations if they were available.[18] We used these data as the starting point for estimating the missing SUTs, and we mainly just updated these available SUTs/IOTs with the NA account data in the two benchmark years of 2005 and 2012.

The supply table and use table can be updated separately by using the popular RAS method. However, the traditional RAS method requires the data on total supply by product in the benchmark years, which were not readily available for most APEC economies. As an alternative, we used the so-called SUT-RAS method, which allowed us to update the supply and use tables simultaneously without using the data on total supply by product (Temurshoev and Timmer, 2011). This method was also used in the construction of the WIOD database.

Other than the supply-use structure from all available sources, additional information required for updating SUTs can be summarized in table 1.3.1. The figures in the grey area are to be estimated and the figures in the remaining area are to be obtained from other official sources for the benchmark years (except the gross output by product $\mathbf{q}$, which is determined endogenously).

Table 1.3.1 Required information for updating SUTs

	Product	Industry	Final demand	Total
Product		$\mathbf{U}$ (Intermediate use matrix)	$\mathbf{Y}$ (Final demand matrix)	$\mathbf{q}$
Industry	$\mathbf{V}$ (make matrix)			$\mathbf{x}$
Import	$\mathbf{m}'$ (Import vector)			$\mathbf{M}$
	$\mathbf{T}$ (Valuation adjustment matrix)			$\mathbf{t}$
Total	$\mathbf{q}'+\mathbf{c}'$	$\mathbf{u}'=\mathbf{x}'-\mathbf{v}'$ (Intermediate use totals)	$\mathbf{y}'$ (Final demand totals)	

[18] For Papua New Guinea (PNG), we obtained Fiji IOTs from WIOD as the starting point.

Define

$$\bar{\mathbf{x}} = \begin{bmatrix} \mathbf{x} \\ M \\ \mathbf{t} \end{bmatrix} \text{ and } \bar{\mathbf{u}} = \begin{bmatrix} \mathbf{u} \\ \mathbf{y} \end{bmatrix}$$

and further define $z_{ij} \equiv x_{ij} / a_{ij}$, where x_{ij} is the element to be estimated and a_{ij} is its corresponding element in the benchmark year (known). For $a_{ij} = 0$, set $z_{ij} = 1$. Define sets s_1={products}, s_2={industries, final demand categories}, s_3={industries, total import, margins and next taxes on products}. Then, the SUT updating task can be modeled by solving constrained optimization problem.

Step 2: Estimating SUTs at Basic Price

After harmonizing and benchmarking single-economy SUTs at purchaser's price, the next step was to estimate SUTs at basic price, mainly transforming use tables from purchaser's price to basic price.

The difference between purchasers' prices and basic prices is described as follows: [19]

$$\begin{aligned} \text{basic prices} = \text{purchaser's prices} - \text{Domestic Trade margins} - \text{Domestic Transport margins} \\ - \text{ Taxes and duties on imports} - \text{Tax on products} + \text{ Subsidies on products} \end{aligned}$$

The equation can be shortened as:

$$\text{basic price} = \text{purchaser's price} - \text{margins} - \text{net taxes}$$

Margins and net taxes mentioned above are usually called the valuation matrices in the supply and use framework. More specifically, the valuation matrices are comprised of domestic trade and transport margins, as well as taxes and subsidies on products.

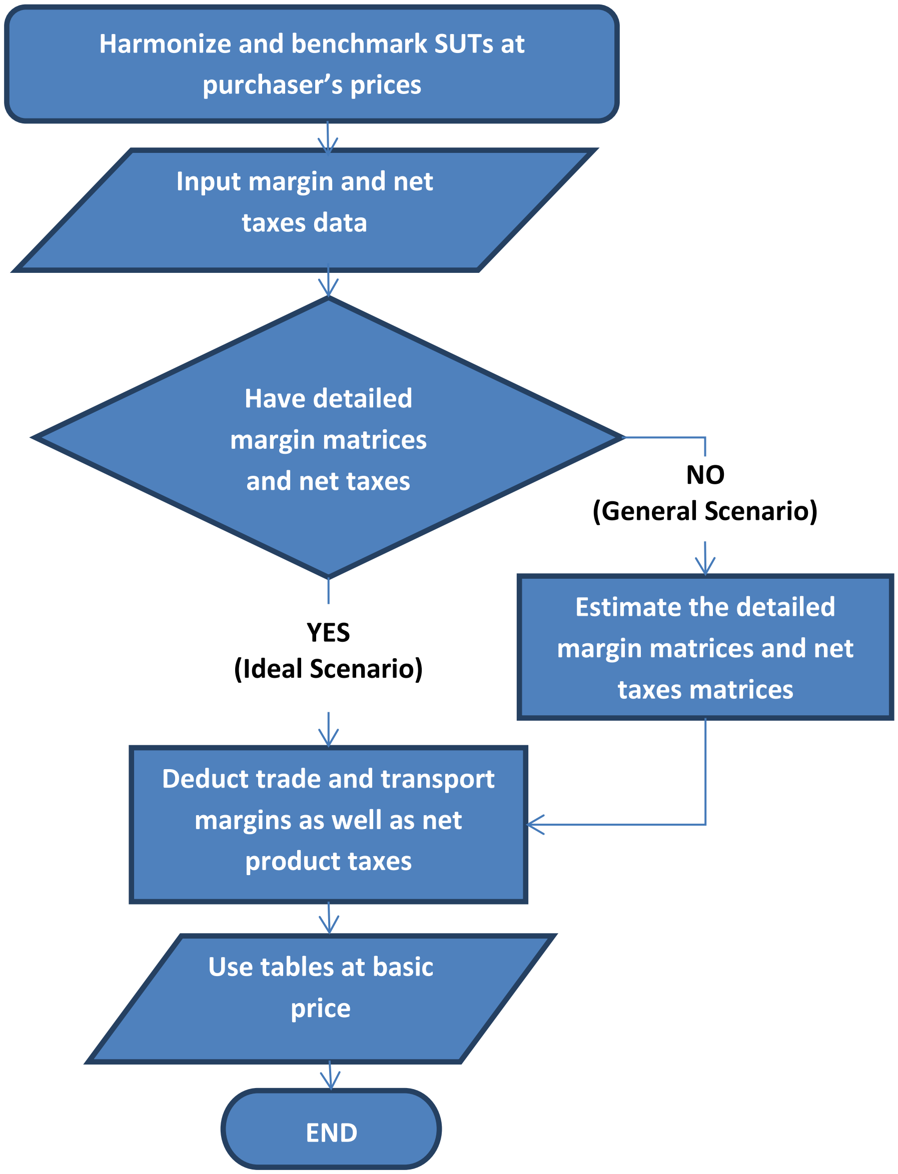
Some APEC economies provided the valuation matrices in detail, and some did not provide any data, which made the estimation process differently under these scenarios. If the economy provided the detailed valuation data, referred to as the ideal scenario, we would obtain the use tables at basic price by deducting margin matrices and net taxes matrices directly. On the other hand, if the economy only provided the total amount of each item in the supply tables, referred to as the general scenario, we would need to estimate the valuation matrices first (diagram 1.3.2).

The ideal scenario

The ideal scenario means all valuation matrices we needed to estimate the use tables at basic price were readily available, including domestic trade and transport margin matrices, and net taxes (taxes less subsidies) on products matrices. In this scenario, we simply deducted the valuation matrices from the use tables at purchaser's price to derive the use tables at basic price.

[19] For more information on these price concepts, please see "Key Price Concepts and Valuation Adjustment" in chapter 1 of Section one.

Diagram 1.3.2 The process of transforming use tables from purchaser's price to basic price



The general scenario

The general scenario means the detailed valuation matrices we needed to estimate the use table at basic prices were not readily available. Since most economies did not submit such detailed data after two rounds of data submission, what we could obtain was a vector of total margins and net taxes from the supply table. In this scenario, we needed to estimate these matrices first with the assumption that the same product group shared the same margin and net tax rate regardless its use. The matrices estimation processes are as follows:

Net tax (taxes less subsidies) matrix

Net taxes here mean taxes less subsidies on product. Because we did not have the detailed information on the net tax distribution, we assumed net taxes were distributed in proportion to the use, and added a new row called taxes less subsidies on product, with each cell equals the sum of each column (table 1.3.2). We did not need to use the RAS method to balance the matrix, as there were no constraints on columns. With the proportionality assumption above, we could get the net tax rate for each product:

$$Ntaxr_i = \frac{Ntax_i}{Xtb_i}$$

The initial values of net taxes matrix were then calculated:

$$Ntax_{ij}^0 = Ntaxr_i \times U_{ij}, Ntax_{ik}^0 = Ntaxr_i \times F_{ik}$$

Table 1.3.2 Construction of net tax matrix

	Industries	Final uses	Total
Products	$Ntax_{ij}^0$	$Ntax_{ik}^0$	$Ntax_i$
Total: taxes less subsidies	$\sum_i Ntax_{ij}^0$	$\sum_i Ntax_{ik}^0$	

Margin matrix

Margins here contains domestic trade margin and transport margins. We also assumed domestic margins were distributed in proportion to the use. The sum of the margin matrix rows is the total margin for each product, and the sum of the margin matrix columns is total margin for each industry.

We first computed domestic margin rates from supply table as follows:

Domestic trade margin rate: $trmr_i = \frac{Tr_i}{Xtp_i}$

Domestic transport margin rate: $tpmr_i = \frac{Tp_i}{Xtp_i}$

Then we calculated the initial values of the margin matrix as follows:

$$Trm_{ij}^0 = trmr_i \times U_{ij}, Trm_{ik}^0 = trmr_i \times F_{ik}$$

$$Tpm_{ij}^0 = tpmr_i \times U_{ij}, Tpm_{ik}^0 = tpmr_i \times F_{ik}$$

Table 1.3.3 Construction of trade margin matrix

	Industries	Final uses	Total
Products	Trm_{ij}^0	Trm_{ik}^0	Tr_i
Total	0	0	0

Table 1.3.4 Construction of transport margin matrix

	Industries	Final uses	Total
Products	Tpm_{ij}^0	Tpm_{ik}^0	Tp_i
Total	0	0	0

But the sum of the columns (initial value) may not satisfy the column restrictions:

$$\sum_i Trm_{ij}^0 = 0, \sum_i Trm_{ik}^0 = 0, \sum_i Tpm_{ij}^0 = 0, \sum_i Tpm_{ik}^0 = 0$$

In the construction of domestic margin matrix, we used the RAS method to make the matrix satisfy both the row and column constraints to obtain the balanced margin matrix.

Step 3: Compiling and adjusting import use table at basic price

The import use tables contain important information for compiling the APECSUTs. However, most APEC economies did not provide the import use tables along with the standard SUTs. Therefore, after harmonizing and updating the SUTs with NA data in the first step, and transforming the SUTs from purchaser's price to basic price in the second step, we were ready to compile the import use tables in the third step.

Compiling the import use table at basic price includes the additional three steps: first, we compiled the import use table at the CIF valuation, which also contained import duties; then we estimated the import use table at FOB_{PP}; and at last constructing the international use table with trading partners and estimating international use table at FOB_{bp}.[20]

Step a: compiling the import use tables at CIF price including import duties

The key to estimate the import use matrix is to construct the import use structure. To accomplish it, we maximized the utilization of information from all available sources, including the economy's direct submitted SUTs or IOTs, the NA data, and any other data available. In the ideal situation, economy has compiled an import use structure by product from the surveys, and we simply apply the structure to disaggregate the import column into the import use matrix. However, since most of APEC economies didn't have the structure readily available. Instead, we encountered the following two common scenarios and adopted different approaches accordingly:

① Economies have the import use matrix in non-benchmark years: In this scenario, we adopted the import use structure from the years that were the closest to the two APEC benchmark years, and applied these structures to estimate the import use matrix in the APEC benchmark years.

