Part I:

Compilation of the Input-Output Tables and Its Application with Trade Statistics

1. Compilation of the Taiwan-Japan International Input-Output Tables 2016 and Export Status-Based Extension*

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1. Introduction

While research on Global Value Chains (GVCs) has advanced significantly in recent years, data that enables detailed understanding of the different roles and interrelationships between exporting and non-exporting firms in the East Asian region remains insufficient. This project aims to compile a granular international input-output table for Japan and Taiwan, extended by export status, to more precisely understand the reality of both countries' GVC participation.

GVC research has recently developed in two directions: the development of value-added trade concepts and attempts focusing on firm heterogeneity. Koopman et al. (2014) developed the value-added trade concept and revealed the dynamics of increasingly complex international production activities using international input-output tables. Meanwhile, the firm heterogeneity model (Melitz 2003) showed that differences in firm productivity are determinants of international trade participation, theoretically explaining that there are fundamental differences between firms that participate in GVCs and those that do not.

Recently, these two approaches have been merged, and development of new international IO incorporating the concept of firm heterogeneity has progressed (e.g., Cadestin et al. 2018). Firm heterogeneity refers to differences between firms in terms of productivity and scale. To apply this concept to international IO, efforts are being made to subdivide transactions mainly from three perspectives: by firm size, ownership structure, and export status.

While production networks in the East Asian region are characterized by close collaboration between exporting and non-exporting firms, large firms and SMEs, international input-output tables (international IO) reflecting this complex structure have not yet been created. To fill this gap, this project has developed data considering the differences between exporting and non-exporting firms for Japan and

Taiwan as a first step in a phased approach. Future plans include expanding to divisions by firm size, ownership, and combinations thereof.

A distinctive feature of this data is that it not only divides the international IO but also captures the Information and Communication Technology (ICT) industry in more detail than tables published by other international organizations. The ICT industry has high strategic importance for Japan and Taiwan, with complex GVC structures and significant spillover effects on other industries. Therefore, understanding the input-output structure of the ICT industries in Japan and Taiwan in detail is also significant for industrial policy planning in both countries. Particularly as the geopolitical importance of Taiwan's semiconductor industry increases, this data is expected to contribute to evaluating inter-firm dependencies, important nodes in industrial structures, and supply chain vulnerabilities, supporting policy planning and corporate strategies for effective risk management and sustainable industrial development.

This project provides a standard Taiwan-Japan international input-output table (NJIO)[1] with detailed sector classification (86 sectors) and an extended table based on export status (22 sectors), as well as explaining their compilation methods.

This paper first explains the overview of international input-output tables and details the compilation method for the standard table (86 sectors). After explaining data consistency checks and adjustment techniques, it describes the overview and compilation method of the extended table based on export status (22 sectors). Finally, it addresses future challenges. This paper is based on Uchida et al. (2023) with additions and revisions.

1. Overview of the NJIO

International IO have more of a "model" nature rather than pure data, as they are compiled by combining multiple data sources with specific assumptions. Therefore, this paper positions the constructed table as an "input-output model" rather than a pure dataset.

The Institute of Developing Economies (IDE) has played a pioneering role in developing such international input-output models. Since publishing the "ASEAN International Input-Output table for 1975" in 1982, IDE has accumulated expertise in compiling international IO through meticulous methods such as conducting surveys and scrutinizing trade statistics. This effort continued until the compilation of the Asian International Input-Output Table (AIO) for 2005, with six tables published[2]. In recent years, universities and international organizations have also begun publishing international IO, and the compilation of international IO is developing in various directions.

For example, the OECD began compiling and publishing Inter-Country Input-Output tables (ICIO) from 2013, and in 2023 provides data up to 2020 covering 77 countries and regions across 45 industrial sectors. Furthermore, the OECD has enabled analysis of global value chains considering corporate ownership structures by connecting the AMNE database (Activities of Multinational Enterprises) with international IO.

The World Input-Output Database (WIOD), funded by the European Commission, published its first international IO in 2013. The 2016 version of WIOD covers the period from 2000 to 2014, including 43 countries and regions across 56 industries. Additionally, in 2022, a time-series version of WIOD was released covering the period from 1965 to 2000, including 25 countries and regions across 23 industrial sectors.