② Economies don't have more available data other than SUTs. In this scenario, we adopted the proportionality approach, and combined it with the BEC end use classification. We used imports and import duty columns from the supply tables as total control. We applied the BEC end use classification to disaggregate imports into three different end use categories: intermediate, consumer, and capital goods. Based on any additional NA data available (e.g. the survey on the use of import goods), we estimated the import use structure and derived the import use tables on CIF prices that also included import duties. [21]

③ Regarding re-exports, if by product, the sum of intermediate and final use of one economy is larger than imports, we assumed there were no re-exports. If not, we assumed re-exports incurred, and that the re-export rate of imports(?) equals to the import rate of total supply at basic price. We also sought the comments from each economy so that we could adjust re-exports by product to be more consistent with NA data and trade statistic.

[20] For more information on these price concepts, please see "Key Price Concepts and Valuation Adjustment" in chapter 1 of Section one.
[21] For APEC economies that did not produce import use structure based on business survey, the domestic use structure or import use structure by product in similar economies could be used as a substitute.

Step b: Estimating import use table at CIF prices

We applied the import tax rate calculated from the imports and import duty columns in the supply tables, to the import use tables derived in step a, to estimate import duties. Then we took import duties out and converted the import use table to the pure CIF price basis.

Step c: Estimating import use table at FOB_{PP}

The difference between CIF and FOB_{PP} is the international transports and insurance, or international transport margins. We adopted the bilateral CIF-FOB margin rate by product estimated by OECD to calculate the international transports and insurance for imported goods, and then subtracted them from the import use tables at CIF price to obtain the import use table at FOB_{PP}.

Methodologies of Compiling the APECSUTs with Discrepancy

The APECSUTs with discrepancies are the imbalanced version of APECSUTs, which rest of the world (RoW) is treated as exogenous (table 1.3.5). Since we did not produce SUTs for Papua New Guinea,[22] it was included in RoW.

To compile the APECSUTs with discrepancies covering 20 APEC economies, first, we applied the shares of trading partners from balanced trade statistics[23] to disaggregate the single-economy SUTs, and derived the single-economy international SUTs. Following that, we merged the single-economy international SUTs into APECSUT. In this process, the column "export to RoW," was derived as a residual. All measurement errors, aggregation biases, inconsistencies between NA and trade statistics, and other statistical discrepancies that pertain to bilateral trade flows between the APEC economies tend to accumulate in the residual. As a result, it is possible that exports to RoW could become negative.

The APECSUTs with discrepancy preserve more original input data. However, they can't be converted into the symmetric balanced I-by-I APECIOTs from which TiVA indicators could be estimated. Therefore, it is necessary to produce the balanced APECSUTs. The following chapter will introduce the methodologies of compiling the balanced APECSUTs and APECIOTs.

The Summary of Data Characteristics and Estimation Methods

This section summarizes the special treatment of estimating SUTs/IOTs for missing data. The SUT work stream of APEC TiVA Core Technical Task Force (CTTF), consists of four SUT teams from China and the United States. Their tasks were working with participating APEC economies to process submitted data and estimate missing data. The teams made considerable efforts to seek data from alternative sources when limited or no data were submitted. Besides the standard methods presented above, other estimation techniques and processes were also developed and used based on the data availability. These estimation methodologies and techniques can be summarized as follows:

(1) For APEC economies that submitted all or most of SUT data for two benchmark years 2005 and 2012: Most of these submitted data were consistent with the APEC industry and product classifications and valuation requirements. The teams just needed to validate and process the submitted SUT data with or without minor adjustments, such as converting the values of original data from local currency to millions of US dollars, with the exchange rates published by IMF or the advised exchange rates by

[22] We only compiled IOTs for Papua New Guinea, which was used in the process of producing balanced APECIOTs.

[23] For more information on balanced trade statistics, please see chapter 2 of Section one.

economy for the reference benchmark years.

(2) For APEC economies that submitted only partial SUT data in benchmark years: The teams would mainly rely on the submitted data, with additional information from other sources to estimate the missing data. The processes included harmonizing the submitted data with the APEC format, transforming industry/product classifications to the APEC classifications, estimating other SUT components, and applying techniques to balance SUTs.

(3) For APEC economies that submitted SUT data in non-benchmark years: The teams updated the SUTs to the benchmark years using the SUT-RAS approach mentioned early or an integrated RAS balancing approach. The process allowed the full utilization of the structural information from submitted data while updating the NA data to the benchmark years.

(4) For APEC economies that did not submit any data to the APEC TiVA Initiative: The teams mainly relies on the unofficial data available from other research institutes (e.g. WIOD) and estimated the missing SUTs or IOTs through economic modellings.

Table 1.3.5 The template of the APEC Supply and Use system with discrepancy		Econ A	Econ B	Econ C	Econ A	Econ B	Econ C	Econ A	Econ B	Econ C	Export to ROW	Total
		Supply	Supply	Supply	Intermediate use	Intermediate use	Intermediate use	Final domestic use	Final domestic use	Final domestic use		
		Product	Product	Product	Industry	Industry	Industry	Industry	Industry	Industry		
Econ A	Product				Domestic intermediate use	Intermediate use import from A	Intermediate use import from A	Domestic final use	Final use import from A	Final use import from A	Export to Row from A	Total use of A
Econ B	Product				Intermediate use import from B	Domestic intermediate use	Intermediate use import from B	Final use import from B	Domestic final use	Final use import from B	Export to Row from B	Total use of B
Econ C	Product				Intermediate use import from C	Intermediate use import from C	Domestic intermediate use	Final use import from C	Final use import from C	Domestic final use	Export to Row from C	Total use of C
Row					Intermediate use import from Row	Intermediate use import from Row	Intermediate use import from Row	Final use import from Row	Final use import from Row	Final use import from Row		
Econ A	Industry	supply										
Econ B	Industry		supply									
Econ C	Industry			supply								
Imports		Imports	Imports	Imports								
Total supply		Total supply	Total supply	Total supply								
Direct purchases abroad by residents												
Domestic purchases by non-residents												
Net taxes on products												
International Transportation and Insurance												
Value added at basic price					Value added	Value added	Value added					
Total Output by industry					Output of A	Output of A	Output of A					

Chapter 4: Final Trade Balancing under the Supply-Use Framework for Constructing the Balanced APEC Supply-Use Tables and Input-Output Tables

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After populating and balancing trade statistics at sectoral and bilateral levels, as described in chapter 2, and benchmarking and harmonizing single-economy SUTs, as described in chapter 3, we needed to integrate these SUTs with detailed bilateral trade statistics, and disaggregate trade vectors and import use matrices in the SUTs by trading partners to produce a consistent APEC SUT database. To achieve the results, another round of trade reconciliation exercises was required, where a set of global and bilateral balance conditions must hold under the SUT framework. This chapter describes the methodologies we used in this final balancing process for the APEC TiVA Initiative.

To preserve the final balanced data as close to NA as possible, we used a top-down approach with three optimization models: in model one, we achieved global balance in export supply and import demand by product at the economy level. In model two, based on the results from the first stage, as well as other available data on net taxes, margins, and trade adjustments, we then rebalanced each economy's SUTs. In model three, we combined model one and model two, and disaggregated each economy's trade with the world by trading partners using shares from balanced trade statistics. These models apply optimization procedures to solve the inconsistencies in trade and SUT data from different sources using a system of simultaneous equations that only allows the minimum deviation from both official SUTs and trade statistics. The technical details of these three models are described in detail below.

Model One: Balancing Global Export Supply and Import Demand by Product

We developed Model One to balance global export supply and import demand by product under the supply use framework. We utilized total trade from NA and trade structure data from various sources, including SUTs, to produce the globally balanced trade vector for each APEC economy, EU28, and the rest of world.

Input data

Model One used the following two sets of trade data as the initial controls.

1. Total trade
   To be consistent with the SUTs, which have been benchmarked to NA, we used "Exports of goods and services" and "Imports of goods and services" from UNSD's *GDP by Major Expenditure Components Statistics* as the total control (table 1.4.2).

2. Trade structure by product
   Model One used four sets of trade structure data: merchandise trade by product, services trade by product, trade adjustment by product, and re-exports by product. They were pulled from the following four sources:

[24] This article is the result of the ongoing professional research by US International Trade Commission staff and is solely meant to represent the opinions and professional research of its author. It is not meant to represent in any way the views of the USITC, any of its individual Commissioners, or US Government.

- Balanced trade data for goods and services from the previous trade reconciliation exercise (described in chapter 2);
- SUT trade vectors for goods and services trade, trade adjustment, and re-exports;
- WITS for goods trade and re-exports;
- OECD ICIO for trade adjustment and re-exports.

Balancing Approach

Model One dealt with the data inconsistence issue at the global level, by reconciling official estimates of each economy's total merchandise and service trade statistics reported in NA with reported total exports to and imports from the world at product level in that economy's SUTs. It produced a set of total exports and imports at economy and product level, which satisfied the condition that global total exports (f.o.b) plus international shipping margin equal global total imports (c.i.f.). The global use of international margin services was also simultaneously balanced with global supply from margin producing industries, similar to Streicher and Stehrer (2012), but achieved in a unified modeling framework.

First, with additional information from each economy's SUTs and the OECD ICIO tables, we broke down total trade from UNSD into three subsets of data by trade category: goods trade, services trade, and trade adjustment, mainly residents' purchases abroad and non-residents' domestic purchases. They were used as total controls of an economy's trade with the world in these categories.

Using trade data from the four sources mentioned above, we created four sets of trade product composition data for each trade category, defined as a product's share in aggregate trade. We then applied UNSD's total trade by category to these shares to derive four sets of trade vectors by product in value for each data source. Across these data sources for the same product, the largest number was used as the upper bound, and the smallest number was used as the lower bound of an economy's trade in this product with the world. The optimization results were constrained within these upper and lower bounds.

The major constraint of Model One is that by each product, global export supply must equal global import demand, including international transport margin services. The optimization results from Model One included the following seven sets of trade vectors by product and end use for each economy (table 1.4.1).

Table 1.4.1 Outputs of Model One

Trade Vector	Note
Exports	f.o.b.
Imports	c.i.f.
Re-exports	f.o.b.
CIF margins	
Trade adjustment:	
Residents' purchases abroad	Used for import adjustment
Non-residents' domestic purchases from domestic source	Used for export adjustment
Non-residents' domestic purchases from import source	Used for re-export adjustment

Global Supply and Demand of International Transport Margin Services

From goods trade and CIF margin rate estimates, we produced the CIF margin vector, which equals the global demand of international transport margin services. For services trade of air, water, and other transport, we split them by margin and non-margin products, where margin products are used for transporting freight. Exports of transport margin products as well as freight insurance were treated as the global supply of international transport margin services from non-resident source of importing economies.[25] The global supply of international transport margin services from resident source of importing economies was derived as the residual between the above global demand and supply.

Model Two: Rebalancing Single-Economy SUTs

Model Two adopted a gradual approach to reconcile each economy's SUTs with the globally consistent exports and imports estimates from model one, and pin–point data inconsistencies in a particular set of SUTs by economy and year. In principal, we rebalanced each economy’s SUTs while trying to preserve the aggregate macroeconomic and industry level data (e.g. GDP by industry), to the extent possible.

Input data

Model Two mainly used three sets of input data: total GDP and GDP by major expenditure category from UNSD (table 1.4.2), single-economy SUTs,[26] and the globally balanced trade vectors from Model One. In addition, Model Two also used any available data on net taxes, domestic margins, and trade adjustment by product under the supply use framework.