The EORA MRIO, led by the Australian National University, covers the period from 1990 to 2022, including 190 countries and regions across 26 industrial sectors. EORA is equipped with Environmental Satellite Accounts and is widely used for environmental footprint analysis and carbon linkage research.

The Global Trade Analysis Project (GTAP) has been updating a database that provides domestic input-output tables in a unified format since 1993. In April 2023, it released version 11, publishing an international IO for 2017 covering 141 countries and regions across 65 industrial sectors.

The IMF plans to publish its own international IO soon. This international IO will cover from 1990 to 2022 and target 209 countries and regions. It is planned to be a large-scale model covering 178 products and 144 industries.

Each of these international IO has its own characteristics and purposes, contributing to various research and policy-making such as global value chain analysis, environmental policy evaluation, and analysis of the ripple effects of international economic shocks.

Within this international trend, our project constructs a bilateral international IO between Japan and Taiwan. While this NJIO is also published by the IDE, we adopt our own approach in the compilation method. A major difference is that while the IDE conducts surveys and careful verification of trade classifications for their international IO, our project adopts a non-survey method combining estimation using multiple data sources and verification of trade classifications without conducting surveys.

The structure of the NJIO is shown in Figure 1. The endogenous countries/regions are Japan and Taiwan, with all others classified as exogenous countries under "Rest of the World." The endogenous sectors consist of 86 sectors, and both value-added and final demand consist of 4 items each. Value-added is divided into operating surplus, compensation for employee, gross domestic fixed capital formation, and net indirect taxes, while final demand consists of private consumption expenditure, government consumption expenditure, gross domestic fixed capital formation, and change in stocks. Additionally, statistical discrepancy is established to account for trade discrepancies arising from differences in classifications and inventory in transit.

Figure 1. The schematic image of the 2016 NJIO

			Intermediate Demand (A)		Final Demand (F)				
			Japan	Taiwan	Japan	Taiwan	R.O.W	Statistical Discrepancy	Total Output
			(AJ)	(AN)	(FJ)	(FN)	(LW)	(QL)	(XX)
	code		001-086	001-086	001-004	001-004	001	001	600
Japan	(AJ)	001-086	A^{JJ}	A^{JN}	F^{JJ}	F^{JN}	L^{JW}	Q^{J}	X^{J}
Taiwan	(AN)	001-086	A^{NJ}	A^{NN}	F^{NJ}	F^{NN}	L^{NW}	Q^{N}	X^{N}
Freight and Insurance	(BF)	001	BA^{J}	BA^{N}	BF^{J}	BF^{N}			
R.O.W	(CW)	001-086	C^{WJ}	C^{WN}	F^{WJ}	F^{WN}			
Duties and Import Commodity Taxes	(DT)	001	DA^{J}	DA^{N}	DF^{J}	DF^{N}			
Value Added	(VV)	001-004	V^{J}	V^{N}					
Total Inputs	(XX)	600	X^{J}	X^{N}					

Source: prepared by the authors.

Using this table, economic structures can be understood from different angles in the column and row directions. The column direction shows the input structure of each industry, with A^{JJ} representing input from within Japan, A^{NJ} representing input from Taiwan, and C^{WJ} representing input from the rest of the world. V^{J} shows the amount of value-added input in each industry in Japan.

On the other hand, the row direction represents the output structure, with A^{JJ} showing intermediate goods supply to domestic Japan and A^{JN} showing intermediate goods supply to Taiwan. $F^{JJ}$and F^{JN} represent supply for final demand in Japan and Taiwan respectively, and LW shows exports to the rest of the world. Q^{J} is an item that accounts for discrepancies in trade statistics between Japan and Taiwan.

Note that this table collectively records service imports as imports from the rest of the world, which should be taken into consideration when interpreting the data.

Table 1 shows the sector classification of the NJIO. A characteristic of this classification is that compared to the conventional AIO table, it subdivides machinery, electronic equipment, and transportation machinery sectors, and newly establishes 9 sectors including semiconductor manufacturing equipment, office equipment, medical equipment, railways, aircraft, transport services, land transport, water transport, air transport, warehousing and transport support activities. The coding system is shown in Table 2.