Table 1.4.2 GDP by Expenditure Category

Variable code	Description
FCE	Final consumption expenditure
HCE	Household consumption expenditure
GCE	General government final consumption expenditure
GCF	Gross capital formation
GFC	Gross fixed capital formation
GII	Changes in inventories
EXP	Exports of goods and services
IMP	Imports of goods and services
GDP	Gross domestic product

Note:
1. FCE = HCE + GCE; GCF = GFC –CII; GDP = FCE + GCF + EXP – IMF;
2. Household consumption expenditure including Non-profit institutions serving households;
3. NA Main Aggregates Database, "Basic Data Selection", "GDP by Expenditure, at current prices-US dollars", Available Online: https://unstats.un.org/unsd/snaama/selbasicFast.asp,

Balancing Approach

Model Two adopted a multi-round approach to rebalance the SUTs, in which a series of controls were gradually relaxed in a hierarchical order and only for the SUTs that remained imbalanced after previous rounds of the balancing process. In principle, we tried to preserve the production structure of the original SUTs and the aggregate macroeconomic data to the best we could.

[25] See more information on why margin services trade only presents the global supply of international transport margin services from non-resident sources of importing economies, see text box 1.2.1 in chapter 2.
[26] Including SUTs of all APEC economies except Papua New Guinea through direct submission, EU28 provided by FIGARO, and Rest of World estimated by OECD.

We used the following data as the initial controls: import and export vectors from Model One; total gross output; total GDP; GDP by major expenditure category; and aggregate data from SUTs, such as intermediate use, value added and gross output by industry, total supply and use by product, domestic and import intermediate use, and domestic and import final use.

In addition, we generated two sets of margin matrices from SUTs. First, we divided margin and net tax vectors in the supply tables by total supply to derive margin and net tax rates by product; and then we used these rates to multiply the purchaser's price use tables to derive the first set of margin and net tax matrices. We also used the purchaser's price use tables to subtract the basic price use tables to derive the second set of margin and net tax matrices. These two sets of data were used as the upper- and lower-bound controls for domestic margins and net tax in each cell.

We applied the following five sets of constraints during the balancing process for economy k, though we gradually relaxed them through each round of balancing process for the remaining imbalanced SUTs:

1. For each industry, total intermediate inputs purchased from all product groups and all sources (domestic and imported) as well as direct value-added generated by the industry sum up to the industry's total gross output at purchaser's and basic prices ($\sum_i (ID^k_{i,j} + IM^k_{i,j}) + V^k_j = O^k_j$);
2. For each product group, the amount used as domestic intermediate inputs by all industries plus the amount used as domestic final goods and services by final users plus the amount of domestic exports equal total product output produced by the industries ($\sum_j ID^k_{i,j} + FD^k_i + ED^k_i = O^k_i$);
3. For each product group, imported intermediate use plus imported final use plus the amount of re-exports, equal total imports of that product group at cif prices ($\sum_i FM^k_i + \sum_j IM^k_{i,j} + \sum_i RE_{i,fob} - \sum_i RE_{mark\text{-}up} = \sum_{world} M^k_{i,cif}$), which is also fixed at the global consistent level solved from Model One;
4. Domestic exports plus re-exports equal each product groups' gross exports at fob prices ($\sum_i ED^k_{i,\,fob} + \sum_i RE_{i,fob} = \sum_i E^k_{i,\,fob}$), which is also fixed at the global consistent level solved from Model One;
5. The sum of each type of final domestic demand by product group plus margin and net taxes on products and imports equals total final domestic demand for each category as recorded in each economy's GDP by expenditure account (e.g. $\sum_i FCE^k_i = \sum_i FD^k_i + \sum_i FM^k_i + \sum_i MG^k_i + \sum_i NTAX^k_i$).

The data quality and internal consistency varied in a great deal in the 44 sets of SUTs by economy and years (including 20 APEC economies, EU28, and RoW for year 2005 and 2012). Therefore, we only allowed a gradual relaxation of constraints and controls in Model Two so that we could best preserve the initial values and structure in SUTs with better quality. With seven rounds of optimization procedures, we were able to achieve the final balance of all 44 sets of SUTs:

1. 1st run: we maintained all constrains (macroeconomic data from UNSD; globally balanced export supply and import demand data from Model One; SUTs data rows and columns) and none of the SUTs could be balanced.
2. 2nd run: we relaxed the globally balanced export supply and import demand from Model One, yet all SUTs remained imbalanced.
3. 3rd run: we relaxed margin and net taxes, as well as total supply and use by product but produced no balanced SUTs.
4. 4th run: we relaxed production composition by industry, but kept total industry output fixed. The 4th run produced 30 balanced SUTs, with 14 remaining unsolved.
5. 5th run: we relaxed gross output by industry, and solved 5 additional sets of SUTs.

6. 6th run: We relaxed the total of major expenditure category (HCE, GCE, and GCF), and solved 3 additional sets of SUTs.
7. 7th run: We relaxed value added by industry, and finally solved the last 6 sets of remaining imbalanced SUTs.

The rebalanced SUTs out of Model Two maintained most APEC economies' total GDP and GDP by industry (40 SUT sets), with only four exceptions (China 2005, 2.5%; Viet Nam 2005, 0.5%; USA 2012, 0.4%; the Philippines 2012, 1.3%). The optimization results from Model Two included 44 sets of balanced SUTs. Each set included three tables: supply and use tables at basic price; import use table at c.i.f. price; plus margin matrix and net tax matrix. However, Model Two can not maintain the balance of global export supply and import demand under the SUT framework, which would be addressed in Model Three.

Model Three: Producing Balanced APECSUTs

In Model Three, we combined model one and model two to disaggregate export vector and import matrices in SUTs by trading partner and end use, and then restored the balance of export supply and import demand at both bilateral and global level for each product.

Input Data

Model Three used the results from the first two stages, as well as balanced trade statistics from early trade balancing exercise (see chapter two), and GDP by expenditure from UNSD.

Balancing Approach

At the last stage, we integrated single-economy SUTs with balanced bilateral trade statistics. To do so, we disaggregated each economy's total exports by product and every cell of its import use table by trading partner, using shares computed from balanced bilateral trade statistics (chapter 2). Each economy's total exports to and imports from the world derived from the first stage were used as controls in this process.[27.]

In addition, we also applied other constrains used at the first two stages. They are 1) supply equals demand at global, bilateral, and product levels; 2) exports equal imports at global and bilateral level by product and end use; and 3) global demand equals global supply of international margin services, which becomes a part of inter-economy, inter-industry intermediate transaction flows. It is worth to note that the treatment of international margin services is different from other available IEIO tables, which typically record international shipping margin as exogenous, and only show where these margin services are used but provide no information on where these margin services come from.

Outputs

After the optimization process of Model Three, we produced balanced APEC regional SUTs at basic price, which maintained each APEC economy's GDP by industry the same as the results from Model Two. We then converted the APECSUTs into industry-by-industry symmetric APECIOTs, based on the assumption of fixed product sales structure (model D) (Eurostat, 2008). At last, we split Papua New Guinea (PNG)

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[27] One important spillover from the model is its ability to produce updated APEC SUTs as and when (normal) revisions to GDP and trade statistics occur (i.e. excluding revisions related to conceptual changes in the accounting framework, such as the capitalization of R&D in the 2008 SNA).

from the rest of world based on PNG IOT estimates. The final APECIOTs contain 21 APEC economies, EU28, and RoW with 34 industries.

Chapter 5: APEC Trade in Value Added Indicators[28]

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Once the APECIOTs are produced, we then can estimate trade in value added (TiVA) indicators from them. This chapter describes the Leontief input-output model that underlies the calculation of TiVA measures, presents three IO-based GVC analytical frameworks, and explains major TiVA indicators produced by the APEC TiVA Initiative and their application of GVC analysis.

The Input-Output Model for Estimating the APEC TiVA Indicators

Measuring TiVA is directly relevant to the underlying input-output structure. The IO model has been used to measure the inter–industry linkages and investigate the effect of final demand changes on production at the industry level in a single economy framework (Miller and Blair, 2009). Applying the IO model to international IOTs, we can measure inter-industry linkage across economies, and evaluate the effect of final demand changes in one economy on industry production in another economy.

Table 1.5.1 An inter-economy input-output table (IEIOT) with G economies

		Intermediate Uses				**Final Use**				**Output**
		Econ. 1	Econ. 2	…	Econ. G	Econ. 1	Econ. 2	…	Econ. G	
Intermediate Inputs	Econ. 1	$\mathbf{Z}^{11}$	$\mathbf{Z}^{12}$	…	$\mathbf{Z}^{1G}$	$\mathbf{Y}^{11}$	$\mathbf{Y}^{12}$	…	$\mathbf{Y}^{1G}$	$\mathbf{X}^{1}$
	Econ. 2	$\mathbf{Z}^{21}$	$\mathbf{Z}^{22}$	…	$\mathbf{Z}^{2G}$	$\mathbf{Y}^{21}$	$\mathbf{Y}^{22}$	…	$\mathbf{Y}^{2G}$	$\mathbf{X}^{2}$
	…	…	…	…	…	…	…	…	…	…
	Econ. *G*	$\mathbf{Z}^{G1}$	$\mathbf{Z}^{G2}$	…	$\mathbf{Z}^{GG}$	$\mathbf{Y}^{G1}$	$\mathbf{Y}^{G2}$	…	$\mathbf{Y}^{GG}$	$\mathbf{X}^{G}$
Value Added		$\mathbf{V}^{1'}$	$\mathbf{V}^{2'}$	…	$\mathbf{V}^{G'}$					
Output		$\mathbf{X}^{1'}$	$\mathbf{X}^{2'}$	…	$\mathbf{X}^{G'}$					

Matrix $\boldsymbol{Z}$ (with a dimension of NG*NG; N industries; G economies) denotes supply-use flows of intermediate products. $\boldsymbol{Z}_{i,j}^{s,r}$ denotes industry i in sourcing economy s supplies product to industry j in receiving economy r for intermediate use. When the sourcing and receiving economies are different, it denotes international intermediate transactions; when they are the same, it denotes domestic intermediate transactions. For example, $\boldsymbol{Z}_{AGR,FOD}^{chn,chn}$ denotes China's domestic intermediate supply-use transactions, which

[28] The UIBE team, mainly WANG Fei and CHEN Quan Run, compiled the APEC TiVA indicators for the APEC TiVA database.

Chinese agricultural industry ($_{AGR}$) supplies inputs to domestic food industry ($_{FOD}$); $\boldsymbol{Z}_{RBP,MTR}^{mex,usa}$ denotes cross border intermediate supply-use transactions, which rubber and plastic industry ($_{RBP}$) in Mexico supplies inputs to motor vehicle industry ($_{MTR}$) in the United States.

Matrix $\boldsymbol{Y}$ (with a dimension of G*NG) denotes supply-use flows of final products. $\boldsymbol{Y}_i^{s,r}$ denotes the products supplied by industry *i* in sourcing economy *s* to receiving economy *r* for final use (including final consumption and capital formation). For example, $\boldsymbol{Y}_{AGR}^{CHL,USA}$ denotes products supplied by the agricultural industry in Chile to the United States for final consumption.

Vector $\boldsymbol{V}$ (with a dimension of NG*1) denotes industry value added in a specific economy. $\boldsymbol{V}_i^s$ denotes value added of industry *i* in economy *s*.

Vector $\boldsymbol{X}$ (with a dimension of NG*1) denotes industry gross output in a specific economy. $\boldsymbol{X}_i^s$ denotes gross output of industry *i* in economy *s*.

From the above matrices, the direct input coefficient matrix $\boldsymbol{A} = \boldsymbol{Z} * \widehat{\boldsymbol{X}}^{-1}$ (with a dimension of NG*NG) can be derived. Its element $\mathbf{A}_{i,j}^{s,r}$ indicates intermediate input sourced from industry *i* of economy *s* per unit gross output of industry *j* of economy *r*. $\widehat{\boldsymbol{X}}$ is the diagonal matrix generated from gross output vector $\boldsymbol{X}$.

Based on the above input-output structure, the Leontief input-output model can be written as

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{Y} = \mathbf{BY}$$

Where $\boldsymbol{I}$ is an identity matrix; $\boldsymbol{B}$ is the Leontief inverse matrix. Elements of this matrix express the total output, used both directly and indirectly, required to produce $1 of final product.

Form the backward linkage perspective, given final use of product $\boldsymbol{Y_i}$, the total gross output required to produce this bundle of final product is

$$\boldsymbol{X_i} = \mathbf{B}\boldsymbol{Y_i}$$

Value added created to produce this bundle of final product $\boldsymbol{Y_i}$ is

$$\boldsymbol{v_i} = \widehat{\mathbf{V}}\boldsymbol{X_i} = \widehat{\mathbf{V}}\mathbf{B}\boldsymbol{Y_i} \tag{1}$$

Where $\widehat{\mathbf{V}}$ is a diagonal matrix generated from value added ratio vector $\mathbf{w} = \boldsymbol{V} * X^{-1}$ (i.e. the value added per unit gross output).

From the forward linkage perspective, Equation (1) also indicates that value added $\boldsymbol{v_i}$ goes to produce $\boldsymbol{Y_i}$.

Three IO-Based GVC Analytical Frameworks

TiVA indicators presented in the APEC TiVA database are primarily drawn from three IO-based GVC analytical frameworks: Koopman, Wang, and Wei (KWW 2014) and Koopman, Wang, Wei, and Zhu (KWWZ 2018) gross exports accounting framework; Wang, Wei, Yu, and Zhu (WWYZ 2017) GDP and final production decomposition frameworks.

KWW (2014) gross export accounting framework breaks down gross exports (EXGR) into three major value-added categories: 1) domestic value added exports (VT); 2) domestic value added content embodies in intermediate exports that eventually return home (VS1*); and 3) foreign value content (VS). Under these three broad categories, nine sub-categories are further defined (diagram 1.5.1). The sum of VT and VS1* equals domestic content (DC) in gross exports.

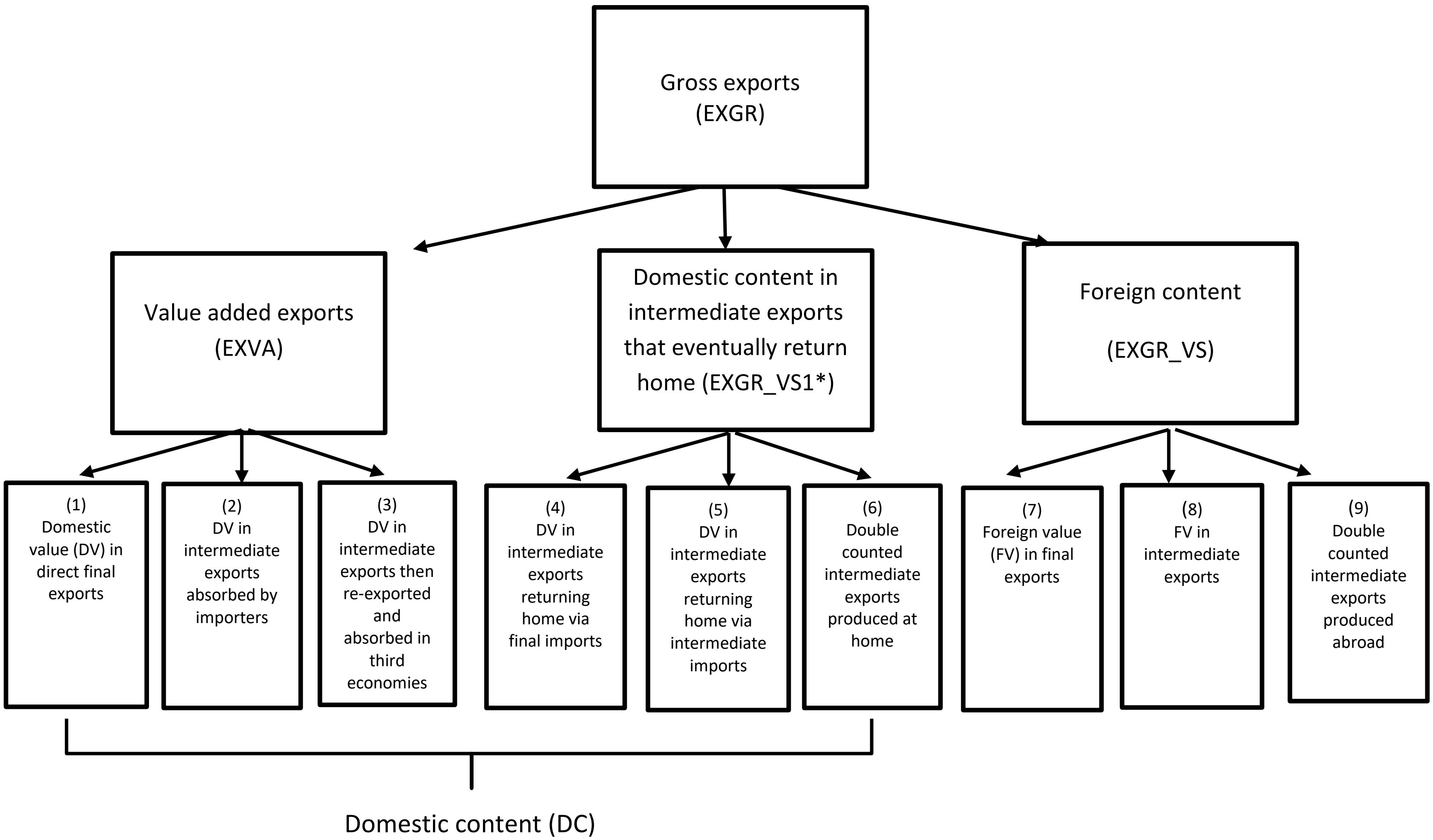
KWWZ (2018) revised KWW (2014) gross export accounting framework, making trade transactions more linked to GDP. The major change in this revised version is that double counted items are separated from the previous three major value-added categories (diagram 1.5.2).

Building upon the KWW framework, WWZ (2017) developed two additional analytical frameworks, the GDP and final production decomposition frameworks. GDP decomposition provides a producer-perspective, forward linkage-based analytical framework. It links an economy's GDP (V) with the forward destination by breaking it down into three segments: 1) a pure domestic segment, which production activities directly satisfy domestic final consumption (V_D); 2) a segment for producing final product exports as in traditional trade, which production activities are for direct final consumption abroad (V_EXFIN); and 3) a segment for producing intermediate product exports, which production activities are for intermediate trade that would be further processed along GVCs (V_EXINT). Under this framework, the second segment is considered traditional-trade related GDP production, and the third segment is considered GVC-related GDP production (diagram 1.5.3).

Final production decomposition provides a user-perspective, backward linkage-based analytical framework. It breaks down an economy's final production (Y) into three segments: 1) a pure domestic segment, which domestic value added is directly embodied in final production for domestic consumption (Y_D_DVA); 2) traditional-trade related final production, which domestic value added is directly embodied in final production for foreign consumption (Y_F_DVA); and 3) GVC related final production, which includes domestic value added returning home (Y_RDVA) and foreign value added (Y_FVA), both embodied in imported intermediate use in final production (Y_IMINT)[29] (diagram 1.5.4).

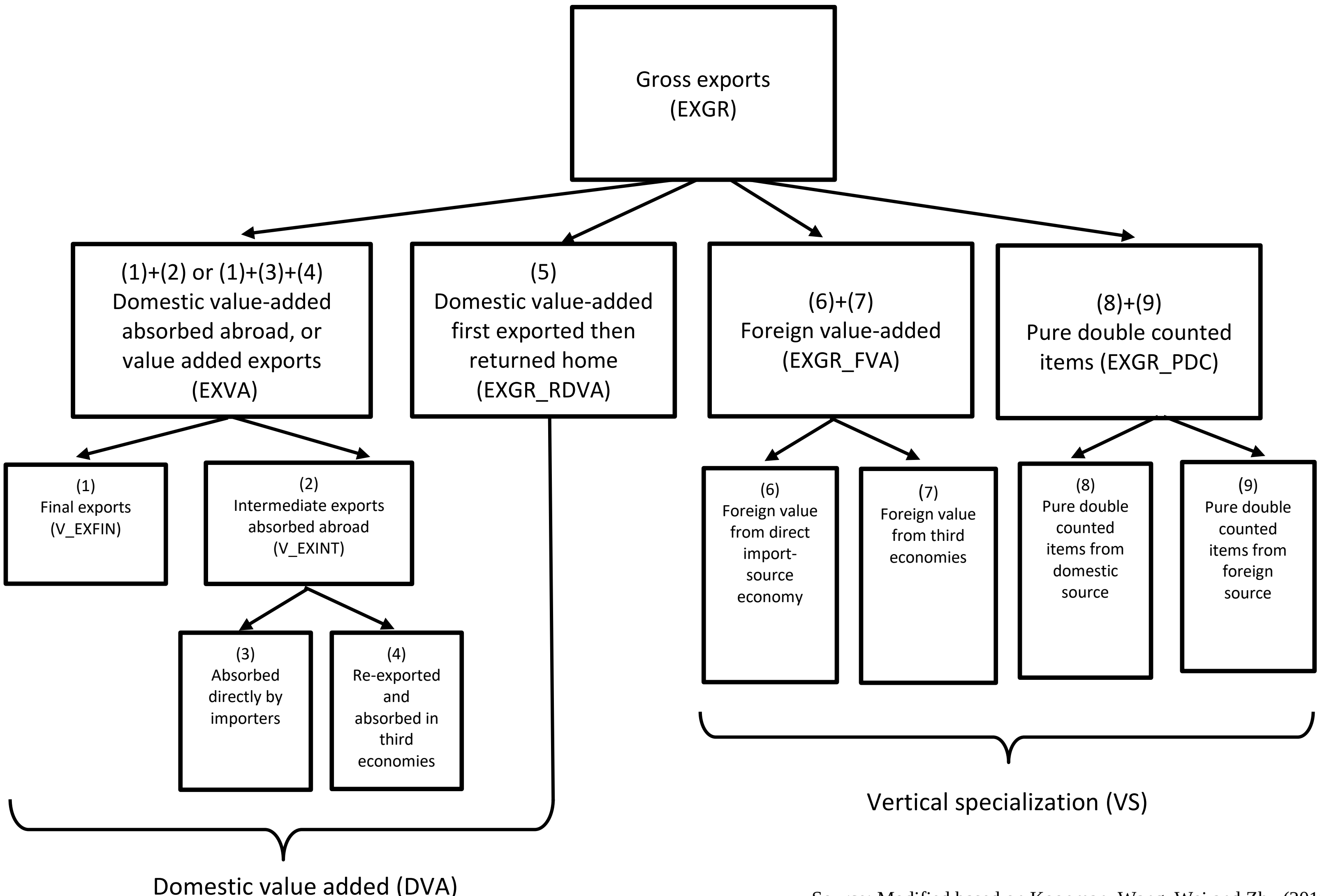
[29] Depending on how much domestic value added returning home is embodied in imported intermediate use, the share of imported intermediate use in final production and the share of foreign value added in final production can be closely aligned with each other, or deviate somewhat from each other, as we will see in economy profiles in Section two.