2. Data Sources for Compiling the NJIO

This section explains the data used in compiling the NJIO. The data used includes five types: domestic input-output tables (domestic IO) for Japan and Taiwan, international freight insurance rates, duties and import commodity taxes, trade and transport margins, and trade statistics. In the process of constructing the NJIO, it is necessary to convert not only domestic transactions but also import transactions to producer prices, and data on international freight, duties and import commodity taxes, and trade and transportation margins (TTM) are particularly important for this conversion. Below, we first introduce the domestic IO for Japan and Taiwan, then explain the data needed for price evaluation conversion of import tables, and finally discuss the sources and aggregation methods of trade statistics.

2.1. Domestic IO for Japan and Taiwan

The overview of domestic IO for Japan and Taiwan is as follows. For Japan, since both the benchmark year table and extended estimation table are used, information for both is shown. Both Japan and Taiwan compiles tables with detailed sector classifications, making it easy to establish common sectors. Price evaluation and format are common between Japan and Taiwan.

2.1.1 Characteristics of Each Domestic IO

A characteristic of Japan's benchmark year domestic table is the existence of dummy sectors. Dummy sectors do not actually exist as independent industries but are convenient sectors set up to make the compilation and analysis of input-output tables more effective. Value-added is not recorded since these sectors do not directly represent substantive industrial activities[3]. Dummy sectors are not established in the NJIO, therefore it is necessary to distribute these to endogenous sectors and then delete them. The details of dummy sector processing will be introduced in the next section.

Additionally, negative values exist in the intermediate transactions of Japan's domestic table (JIO). While the policy in the NJIO is not to have negative values in endogenous sector, JIO adopts negative values to represent transactions of scrap and by-products, and this method is maintained in the NJIO as well.

For Taiwan domestic IO (NIO), it contains re-export in the table. Since we do not treat re-export in NJIO, re-export value in NIO is deleted.

Table1: Sector Classification

7 sectors		22 sectors		86 Sectors	
code	Description	code		code	Description
INTERMEDIATE SECTORS					
001	Agriculture, livestock, forestry, fishery, and mining	001	Agriculture	001	Paddy
				002	Other grain
				003	Food crops
				004	Non-food crops
		002	Livestock and poultry	005	Livestock and poultry
		003	Forestry	006	Forestry
		004	Fishery	007	Fishery
		005	Crude petroleum and	008	Crude petroleum and natural gas
		006	Mining and quarrying	009	Mining and quarrying
002	Food and beverage,	007	Food, bevarage and tabacco	010	Milled grain and flour
				011	Fish products
				012	Slaughtering, meat products and dairy products
				013	Other food products
				014	Beverage
				015	Tobacco
		008	Textile manufacturing	016	Spinning
				017	Weaving and dyeing
				018	Knitting
				019	Wearing apparel
				020	Other made-up textile products
				021	Leather and leather products
		009	Wood processing and paper production	022	Timber
				023	Wooden furniture
				024	Other wooden products
				025	Pulp and paper
				026	Printing and publishing
003	Petrochemicals, ceramic earth and metal industry	010	Chemical products	027	Synthetic resins and fiber
				028	Basic industrial chemical
				029	Chemical fertilizers and pesticides
				030	Drugs and medicine
				031	Other chemical products
		011	Petroleum and petrol products	032	Petroleum and petrol products
		012	Rubber and non-metallic mineral productcs	034	Tires and tubes
				035	Other rubber products
				036	Cement and cement products
				037	Glass and glass products
				038	Other non-metallic mineral products
		013	Metal products	039	Iron and steel
				040	Non-ferrous metal
				041	Metal products
004	Machinery, electronics	014	Industrial machinery and power equipment	042	Boilers, engines and turbines
				043	General machinery
				044	Metal working machinery
				045	Specialized machinery
		015	Smiconductor manufacturing	046	Semiconductor Manufacturing Equipment
		016	Computer and other Electronic Products	049	Electronic computing equipment

		017	Semiconductors and integrated circuits	050	Semiconductors and integrated circuits
		016		051	Other electronics and electronic products
		018	Electrical and Electronics Manufacturing product	047	Heavy electric equipment
				048	Television sets, radio, audio and communication equipment
				052	Office machinery
				053	Household electrical equipment
				054	Lighting fixtures, batteries, wiring and others
		019	Transport Equipment	055	Motor vehicles
				056	Motor cycles
				057	Shipbuilding
				058	Rolling Stocks
				059	Aircraft
				060	Other transport equipment
		020	Other manufacturing products	033	Plastic products
				061	Precision machines
				062	Medical equipment
				063	Other manufacturing products
005	Electricity, gas, water supply, and construction	021	Electricity, gas, and water supply	064	Electricity and gas
				065	water supply, Sewerage, Waste Management, Remediation activities
		022	Services	066	Construction
006	Trade and transport			067	Wholesale and retail trade
				068	Land transport
				069	Water transport
				070	Air Transport
				071	Warehousing and support activities for transportation
007	Services			072	Postal and courier activities
				073	Telephone and telecommunication
				074	Accommodation and food service activities
				075	Audiovisual and broadcasting activities
				076	Education
				077	Human health and social work activities
				078	IT and other information services
				079	Finance and insurance
				080	Real estate
				081	Professional, scientific, and technical activities
				082	Administrative and supportive activities
				083	Art, entertainment and recreation
				084	Other service activities
				085	Public administration
				086	Unclassified
FINAL DEMAND SECTORS					
001	Private Consumption Expenditure				
002	Government Consumption Expenditure				
003	Gross Domestic Fixed Capital Formation				
004	Changes in Stocks				
VALUE ADDED SECTORS					
001	Wages and Salaries				
002	Operating Surplus				
003	Depreciation of fixed capital				
004	Indirect Taxes less subsidies				
600	Total output				

Source: prepared by authors.

Table2: Coding System

Row	Column	Description
AJ001 | AJ086	AJ001 | AJ086	Intermediate sectors, Japan
AN001 | AN086	AN001 | AN086	Intermediate sectors, Taiwan
BF001		International Freigth and Insurance
CW001 | CW086	CW001 | CW086	Intermediate input from Rest of the World (CIF price)
DT001		Duties and Import Commodity Taxes
VV001		Wages and Salary
VV002		Operating Surplus
VV003		Depreciation of fixed capital
VV004		Indirect Taxes less subsidies
	FJ001	Private consumption
	FJ002	Government consumption
	FJ003	Gross domestic capital formation
	FJ004	Increase in stock
	FN001	Private consumption
	FN002	Government consumption
	FN003	Gross domestic capital formation
	FN004	Increase in stock
	LW001	Export to Rest of the World
	QX0001	Statistical Discreapancies
XX600	XX600	Total Input, Total Output

Source: prepared by authors.

Table 3: Summary of Domestic Input-Output Tables for Japan and Taiwan

	Japan	**Japan**	**Taiwan**
Organization	MIC[1]	METI[2]	DGBS[3]
Benchmark year	2015	--	2016
Reference year	--	2016	--
Sector	509 x 391	506 x 386	487 x 164
Valuation	producer's and purchaser's	producer's and purchaser's	producer's and purchaser's
Unit	million yen	million yen	million NT dollar
Format	commodity by commodity	commodity by commodity	commodity by commodity
Re-Export	no	no	yes
Dummy sector	yes	no	no
Negative entries	yes	yes	no
SUTs	Make marix	no	yes
Employment matrix	yes	no	no

Source: prepared by authors.

1. Ministry of Internal Affairs and Communications, Japan (2019)
2. Ministry of Economy, Trade and Industry, Japan (2020)
3. Directorate-General of Budget, Accounting and Statistics, Taiwan

2.1.2 Duties and import commodity taxes

In building international IO, it is necessary to convert not only domestic transactions but also import transactions to producer prices. Regarding import tables, in Japan's case, they are recorded at CIF price evaluation plus duties and import commodity taxes, so data is needed to remove duties and import commodity taxes from the import table. In JIO, duties and import commodity taxes are recorded as a deduction item in a column vector (classification number 851100). On the other hand, in import table of NIO, duties and import commodity taxes are already removed and recorded as net import duties in a row vector (P4-(2)). By processing duties and import commodity taxes using these data, the import table can be converted to CIF price.

2.1.3 International Freight Insurance Rates

To construct an import table valued at FOB price from an import table valued at CIF price, international freight insurance rates (CIF-FOB margins) are necessary. This margin is one of the most difficult data to obtain in constructing international IO and is normally derived from trade statistics by comparing CIF prices and FOB prices, which allows us to calculate the CIF-FOB margin. However, in many countries, imports are only published at CIF prices, and Japan and Taiwan are no exceptions.