Diagram 1.5.1 KWW (2014) gross exports decomposition framework



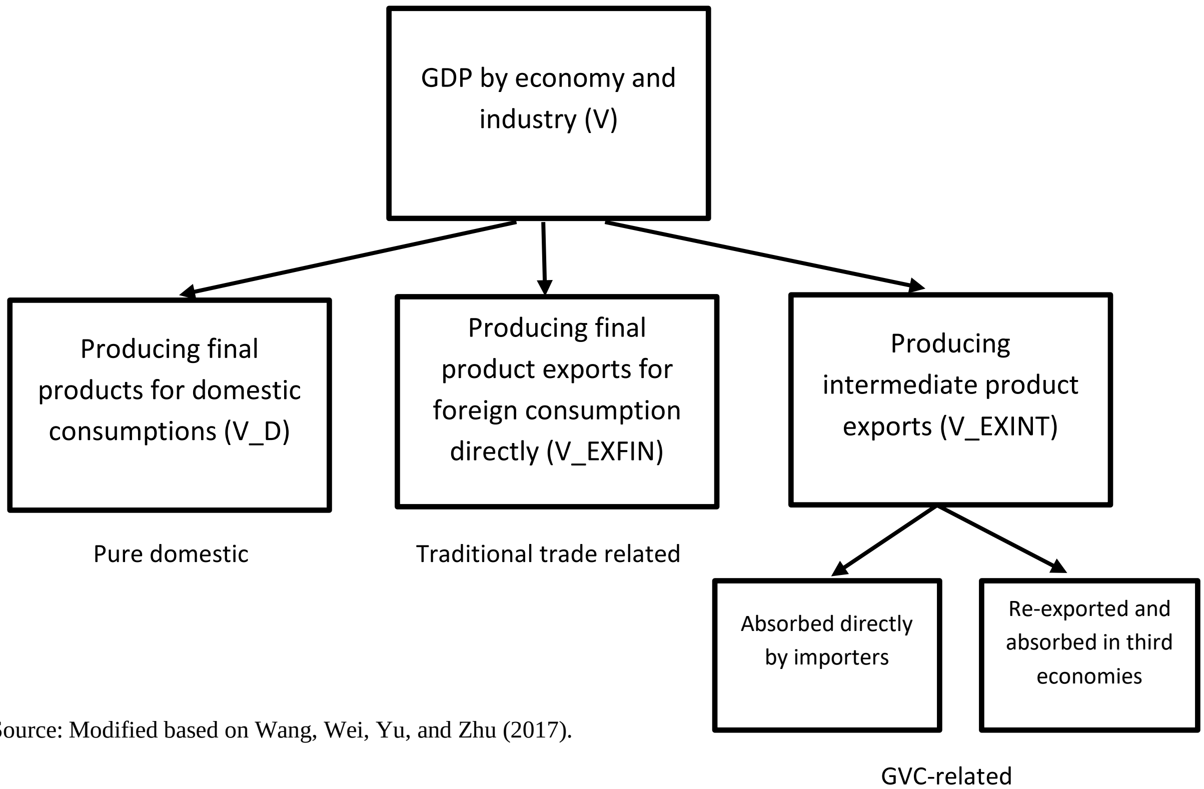
Source: Koopman, Wang, and Wei (2014).

Diagram 1.5.2 KWWZ (2018) gross exports decomposition framework



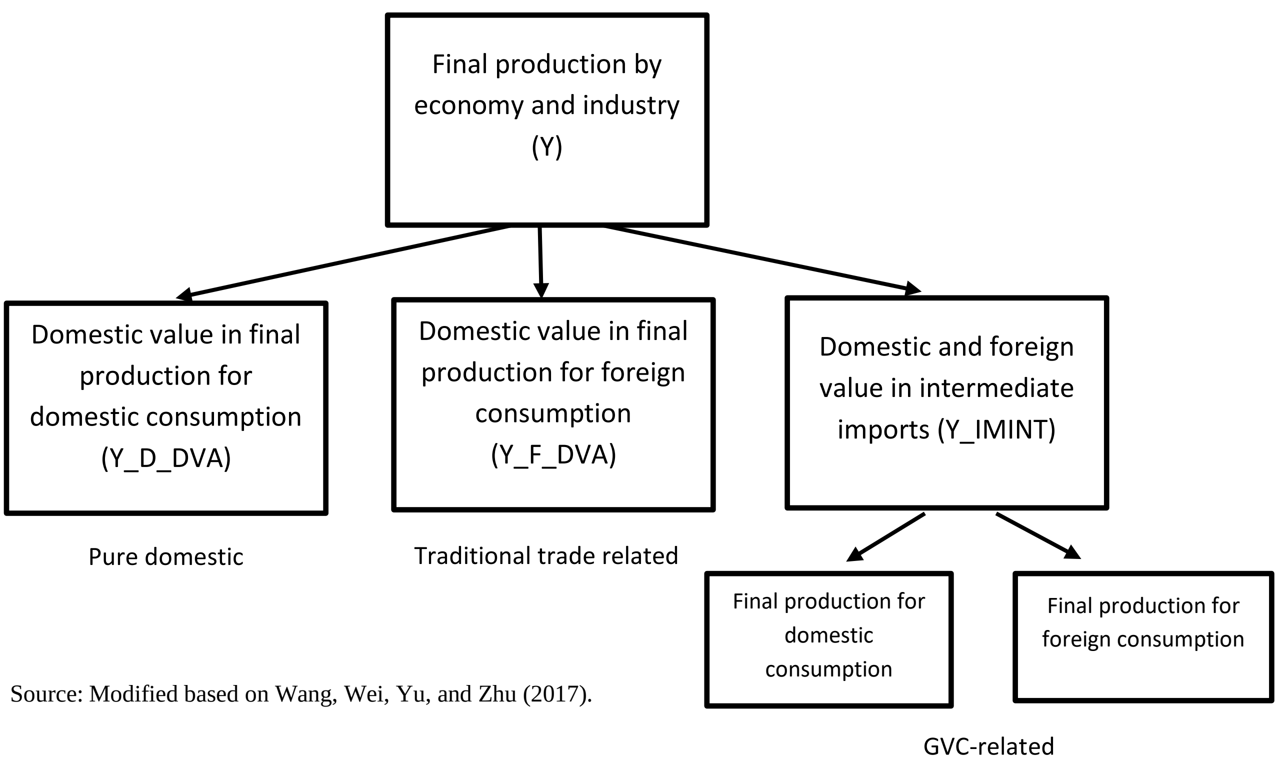
Source: Modified based on Koopman, Wang, Wei and Zhu (2018).

Diagram 1.5.3 WWYZ (2017) GDP decomposition framework



Source: Modified based on Wang, Wei, Yu, and Zhu (2017).

Diagram 1.5.4 WWYZ (2017) final production decomposition framework



Source: Modified based on Wang, Wei, Yu, and Zhu (2017).

APEC TiVA Indicators

In the era of global supply chains, the production of gross exports often uses substantial amount of imported intermediate inputs. As a result, gross exports are no longer a precise measure of an economy's income generated from international trade, nor an accurate reflection of an economy's competitiveness in global market. Recognizing such issues underlying the gross trade measures, a series of TiVA indicators have been developed as alternative, supplemental trade measures. In addition to traditional gross trade indicators, the APEC TiVA Initiative adopted five sets of major TiVA indicators. They include value added trade indicators; gross exports decomposition indicators; GDP production indicators; final production indicators; and global production indicators (table 1.5.2).

Value Added Trade Indicators

Value added trade indicators can be used to measure bilateral trade relations in value added term. They include value added exports (EXVA), value added imports (IMVA), and value added trade balance (BALVA).

Value added exports and imports describe how much value added from sourcing economy *s* is consumed by economy *r*. It satisfies

$$\boldsymbol{v}^{s,r} = \mathbf{w}^{s'}\mathbf{B}\mathbf{Y}^{r} \tag{2}$$

where $\mathbf{w}^{s'}$ is a vector of value added ratios of economy *s*, with zeros for other economies; and $\mathbf{Y}^{\boldsymbol{r}}$ is a vector of final use by economy *r*. For sourcing economy *s*, $\boldsymbol{v}^{s,r}$ is value added exports to economy *r*. From receiving economy *r*, $\boldsymbol{v}^{s,r}$ is value added imports from economy *s*.

Economy *c*'s net trade with Economy *k* (n^{ck}) in value added term is defined as the difference between economy *c*'s value added export to economy *k* (v^{ck}) and economy c's value added import from Economy *k* (v^{kc}). It satisfies

$$\boldsymbol{n}^{ck} = \boldsymbol{v}^{ck} - \boldsymbol{v}^{kc} \tag{3}$$

Gross Exports Decomposition Indicators

Gross exports decomposition indicators can provide useful information on an anatomy of an economy's gross exports. This set of APEC TiVA indicators is based on the KWWZ (2018) gross exports account framework mentioned above, including domestic value added in gross exports (EXGR_DVA), value added exports (EXVA), domestic value added returning home (EXGR_RDVA), foreign value added in gross exports (EXGR_FVA), and pure double counted items (EXGR_PDC).

Domestic value added in gross exports consists of two parts: value added exports (EXVA), and domestic value added returning home (EXGR_RDVA). It can be embodied in gross exports in two forms: either embodied in final product exports, or embodied in intermediate product exports. Domestic value added returning home is initially embodied in intermediate product exports, which is further processed abroad into downstream intermediate products or final products, and then are reimported back and consumed in home economy.

Foreign value added in gross exports is foreign value added embodied in imported intermediates that are used to produce an economy's gross exports. It is worth to note that due to intermediate trade, which intermediate products are often exported and imported directly or indirectly by an economy more than once, and thus cross border multiple times, gross exports contain double counted items (EXGR_PDC), which have been separated from the above indicators.

For instance, in 2012, Australia's total gross exports contained 78.9 percent of domestic value added, 12.4 percent of foreign value added, and 8.6 pure double counted items. About 76.4 percent was Australia's value added exports, or Australian value added absorbed abroad; and 2.5 percent was Australian value added embodied in its imports and returning home.[30]

GDP Production Decomposition Indicators

GDP production indicators provide a forward perspective on how much an economy's value added is used for producing exports. They can be used to measure an economy's forward linkage, such as how susceptible an economy is to external demand, and how integrated an economy is in global or regional production network.

GDP production indicators are broken down into two categories: value added for producing final product exports (V_EXFIN), which is considered as traditional trade-related GDP production activities; and value added for producing intermediate product exports (V_EXINT), which is considered as GVC-related GDP production activities.

For example, in 2012, China's total GDP was $8.6 trillion. About 18.6 percent of China's GDP, or $1.6 trillion, was for producing exports, directly or indirectly. About 13.0 percent of China's GDP was for producing intermediate product exports; and 5.6 percent of China's GDP was for producing final product exports.[31] Compared to gross exports, these measures reflect more accurately how much China's income was generated from export productions; and to what degree China's GDP was subject to the changes in foreign final demand and GVC production activities.

[30] Based on the preliminary APEC TiVA results, and subject further revisions.
[31] Based on the preliminary APEC TiVA results, and subject further revisions.

Final Production Decomposition Indicators

Final production indicators provide a backward perspective on the source of value added in an economy's final production, which can be from domestic (Y_DVA) or foreign source (Y_FVA). They can be used to measure an economy's backward linkage, such as how sensitive an economy is to upstream production activities in other economies, and how important imported intermediates is to an economy's final production.

For example, in 2012, Malaysia's production of final products were at $262.5 billion, 19.4 percent of which was to meet foreign final demand. Foreign value added accounted for 33.2 percent of Malaysia's total final production, while imported intermediate use accounted for 35.3 percent of Malaysia's total final production.[32] The difference between foreign value added share and imported intermediate share in final production was domestic value added embodied in imported intermediates.

Global Production Indicators

Based on GDP and final production decomposition frameworks, we compiled an additional set of TiVA indicators more targeted at measuring GVC impact.