In previous research, estimates have been made using the gravity equation of trade, using the distance between countries as a proxy for transportation costs. However, this project utilized the Organization for Economic Cooperation and Development (OECD)'s International Transport and Insurance Costs of Merchandise Trade (ITIC) dataset[4]. This dataset contains CIF-FOB margins for over 200 reporting countries, 240 partner countries, and more than 1,200 products from 1995 to 2022 in HS2017 4-digit classification.

In this research, CIF-FOB margins between Japan and Taiwan for 2016 were obtained in HS2007 classification from this data[5]. First, trade statistics in HS2012 6-digit were converted to HS2007 4-digit, and freight insurance amounts were derived using HS2007 CIF-FOB margins. In this process, several adjustments were made, such as applying the average margin of surrounding HS codes when margin information was not available in the ITIC data. Next, the freight insurance amounts for 2016 were converted to HS2012 classification using trade code correspondence tables, and finally converted to NJIO classification. When converting from HS2007 to HS2012, if large amounts appeared in CIF-FOB margins despite no trade, they were redistributed to other codes in the same HS 4-digit group according to trade amounts.

As a result of these adjustments, in Japan's case, out of a total of 4,495 codes, the majority could be processed directly, with about 1,710 codes requiring allocation. Similarly, in Taiwan's case, the majority were processed directly. Looking at redistribution by trade code level, 672 cases were processed at the 4-digit level and 14 cases at the 3-digit level. This method allowed for appropriate estimation of CIF-FOB margin between Japan and Taiwan, building the foundation for compiling import tables at FOB price.

2.1.3 Trade and Transport Margins (TTM)

To convert import tables from FOB prices to producer prices, TTM related to the trading partner country's exports are necessary. Specifically, to convert Japan's imports from Taiwan to producer prices, TTM related to Taiwan's exports are needed, and for Taiwan's imports from Japan, TTM related to Japan's exports are needed. These TTM can be obtained by subtracting the values of domestic table at producer's price from the domestic table at purchaser's price. Export-related TTM can be calculated by computing the difference in the export portion between the two price evaluations. In this project, purchaser price and producer price input-output tables are officially published in both Japan and Taiwan, allowing us to directly obtain the necessary TTM. However, there were also cases where TTM did not exist despite exports. In such cases, the TTM of the trading partner country were used.

2.1.4 Trade Statistics

Trade statistics are necessary to determine ratio data when dividing domestic IO' import tables and export vectors by country and by sector. In this project, data for 2016 in HS2012 classification was obtained from World Trade Atlas. These data were converted from HS2012 classification to NJIO classification using correspondence codes between the NJIO and domestic IO, as well as between domestic IO and HS2012. This converted trade statistics data is used as basic data when dividing domestic IO by country and by sector.

In the conventional AIO construction, a method of directly using the ratio of the converted trade statistics to divide import tables was adopted. However, this method had the problem that the import structures of each country would become similar. To solve this challenge, this project introduced a new approach. First, trade statistics were converted from HS classification to NJIO classification by country and by sector, and then aggregation was performed using the fifth version of the Broad Economic Category (BEC) classification provided by the United Nations (2018). The BEC classification is a system that classifies goods by final use such as intermediate goods, consumer goods, and capital goods. By using data organized with this HS-BEC correspondence relationship as initial values and applying the entropy method, we build import tables by country and by sector that more accurately reflect the actual conditions of each country.

3. Method for building the NJIO

This section explains the method for constructing the NJIO. The input-output tables published by Japan and Taiwan have slight differences reflecting each country's industrial structure. These differences need to be resolved, and the tables unified into a standardized format before connecting them to compile the NJIO. This section first explains the adjustments made to domestic IO by country. Next, it shows the process of connecting domestic IO to compile an international IO. The adjustment policy in this project conforms to the policy used when the 2000 AIO was compiled.

3.1 Adjustments to JIO

3.1.1 Updating Estimation and Aggregation of the Sector Classification

The target year for the NJIO is 2016. Meanwhile, the closest benchmark year for JIO is 2015. Therefore, it is necessary to update the JIO from 2015 to 2016. Additionally, since this project requires a non-competitive import type domestic table, the table for 2016 must be a non-competitive import type input-output table.