(1) Interdependence indicators (GDP_FD)

An economy's final demand can directly and indirectly drive another economy's GDP growth via the complex global production network. The interdependence indicator attempts to measure an economy's dependence on foreign final market. The dependence ratio of economy *c* on the final demand of economy k (d^{ck}) is measured by

$$d^{ck} = \frac{v^{ck}}{GDP^c} = \frac{\mathbf{w}^{c'}(\mathbf{I}-\mathbf{A})^{-1}\mathbf{Y}^k}{GDP^c} \tag{5}$$

v^{ck} is the value added of economy *c* generated by the final demand of economy *k*, which is measured by Equation (2); GDP^c is the GDP of economy *c*. It measures to what extent Economy *c*'s production depends on Economy *k*'s final demand. It indicates the proportion of Economy *c*'s GDP driven by Economy *k*'s final demand.

For example, of 2012 US GDP, 93.1 percent was driven by domestic final demand; 1.4 percent was driven by final demand from EU28, and 1.2 percent was driven by final demand from Canada. Of 2012 China's GDP, 82.3 percent was driven by domestic final demand; 6.2 percent was driven by final demand from EU28, and 2.8 percent was driven by final demand from the United States.[33]

[32] Based on the preliminary APEC TiVA results, and subject further revisions.
[33] Based on the preliminary APEC TiVA results, and subject further revisions.

(2) GVC income indicators (GDP_GVC)

The income (value added) of an economy directly and indirectly obtained from the global production of final products is called GVC income (Timmer et al., 2013). GVC income indicators measures an economy's capability to create value added in global value chains.

For example, in computer, electrical, and optical equipment (CEQ), an industry with one of the most extensive production fragmentation, the economies generating most income from GVC production activities were China ($285.2 billion), EU28 ($220.3 billion), the United States ($195.2 billion), Japan ($117.5 billion), and Russia ($100.1 billion).[34]

(3) GVC participation indicators (FWD_GVC, BCK_GVC)

The GVC participation indicators measure the degree of an economy's participation in global GVC production. They include forward GVC participation indicators and backward GVC participation indicators. If an economy has a large share of value added created by taking part in the production of intermediate exports (FWD_GVC=V_EXINTSH), we say that this economy has high forward GVC participation. If an economy has a large share of imported intermediate inputs used in the value of its final production (BCK_GVC=Y_IMINTSH), we say that this economy has high backward GVC participation. These indicators are constructed based on the KWW GDP and final production decomposition approaches.

[34] Based on the preliminary APEC TiVA results, and subject further revisions.

Table 1.5.2 The list of selected APEC TiVA indicators

Gross trade indicators	
EXGR	Gross exports
IMGR	Gross imports
EXGR_INT	Gross exports of intermediate products
EXGR_FIN	Gross exports of final products
IMGR_INT	Gross imports of intermediate products
IMGR_FIN	Gross imports of final products
BALGR	Gross trade balance
Value added trade indicators	
EXVA	Value added exports
IMVA	Value added imports
BALVA	Value added trade balance
Gross exports decomposition indicators	
EXGR_DVA	Domestic value added in gross exports
EXVA	Value added exports
EXGR_RDVA	Domestic value added in gross exports returning home
EXGR_FVA	Foreign value added in gross exports
EXGR_PDC	Pure double counted items in gross exports
EXGR_DVASH	Domestic value added as a share of gross exports
EXVASH	Value added exports as a share of gross exports
EXGR_RDVASH	Domestic value added returning home as a share of gross exports
EXGR_FVASH	Foreign value added as a share of gross exports
EXGR_PDCSH	Pure double counted items as a share of gross exports
GDP production decomposition indicators	
V	Total value added, or GDP
V_EX	GDP production for exports
V_EXINT	GDP production for intermediate exports
V_EXFIN	GDP production for final exports
V_EXSH	GDP production for exports as a share of total GDP
V_EXINTSH (FWD_GVC)	GDP production for intermediate exports as a share of total GDP
V_EXFINSH	GDP production for final exports as a share of total GDP
Final production decomposition indicators	
Y	Total final production
Y_D	Final production for domestic consumption
Y_F	Final production for foreign consumption
Y_DVA	Domestic value added in final production
Y_FVA	Foreign value added in final production
Y_IMINT	Imported intermediate use in final production
Y_DSH	Domestic consumption as a share of total final production
Y_FSH	Foreign consumption as a share of total final production
Y_DVASH	Domestic value added as a share of total final production
Y_FVASH	Foreign value added as a share of total final production
Y_IMINTSH (BKD_GVC)	Imported intermediate use as a share of total final production
Global production indicators	
Interdependence Indicator	GDP driven by final demand from a specific economy
GVC income indicator	Value added from the global production of a specific industry’s final product
Forward GVC participation index (V_EXINTSH)	Domestic value added embodied in a specific economy’s intermediate exports as a share of total value added
Backward GVC participation index (Y_IMINTSH)	Imported intermediate use as a share of total final production

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SECTION II: Methodologies of Compiling Single-Economy Extended SUTs[35]

Compiled by Jiemin Guo, BEA

[35] This section is compiled based on the information provided by Statistics Canada (Canada), Chinese Academy of Sciences (China), Instituto Nacional de Estadistica y Geografia (Mexico), and US Bureau of Economics (the United States).

Summary:

Four economies participating in the APEC TiVA project have compiled preliminary extended supply-use tables (E-SUTs). These economies include Canada, China, Mexico, and the United States. This section provides general information on the methodologies, compilation processes, analytical results, and experiences of these economies in preparing E-SUTs. The information in this section is based on reports and documentation provided by each economy.

The E-SUTs constructed by the four economies present intensive work on data collection beyond the data required to compile standard SUTs. The experiences of these economies are valuable in improving the measurement of global value chains by identifying heterogeneity within certain industries that is not disaggregated in standard SUTs.

Each of the four economies constructed the E-SUTs with a different focus, and all had unique practices and estimation methodologies. Canada and Mexico reported E-SUTs disaggregated by all the criteria suggested in the OECD proposed E-SUT framework by identifying firm heterogeneity along the dimensions of firm ownership, exporter/non-exporter, and firm size. The E-SUTs constructed by China identified firm heterogeneity by distinguishing between domestic owned enterprises (DOEs) and foreign invested enterprises (FIEs). China was also the only economy to construct E-SUTs using the APEC TiVA industry/product classification, which allows more direct comparison between their results and the full APEC TiVA database. The United States identified firm heterogeneity by distinguishing US multinational enterprises (MNEs) and non-MNEs, with MNEs further broken down into US parents and US affiliates of foreign parents. US results allowed them to demonstrate how domestic value added embodied in inputs from upstream foreign affiliates makes a significant contribution to the content of exports in downstream industries.

Chapter 1: Canada[36]

Analytical Summary:

The E-SUTs for Canada take into account firm heterogeneity by size, economy of control and export status (disaggregated by only one characteristics at a time) and use the resulting E-SUTs to construct TiVA measures for 2010, 2011 and 2012. Analyzing these results, they were able to demonstrate that the E-SUTs reduced bias in the TiVA measures estimated from the standard tables, and TiVA statistics based on the E-SUTs had lower estimates of the domestic value-added content of exports. In addition, the E-SUTs and TiVA measures derived from them provide richer insights into the participation of small vs. large firms, domestic vs. foreign controlled firms, and non-exporters vs. exporters in the global value chain. There remains a number of issues and challenges for the construction of E-SUTs including: inconsistencies in the concept of output and inputs between micro data files and SNAs; limited information on the final using industries of the products imported by distributors; limited information on the product details used to allocate output and inputs (including both domestic and imported inputs); and limited information on inter-firm transactions of intermediate inputs between different types of firms.

Data Sources:

The E-SUTs were derived by combining standard SUT tables with firm-level data on production, economy of control, imports, and exports.

The standard SUTs are published annually with roughly a three-year lag and include 481 products and 235 industries at the most detailed classification level. To create the E-SUTs, the standard SUTs are linked to available microdata at the level of 466 products and 98 industries, including 97 business sector industries and 1 aggregate nonbusiness sector. These 98 industries are further aggregated to 87 industries by combining the detailed construction industries and combining the detailed beverage industries (e.g., wine, beverage).

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Methodology:

The firm-level data used to account for firm heterogeneity in the E-SUTs are derived by linking firm-level surveys and administrative databases using common enterprise identifiers. The final linked microdata file provides information on output, intermediate inputs, value added, imports and exports of goods, imports and exports of commercial services, and economy of control at the enterprise level for all incorporated

[36] For more information, see http://www.iariw.org/copenhagen/wulong1.pdf.

businesses in Canada. The final linked microdata file links the NA business microdata file with the following cross-sectional microdata files:

- Trade by Enterprise Statistics (TEC) Micro Database (Imports and Exports): The TEC dataset is a database obtained by linking customs trade records to the Canadian Business Register (BR). The customs data are extracted from administrative files from the Canadian Border Services Agency (CBSA). The statistical unit for exports and imports is the business number (BN) that is required for all businesses that deal with CBSA for various programs including exports-imports, taxes, and payroll. A BN number could be assigned to a factory, plant or head office. The data on exports and imports at the BN level are aggregated to the enterprise level using the Business Registry.

- International Transactions in Commercial Services: There are four types of international trade in services: travel, transportation, commercial services and government services. For the E-SUTs, only international trade in commercial services by enterprises are used.

- Inward Foreign Affiliate Statistics (FAS): FAS data describe the activities and financial positions of majority-owned domestic affiliates (MODAs) by foreign investors operating in the Canadian economy. MODAs are defined as domestic entities where a foreign direct investor owns more than 50% of the voting shares. Inward FAS data are an extension of statistics on Foreign Direction Investment, and they provide insight on the effect of foreign controlled enterprises on output, employment, productivity, and international trade in the Canadian economy.

  The economy of control in the FAS data can be defined as the economy of the ultimate investor or the economy of immediate investor. The economy of the ultimate investor gives information about who controls a domestic direct investment enterprise. The economy of the immediate investor expands on this by providing, down the chain of related enterprises, the economy that is the direct investor before entering the domestic economy. In the context of MNEs using complex enterprise structures, the notions of both ultimate and immediate investors provide relevant perspectives on majority ownership and control in the domestic economy. For the E- SUTs, both concepts were used to define foreign and domestic controlled enterprises.

Almost all the enterprises in the TEC-exports data, FAS database, and trade in commercial services database are linked to the enterprises in the NA business microdata file. For the TEC-imports database, about 75% of business units BNs are linked to the NA business micro database, accounting for about 95% of the total imports in the imports database. The businesses that are not linked are small and are likely to be unincorporated businesses which would not be found in the NA business microdata file which only includes incorporated businesses.

To develop E-SUTs, the enterprises in the linked file are classified by size, economy of control or export status as follows:

- Firm Size: small (0 to 49); medium (50 to 249) and large (250 or above);
- Export Status: exporters and non-exporters, and
- Economy of Control: Foreign- and domestic-controlled firms.

The firms are disaggregated by only one characteristic at a time. When firms are disaggregated by more than one characteristic, the number of firms in a large number of industry–firm type cells are found to be small, raising concerns about both confidentiality and reliability.

Chapter 2: China:

The Chinese Academy of Sciences (CAS) team constructed E-SUTs for China for 2012 using the commodity/industry framework from the APEC TiVA project. The methodology outlined below includes a description of data sources used, the overall estimation process and methodology, and issues encountered during the estimation process along with corresponding solutions.

Data Sources:

The data sources for the E-SUTs include the APEC SUTs provided by the Chinese National Bureau of Statistics (NBS), the extended input-output tables (E-IOTs), and the supply-use tables prepared following the NBS commodity/industry classification. The APEC SUTs provided the main foundation for the construction of the E-SUTs and included supply tables, import use tables, and use tables at basic prices and purchasers' prices.

In addition to the APEC SUTs, other data sources included extended product-by-product input-output tables on the NBS classification with 139 products, and supply-use tables on the NBS classification with 62 industries and 96 products. Considering limitations on data to measure firm heterogeneity for certain industries, the supply-use tables had to be rolled up into 52 industries and 84 products. The E-IOT was also rolled up into 84 products to satisfy the requirement of the extended use table calculation.