A table extending the 2015 benchmark table to 2016 is available from the Ministry of Economy, Trade and Industry (METI) (2020). However, since the 2016 METI table is a competitive import type table without an import table, it cannot be used for this project as is. Therefore, this project obtains data for gross output, value-added, and trade amounts from the 2016 METI table and performs an updating estimation for 2016. The estimation uses the structure of the 2015 JIO for independent estimation. The entropy method (or a technique called Generalized RAS) is used for estimation. An overview of the estimation method is shown in section 4, and a detailed explanation is provided in the first technical notes in Part 2.

As preparation for updating to the 2016 table, it is necessary to select the 2015 JIO and integrate the sector classifications of both the 2015 JIO table and the 2016 METI table into the NJIO classification. First, an appropriate table is selected from various types of basic tables for updating estimation. The basic classification 2015 JIO comes in two types, with and without in-house transportation sector presentation, and since the 2016 METI table does not present the in-house transportation sector, the one without in-house transportation sector presentation is selected for 2015 as well. Additionally, since the 2016 METI table does not have social capital depreciation, classification number 9321000 "Social Capital Depreciation" is deleted from the 2015 JIO. Finally, the 2016 METI table is unified with the same sector classification by aligning it with the 2015 JIO's sector classification, and then both tables' sector classifications are converted to the NJIO classification.

Of the two tables converted to NJIO classification, the 2015 JIO has dummy sectors, while the 2016 METI table does not. Subsequent processing involves handling scrap for both tables, while dummy sector processing targets only the 2015 JIO table.

When building an international IO, it is essential to adjust these differences and integrate them into a unified format. In constructing this unified table, four items were adjusted for the JIO and the METI table: (1) scrap and dummy sector processing, (2) machinery repair, (3) price evaluation change, (4) special trade. After making these adjustments and unifying them into a common sector classification, we conduct updating estimation.

3.1.2 Processing of Scrap and Dummy Sectors

The 2015 JIO has four independent stand-alone dummy sectors: business consumption, office supply, in-house research, and machine repair. Below, we explain the process of allocating the values of the dummy sectors to endogenous sectors, emptying the dummy sectors, and then deleting them. Note that the final values of the table will differ depending on the order in which the dummy sectors are deleted. In compiling the 2016 NJIO, "scrap" was processed first, followed by dummy sector processing. Dummy sector processing was performed in the order of (1) business consumption, (2) office supply, (3) in-house research and development, and (4) machinery repair.

(0) Scrap Processing:

The 2015 JIO has three scrap sectors: wastepaper, iron scrap, and non-ferrous metal scrap. These scrap sectors are integrated into sectors with similar uses and physical characteristics. Specifically, 1631021P (waste paper) was integrated into 1631011 (pulp), 2612011P (iron scrap) into 2611041 (crude steel: electric furnace), and 2712011P (non-ferrous metal) into 2711099 (other non-ferrous metals).

(1) Business Consumption Sector:

The classification numbers for business consumption are 7111000 (Total business consumption: Row), 7111001 (Daily allowance and accommodation: Row), 7111002 (Social expense: Row), 7111003 (Welfare expense: Row), and 71110 (Business consumption: Col). The business consumption sector has values in intermediate transactions and gross output (also referred to as Control Totals: CT), but not in final demand and value-added. The values in intermediate transactions and CT are distributed to the transaction table using the entropy method, with the 2015 table as the initial value. The allocation of business consumption expenditure to endogenous sectors increases the CT of the allocated sectors. Therefore, the increase in CT caused by the allocation is offset by the operating surplus of value-added, maintaining a constant CT. Through these processes, the values of the business consumption sector are eliminated, resulting in the removal of business consumption from the table.

(2) Office Supply

The classification numbers for office supply are 6811000 (row) and 681100 (column). The office supply sector has values in intermediate input and gross output (CT) items, but not in value-added and final demand items. The location of each figure in the office supply sector is similar to that of the business consumption sector, and the adjustment method is also similar. The entropy method is used for the distribution of office supply sector values, with the 2015 transaction table as the initial value. As explained for the business consumption sector, although intermediate transaction amounts increase, CT remains unchanged as it is adjusted in the operating surplus of value-added.

(3) In-house Research and Development Sector

The classification numbers for the in-house research and development sector are 6322011 (row) and 632201 (column). In JIO since 1990, the in-house research and development sector has value-added in addition to intermediate input and CT, positioning it differently from dummy sectors. The in-house research and development sector also has values at the intersection with fixed capital formation in final demand. The values of intermediate input, value-added, and CT are distributed using the entropy method, with the transaction table as the initial value. On the other hand, the value at the intersection of in-house research and development and gross fixed capital formation is proportionally distributed to sectors other than in-house research and development according to the composition ratio of gross fixed capital formation. The increase in endogenous sectors resulting from the processing is offset by the operating surplus of the value-added sector.