Prior to the APEC E-SUT construction, China compiled the product-by-product E-IOTs. These tables subdivided firms into DOEs and FIEs based on China Input-Output table 2012. E-IOTs followed the NBS classification standard of 139 products. E-IOTs are the main foundation for the E-SUTs' construction because most of the E-IOT split ratios were on the NBS classification standard and the E-IOTs have been widely applied and approved in the academic field.

Estimation Methodology:

Supply Table:

The supply table with 62 industries and 96 products was selected as a starting point for calculating the split ratios between DOEs and FIEs since it followed the same classification standard as the related data on firm heterogeneity. This supply table was split into DOE and FIE components to obtain the initial extended supply table under the NBS classification system. The split ratios were the output ratios between the DOEs and the FIEs by industry from statistical yearbooks. After some necessary rollup of details, there remained 52 industries and 84 products in the initial extended supply tables.

To match the APEC classification, the initial supply table was adjusted from the NBS classification to the APEC classification. After the adjustment, the extended supply table on an APEC classification was obtained, but there remained small mismatches between the APEC supply table provided by NBS and the resulting extended supply tables. Further steps were needed to better align the two supply tables.

First, the standard APEC supply table was treated as a constraint and values from the original extended supply table were used as distribution ratios to split out DOEs and FIEs. This ensured that the sum of related DOE and FIE cells in the extended supply table matched the corresponding cells in the APEC supply tables. Next, the domestic supply matrix in the APEC supply table was split into DOEs and FIEs using the distribution ratios calculated from the initial extended supply table, while the valuation vectors remained the corresponding values in the APEC supply table. After the above treatment, the extended supply table under the APEC framework was obtained.

Use Table:

To match the APEC classification, the original extended use table was adjusted from the NBS classification standard to the APEC classification. After the adjustment, the extended use table on the APEC classification was obtained, but there remained small mismatches between the APEC use table and the constructed extended use table. Additional adjustments were needed to align the two use tables.

After aligning the two use tables, the extended use table on the APEC framework was obtained. The data used in this step included the APEC use table at basic prices, the APEC import use table at cost, insurance, and freight (CIF) valuation and the extended use table itself.

The use table was divided into a domestic use matrix, an import use matrix, and a value-added matrix, and there were different requirements for dividing each of these matrices into DOE and FIE components.

- Domestic use matrix: The domestic use matrix needed to be split into four parts: the DOE products used by the DOE industries, the DOE products used by the FIE industries, the FIE products used by the DOE industries, and the FIE products used by the FIE industries. The domestic final use needed to be divided into the domestic final use of the DOE products and the domestic final use of the FIE products.

- Import use matrix: The split of the import use matrix was similar to the split of the domestic use matrix. APEC import use was divided into two parts: the DOEs and the FIEs by industries, while the final use remained the values in the APEC import use table.

- Value added matrix: The split of the value-added matrix was the same as the split of the domestic use matrix. The value-added matrix was divided into the DOEs and the FIEs by industry.

Transformation from the NBS classification to the APEC classification was accomplished using a product classification concordance matrix and an industry classification concordance matrix. After the transformation, the largest error rate for all products and industries between the original SUTs and the transformed APEC SUTs was no higher than 3%.

Results:

Empirical analysis of the results shows that the DOEs and FIEs are different in many respects, including production inputs, export patterns, and impacts on the local economy. For example, compared with DOEs, FIEs are more export oriented. In addition, DOEs and FIEs play different roles in generating local value added. A large portion of value added from global value chains in developing economies is generated by affiliates of MNEs. In addition, DOEs and FIEs show different impacts on technology dissemination and skill building. From these differences, the importance of capturing firm heterogeneity when compiling SUTs and input-output tables is clear. Otherwise, the simple assumption of homogeneity results in biased estimates in many cases that could mislead policy makers. Based on the Chinese E-SUT for 2012, the heterogeneity between DOEs and FIEs on value-added exports is clearly visible.

Chapter 3: Mexico

Mexico constructed E-SUTs for 2013 by adopting the OECD framework of identifying firm heterogeneity by three main dimensions: exporter / non-exporter, ownership, and size of economic unit. The methodology below discusses the data sources used, issues encountered in developing the estimates, and the overall estimation process.

Data Sources:

The two main data sources are the 2014 Economic Census (EC) and the Foreign Trade Database (FTD). The EC provides statistical information at the establishment-level basis for calendar year 2013. The FTD provides transactions that were carried through customs requests based on the Harmonized Commodity Designation and Coding System.

Methodology:

Exporter establishments are identified as establishments where part of their production or sales are sent to a foreign market or if they engaged in some kind of export processing activity. Non-exporters are identified as those establishments that registered only production or sales to the economy. Mexico linked the EC and the FTD to identify those establishments that registered transactions of goods and/or services abroad and to the economy as exporters. The remaining establishments in the EC, which registered transactions of goods and/or services solely in the economy, are labeled as non-exporters. The linkage of the EC and the FTD resulted in coverage of 84% of the total value of exports of goods.

From the linked data, distribution coefficients are estimated based on total census gross production for each economic activity to determine the proportion of the economic activity that consists of exporters versus non-exporters. Each cell of the SUTs are disaggregated based on the coefficients. Non-exporter estimates are obtained by the difference between the total economy value less the value for exporters.

Firm ownership groups the establishments into four categories: domestic owned, domestic owned affiliate, foreign owned, and foreign owned affiliate. The main data sources for this breakout are the FTD and the database of subsidiaries, which is extracted from the EC and contains information on an establishment's amount of foreign capital.

Each category is then further segmented by size into one of three categories based on the number of employed personnel: small (1 to 50), medium (51 to 250) and large (251 and more). The distribution is based on data from the EC which collects information on the number of employees.

Additional sources of data are required to further distribute the categories by size for selected sectors such as the agricultural sector. Estimates for the agricultural sector rely on information from the National Agricultural Survey (NAS) 2012, including hectares for crops and heads for cattle to generate establishment size splits. Hectare of crops and heads of cattle are more stable units of measure compared to personnel employed in the agricultural sector.

Results:

The information contained in the E-SUTs for each profile has great value for decision-making, both in the public sphere for the formulation of public policies, as well as in the private sphere for the development of investment projects. They can be used as an analysis tool to complement the projects of public or private institutions or those developed at INEGI, such as the satellite accounts.

Chapter 4: United States[37]

The United States identified firm heterogeneity by utilizing data on US MNEs and non-MNEs. The following sections outline the main data sources, the methodology and some findings from the development of the E-SUTs.

Data Sources:

The E-SUTs used data from two main sources: 1) a time series of SUTs published as part of the Bureau of Economic Analysis' industry accounts and 2) activities of multinational enterprises (AMNE) statistics and data on trade in services collected and published as part of BEA's international accounts. In addition to these two primary datasets, direct use was also made of several datasets from the Census Bureau.

Firm heterogeneity was introduced into the SUTs through the incorporation of BEA AMNE statistics. The AMNE statistics cover the financial and operating characteristics of US parent companies (domestic-owned MNEs) and US affiliates that are majority-owned by foreign MNEs (foreign-owned MNEs). They are based on legally mandated surveys conducted by BEA and are used in a wide variety of studies to estimate the impact of MNEs on the domestic (US) economy and on foreign host economies.

Methodology:

For both 2005 and 2012, inward AMNE survey data is used to measure the presence of foreign-owned MNEs and data from the outward AMNE surveys for domestic-owned MNEs. For our initial experimental tables, the data include components of value added, sales, and trade in goods for both domestic-owned MNEs and foreign-owned MNEs for 31 industries for which the relevant data were published for both surveys. For domestic-owned MNEs, data exclude those that are majority-foreign-owned from the published outward AMNE data because these companies appear in both the inward and the outward AMNE datasets.

The BEA trade in services data by firm type are allocated to industries based on firm-level bridges between the trade in services and the AMNE data with exceptions for trade in transport, travel, and government goods and services. These three services trade categories could not be matched directly to firms in the AMNE data. Transport data could not be matched directly because there is not currently an ID bridge between BEA's transportation surveys and the AMNE surveys. Travel data could not be matched directly because the source data are classified based on the buyer not the seller. Data for firms supplying goods and services to the government could not be matched directly because they are based on data sources that are aggregated above the firm level.

The ownership type for transport, travel, and government goods and services trade data are based on the types of firms believed to be primarily engaged in this type of trade and on data for gross output by ownership type from the E-SUTs. Exports of travel services were allocated based on 2012 data from BEA's Travel and Tourism Satellite Account, 2013 data from the Survey of International Air Travelers, and 2012 data on gross output by ownership type from the E-SUTs. Since imports of travel services and imports of passenger fares for personal travel are typically not made by firms, but by individual consumers, these imports were allocated to "final demand" rather than to a firm type.

[37] For more information, see https://www.bea.gov/system/files/papers/WP2018-12.pdf.

These tables are a precursor to more precise estimates of E-SUTs that will eventually result from ongoing collaboration between the BEA and the US Census Bureau on a microdata linking project. For the preliminary work that has been done for the microdata linking project, the MNEs were identified by linking the establishment level 2012 Census of Manufactures data with the 2012 BEA outward and inward AMNE surveys. Firm size class for the establishments and export intensity are also identified from linking various Census databases.

In addition, the following adjustments and calculations are made to construct the E-SUTs: enterprise-to-establishment adjustment, decomposing the purchasers' price use table into component matrices, and estimating firm type shares.

Once the E- SUTs are constructed, a symmetric industry-by-industry E-IOT is derived from the E-SUTs. In the E-SUT, export data appear only on a commodity basis; however, the IOT includes a distribution of exports by industry and firm type. The shares for exports are applied at this stage of the process, and offsetting adjustments are made to non-export activity to keep totals for each row unchanged. TiVA statistics can then be calculated from this "export adjusted" IOT.

Results:

Following the development of the E-SUTs, an analysis of the results showed that the imported content of exports is concentrated in a few industries such as petroleum and motor vehicle manufacturing. In addition, most of the content of exports by firms in goods-producing industries is from US MNEs and most of the content of exports in services industries is from non-MNEs. However, domestic value added embodied in inputs from upstream foreign affiliates makes a significant contribution to the content of exports in several industries. The results provide further evidence that accounting for firm heterogeneity matters in measuring production.

Conclusion

APEC has become the premier, and most extensive and influential regional economic cooperation forum in the Asia-Pacific, unified in a common drive to build a dynamic and prosperous Asia-Pacific community. In pursuit of economic growth, better well-being of people, and common prosperity of the region, APEC has propelled progress through “two wheels”-trade and investment liberalization and facilitation and economic and technical cooperation. This has brought APEC economies together and made them become the main engine of global growth.

Global Value Chains (GVCs) have become a dominant feature of the APEC economy. GVC integration provides opportunities to achieve productivity growth, employment gains, increased living standards, and poverty reductions for APEC economies at all levels of development. By linking into GVCs, APEC economies (especially developing economies) do not need to build the entire course of production capacity for a product and instead can use their comparative advantage to concentrate on a specific task, allowing them to integrate into the global economy more rapidly.