(4) Machinery Repair

The JIO has five independent machinery repair sectors: ship repair, railway vehicle repair, aircraft repair, automobile repair, and machinery repair. The classification numbers are ship repair 3541101 (row) and 354110 (column), railway vehicle repair 3591101 (row) and 359110 (column), aircraft repair 3592101 (row) and 359211 (column), automobile repair 6631101 (row) and 663110 (column), and machinery repair 6632101 (row) and 663210 (column). The repair of transport equipment sectors is integrated with the sector being repaired. For example, automobile repair (6632101) is classified under NJIO classification automobiles (055), and ship repair is classified under shipbuilding (057).

The machinery repair sector differs from transport equipment repair in that it needs to identify the sectors to be repaired. Following the AIO policy, this project assumes that sectors classified under machinery repair in the Japan Standard Industrial Classification are the sectors receiving repairs. Here, the capital matrix accompanying the 2015 JIO is restructured into a matrix consisting only of sectors receiving repairs, and the machinery repair sector is distributed using the entropy method with this matrix as the initial value. However, if there is a value in the machinery repair column but no sector in the capital matrix, distribution using the capital matrix as the initial value is not possible, so distribution is performed using the transaction amount of the JIO as the initial value.

For the semiconductor sector, distribution cannot be performed using the entropy method because the number of sectors to be distributed and their amounts are small compared to the amount to be distributed, whether using the capital matrix or the transaction amount table. Therefore, a proportional distribution method was adopted. Regarding CT, the increase due to distribution is offset by value-added.

3.1.3 Updating Estimation

A 2015 JIO with all dummy sectors removed was built after completing dummy sector processing. This processing unified the sector classifications of the 2015 JIO and the 2016 METI table, making them comparable. Next, using the structure of the 2015 non-competitive import type table as the initial value and applying the entropy minimization method with the 2016 total production, value-added, domestic final demand, export, and import data as constraints, a 2016 non-competitive import type input-output table was estimated.

3.1.4 Country-specific Division of the Import Table

Next, the import table is divided. Trade statistics data explained in section 2.1.4 are used for dividing the import table. Specifically, trade statistics are organized by country based on both NJIO classification and BEC classification (classification by final use), and an import table from Taiwan is built by applying the entropy method with these values as the initial value. This approach enables the construction of an import table that more accurately reflects the characteristics of each country's import structure.

3.1.5 Price Conversion of the Import Table

Here, we explain the price conversion process of the import table. First, duties and import commodity taxes are deducted, which is done before country-specific division of the import table. Since the pre-division import table is in CIF price plus duties and import commodity taxes, duties and import commodity taxes are deducted to convert it to CIF price.

After dividing the import table into an import table from Taiwan and an import table from the rest of the world, the import table from Taiwan is converted to producer prices. Using the CIF-FOB margin obtained in section 2.1.3, conversion from CIF price to FOB price is performed, followed by applying Taiwan's TTM to complete the conversion from FOB price to producer price. The TTM removed from the import table from Taiwan in this process are moved to the trade and transport margin sectors of the same import table.

3.1.6 Conversion of the Domestic Table to Dollar Prices

Finally, the entire domestic table is converted to dollar prices. This conversion uses the IMF's period of average rate of 108.79 yen per dollar. Although the unit of the JIO is million yen, the unit of the NJIO is 1,000 US dollars, so the conversion is performed to display in units of 1,000 US dollars.

3.2. Adjustments to Taiwan's Domestic Table

3.2.1 Adjustment Items for Value-added

Taiwan's domestic table does not have dummy sectors, and there are no sectors requiring processing like those performed for Japan's domestic table. However, there are adjustment items (P5) in the value-added of the Taiwan table, which need to be distributed to appropriate sectors.

Adjustment items are displayed as one of the value-added items in the 2016 NIO. These adjustment items mainly represent "abnormal expenses" in the 2016 table, with values appearing in three specific sectors: classification number 108 (Electricity and Steam), classification number 110 (City Water), and classification number 140 (Real Estate development activities).

These adjustment items are distributed as follows during the adjustment of the domestic table.