Under this circumstance, APEC TiVA database produces tools to assist economies to better understand global production networks. The method of global value chains and supply-use tables expands the measurement of APEC economy, and could further analyze the interaction of different APEC economies and sectors. After carefully reviewed the industry output, total value added, imported intermediate use intensity etc, the main findings of this report read as follows:

(a) Total output of the APEC region increased by 73.1 percent from $50.6 trillion in 2005 to $87.6 trillion in 2012.
(b) Total value added, or the equivalent of gross domestic product (GDP), of the APEC region increased by 59.7 percent from $25.3 trillion in 2005 to $40.4 trillion in 2012.
(c) APEC economies used 13.8 percent of intermediate inputs from foreign sources in 2012, a small increase from 13.3 percent in 2005.
(d) Foreign value added share of gross exports for the APEC region increased slightly from 17.0 percent in 2005 to 18.5 percent in 2012, correlating with the increased use of imported intermediate in the region.
(e) In the APEC region, foreign value added as a share of final production increased from 10.7 percent in 2005 to 12.9 percent in 2012, indicating the increasing GVC backward linkage in the region as well.
(f) Consumption innovation drives economic growth, and the importance of service sectors has become more prominent.
(g) GVCs are becoming much more concentrated on the demand side, which increases the importance of speed to market in company decisions about where to produce goods.

Understanding these facts will help to review the real picture about the overall GVCs situation and policy implications within APEC region and beyond.

APEC TiVA database is supported by wide participation among member economies and international organizations and thus demonstrates a significant milestone on economies’ cooperation on Trade in Value-added measurement. May the APEC TiVA project be a good start to bring APEC economies together and enhance the future global and regional TiVA collaboration in the future.

Appendix A APEC TiVA Data Classifications

Table A.1 APEC TiVA product classification

	Product description
1	Cereals
2	Vegetables
3	Fruit and nuts
4	Other products of agriculture, horticulture and market gardening, ne.c
5	Coffee, tea, and spice crops
6	Live animals and Other animal products
7	Forestry and logging products
8	Fish and other fishing products
9	Coal and lignite; peat, crude petroleum and natural gas
10	Other Minerals, n.e.c
11	Electricity, town gas, steam and hot water
12	Water
13	Meat, fish, fruit, vegetables, oils and fats and dairy products
14	Grain mill products, starches and starch products; other food products
15	Beverages and Tobacco
16	Clothing and wearing apparel; leather and leather products
17	Products of wood, cork, straw and plaiting materials; pulp, paper and paper products, printed matters, and related articles
18	Basic Chemical and Other Chemicals
19	Rubber and plastics products
20	Glass and glass products and other non-metallic products n.e.c.
21	Furniture
22	Other transportable goods
23	Basic metals
24	Fabricated metal products, except machinery and equipment
25	General and Special Purpose Machinery
26	Office, accounting and computing machinery
27	Electrical machinery and apparatus;
28	Radio, television and communication equipment and apparatus
29	Medical appliances, precision and optical instruments, watches and clocks
30	Transport equipment
31	Manufacturing, n.e.c
32	Construction services
33	Wholesale and retail trade services
34	Lodging; food and beverage serving services
35	Land transport services
36	Water transport services
37	Air transport services
38	Supporting and auxiliary transport services
39	Postal and courier services
40	Financial intermediation services,and investment banking,
41	Insurance and pension services (excluding reinsurance services), except compulsory social security services
42	Real estate services
43	Leasing or rental services without operator

44	Research and development services
45	Other business and production services, n.e.c
46	Telecommunications services; information retrieval and supply services
47	Public administration and other services to the community as a whole; compulsory social security services
48	Education services
49	Health and social services
50	Recreational, cultural and sporting services
51	Other services, n.e.c

Table A.2 APEC TiVA industry classification

Industry Code	Industry description
AGR	Agriculture, hunting, forestry and fishing
MIN	Mining and quarrying
FOD	Food products, beverages and tobacco
TEX	Textiles and textile products, leather and footwear
WOD	Wood and products of wood and cork
PAP	Pulp, paper, paper products, printing and publishing
PET	Coke, refined petroleum products and nuclear fuel
CHM	Chemicals
RBP	Rubber and plastics products
NMM	Other non-metallic mineral products
MET	Basic metals
FBM	Fabricated metal products, except machinery and equipment
MEQ	Machinery and equipment, nec
CEQ	Computer, electronic and optical equipment
ELQ	Electrical machinery and apparatus, nec
MTR	Motor vehicles, trailers and semi-trailers
TRQ	Other transport equipment
OTM	Manufacturing nec recycling (include Furniture)
EGW	Electricity, gas and water supply
CON	Construction
WRT	Wholesale and retail trade
HTR	Hotels and restaurants
TRN	Transport and storage
PTL	Post and Telecommunications
FIN	Finance and insurance
REA	Real estate activities
RMQ	Renting of Machinery and equipment
ITS	Computer and related activities
BZS	R&D and other business activities
GOV	Public administration and defense, compulsory social security
EDU	Education
HTH	Health and social work
OTS	Other community, social and personal services
PVH	Private households with employed persons & extra-territorial organizations & bodies

Table A.3 The list of 49 EBOPS categories available in the APEC TiVA balanced services trade statistics

	49 EBOPS Category
S0	Total services
SA	Manufacturing services on physical inputs owned by others
SB	Maintenance and repair services nie
SC	Transport
SC1	Sea transport
SC2	Air transport
SC3	Other modes of transport
SC4	Postal and courier services
SCA	Passenger transport
SCB	Freight transport
SCC	Other transport (including postal and courier)
SCC1	Other transport (excluding postal and courier)
SC11	Sea transport: passenger
SC12	Sea transport freight
SC13	Sea transport: Supporting and auxiliary and other services
SC21	Air transport: passenger
SC22	Air transport freight
SC23	Air transport: Supporting and auxiliary and other services
SC31	Other mode of transport: passenger
SC32	Other mode of transport freight
SC33	Other mode of transport: Supporting and auxiliary and other services
SD	Travel
SE	Construction services
SF	Insurance and pension services
SF1	Direct insurance
SF12	Freight insurance
SF11	Life insurance
SF13	Other direct insurance
SF2	Reinsurance
SF3	Auxiliary insurance services
SF4	Pension and standardized guarantee services
SG	Financial services
SH	Charges for the use of intellectual property nie.
SI	Telecommunication computer and information services
SI1	Telecommunications services
SI2	Computer services
SI3	Information services
SJ	Other business services
SJ1	Research and development services
SJ2	Professional and management consulting services
SJ3	Technical and trade-related and other business services
SK	Personal cultural and recreational services
SK1	Audiovisual and related services
SK2	Other personal, cultural and recreational services
SK21	Health services
SK22	Education services
SK23	Heritage and recreational services
SK24	Other personal services
SL	Government goods and services nie

Appendix B The Summary of APEC Data Submission

Table B.1 The summary of available SUTs and IOTs in APEC economies

APEC Economy	SUTs	IOTs
Australia	1994-95 to 2016-17	
Brunei	2005, 2010	2005, 2010
Canada	2005, 2010, 2011, 2013	n/a
Chile	2008-2013	2008-2013
China	2005, 2012	2005, 2012
Indonesia	2005, 2010	2005, 2010
Hong Kong, China	2005, 2011	n/a
Japan	n/a	2005, 2011
Korea	2010-2014	2005-2014
Malaysia	2005, 2010, 2012	2005, 2010
Mexico	2008	2008, 2012
New Zealand	2007, 2013	2007, 2013
Papua New Guinea	n/a	n/a
Philippines	2006, 2012	2006, 2012
Peru	2007*, 2008 -2012	2007*
Russia	2005-2012	n/a
Singapore	2005, 2010	2005, 2007, 2010, 2012
Chinese Taipei	2006, 2011	2006, 2011
Thailand	2007, 2012	2000, 2005, 2010
United States	1997-2014	n/a
Viet Nam	2007, 2012	2007, 2012

Source: based on the questionnaire response from 17 APEC economies, with additional information from the Asian Development Bank.

Table B.2 The available 2005 and 2012 SUT data by APEC economy

APEC economy	2005				2012			
	Supply	Use (pp)	Use (bp)	Import use (CIF)	Supply	Use (pp)	Use (bp)	Import use (CIF)
Australia	*	*	*	*	*	*	*	*
Brunei	√	√	√	√	√	√	√	√
Canada	*	*	*	*	*	*	*	*
Chile (1)	√	√	√	√	*	*	*	*
China	*	*	*	*	*	*	*	*
Chinese Taipei	*	*	*	*	*	*	*	*
Indonesia (2)	*	*	*	*	√	√	√	√
Hong Kong, China	*	*	*	*	*	*	*	*
Japan(3)	√	√	√	√	*	*	√	√
S. Korea (4)	√	√	√	√	*	*	*	*
Malaysia (5)	*	*	*	*	*	*	*	*
Mexico	√	√	√	√	*	*	*	*
New Zealand (6)	√	√	√	√	*	√	*	√
PNG (IOT)	√				√			
Peru	√	√	√	√	√	√	√	√
Philippines(7)	√	√	√	√	√	√	√	√

Russia	*	*	*	*	*	*	*	*
Singapore	*		*	*	*		*	*
Thailand	√	√	√	√	*	*	√	√
USA	*	*	*	*	*	*	*	*
Viet Nam	√	√	√	√	*	*	*	*

Note:

√: Data or documentation was estimated or prepared by CTTF.
*: Data was submitted by economy.
(1) Chile submitted SUTs for years 2008–2013. Based on its submitted data, CTTF compiled its 2005 SUTs.
(2) The Indonesian SUTs are compiled by BPS of Indonesia together with CTTF.
(3) Japan only submitted the supply table at producer’s price and use table at “purchaser’s” price in 2012, which the output and value added by industries are at producer’s price.
(4) Korea submitted SUTs for 2010-2014, and IOTs for 2005-2014. Based on its submitted data, CTTF compiled its 2005 SUTs.
(5) Malaysia prepared and submitted 2005, 2010, and 2012 SUTs.
(6) New Zealand has submitted 2013 SUTs at basic prices in NA06CC. CTTF transformed these tables into APEC classification and estimated the use tables at purchasers' prices.
(7) Philippines' SUTs for 2012 are at producers' prices for the lack of essential information data.

Table B.3 The summary of services trade data with the world submitted by participating APEC economies

APEC economies	**Available EBOPS Categories**			
	2005		**2012**	
	Exports	**Imports**	**Exports**	**Imports**
Australia	71	68	71	69
Brunei Darussalam	18	20	15	20
Canada	26	26	26	26
Chile	15	15	15	15
China	38	39	46	46
Hong Kong, China	38	40	38	40
Indonesia	13	12	13	12
Japan	22	22	25	25
Korea	n.a.	n.a.	46	46
Malaysia	n.a.	n.a.	24	24
Mexico	n.a.	n.a.	21	23
New Zealand	n.a.	n.a.	11	11
Peru	17	17	21	23
The Philippines	24	24	25	25
Papua New Guinea	n.a.	n.a.	n.a.	n.a.
Russia	14	14	40	41
Singapore	23	23	23	23
Chinese Taipei	16	17	16	17
Thailand	12	11	12	11
United States	29	29	38	46
Viet Nam	n.a.	n.a.	21	23

Source: based on participating APEC economies’ submitted services trade data

Table B.4 The summary of bilateral services trade data submitted by participating APEC economies

APEC economies	2005		2012	
	Available trading partners	**Available sectors**	**Available trading partners**	**Available sectors**
Australia	22 (20 APEC)	13	22 (20 APEC)	13
Canada	17 (17 APEC)	15	17 (17 APEC)	15
China	23 (20 APEC)	39	23 (20 APEC)	46
Hong Kong, China	22 (20 APEC)	9	22 (20 APEC)	9
Japan	16 (16 APEC)	12 (EBOPS2002)	16 (16 APEC)	13 (EBOPS2010)
Malaysia	n.a.	n.a.	23 (20 APEC)	16
Mexico	n.a.	n.a.	2 (2 APEC)	1
New Zealand	n.a.	n.a.	135 (20 APEC)	11
Singapore	15 (7 APEC)	12	15 (7 APEC)	12
United States	21 (19 APEC)	17	21 (19 APEC)	28

Source: based on participating APEC economies' submitted services trade data