The adjustment item for classification number 108 corresponds to profits from nuclear power plants and is moved to P2 (operating surplus). The adjustment item for classification number 110 has the nature of disaster preparation funds and is moved to P4-(4) other taxes less subsidies. The adjustment item for classification number 140 has the character of fiscal measures related to city hall operations or real estate development activities and is also moved to P4-(4).

3.2.2 Country Division of Import Table and Price Changes

For NIO, country-specific and commodity-specific division of the import table and price changes are performed similar to the JIO.

3.2.3 Conversion of the Domestic Table to Dollar Prices

Finally, the entire domestic table is converted to dollar prices. This conversion uses the IMF's period of average rate of 32.33 Taiwan dollars per dollar. Although the unit of the NIO is million Taiwan dollars, the unit of the NJIO is 1,000 US dollars, so the conversion is performed to display in units of 1,000 US dollars.

3.3 Linking JIO and NIO

After processing the domestic IO, we move to the "linking" work of connecting both countries' domestic IO using trade data. This linking method is explained in detail in previous studies such as Inomata et al. (2006) and Kuwamori, Tamamura, and Sano (2017). There are no special changes compared to the normal linking method in the linking work of the NJIO.

By linking, domestic IO constructed under different concepts are compiled into a single table under a unified concept. Specifically, Japan's exports to Taiwan are replaced with Taiwan's imports from Japan (and vice versa). The main causes of errors in linking work include discrepancies in trade transaction timing such as marine inventory between Japan's exports to Taiwan and Taiwan's imports from Japan, and differences in industrial classification in both countries' trade statistics.

In this linking work, we proceeded with the goal of keeping errors within 3% of total production (CT). In the first round of linking, errors exceeding 3% of CT were confirmed in 14 sector classifications, with particularly notable errors occurring in NJIO classifications 007 (fishery) and 013 (fish products). This is due to differences in interpretation in the industrial classifications of Japan and Taiwan. For example, in Japan, the activity of freezing on the spot and shipping after catching is classified as "fishery," while in Taiwan, similar activity is classified as "fish products."

Also, in sector 052 (semiconductor and integrated circuit), errors exceeding 5% were recorded in both country tables. The following cases are considered as causes of this error:

1. Differences in industrial classification systems: Taiwan clearly positions the semiconductor industry as a main industry and details trade statistics classifications. Meanwhile, Japan's trade statistics reflect the traditional industrial structure, and the classification of emerging technology industries like semiconductors may be insufficient. For example, for centrifuges in code 8421, Japan uses classification 842119000 (other centrifuges) without a clear distinction of whether it is for semiconductor use. In contrast, Taiwan has a specific classification 8421190010 (spin dryers for semiconductor wafer processing).
2. Differences in focus areas of statistical collection: In Taiwan, the semiconductor industry is positioned as a national strategic industry, and related product trade is tracked in detail. Meanwhile, Japan has a diverse industrial structure, so the statistical emphasis on specific industries such as the semiconductor industry tends to be relatively low.
3. Differences in interpretation of product classification: Even for the same product, what is classified as "electronic components" in Japan may be classified as "semiconductors" in Taiwan.
4. Difficulty in classifying intermediate goods: Various intermediate and capital goods are used in semiconductor manufacturing, but their classification is complex, and what is considered "semiconductor-related" on the Taiwan side may be classified in a different category on the Japan side.

After the first round of linking, detailed adjustment work on trade data was performed, and various correspondences between the two countries were corrected before implementing the second round of linking. However, the second round of linking could not significantly correct the errors. Finally, in this project, errors are kept within 3% by adjusting trade between similar sectors with exports to the rest of the world. We would like to perform more careful linking in the next version.

4. Balance Adjustment Methods

Input-output tables must satisfy the basic constraint that row sums (total output) and column sums (total input) match. This section first outlines balance adjustment methods. Next, it explains how data characteristics influenced method selection. Then, it introduces the basic concept of the entropy minimization method adopted in this project. Furthermore, as an advanced method for this research, we are considering the application of quadratic programming, and an overview of its basic framework is also provided. Details of each entropy minimization method and quadratic programming are described in the technical notes in section 3 of Part II .

4.1 Overview of Balance Adjustment Methods for Input-Output Tables

Various methods have been developed and applied for balancing input-output tables. The most widely used method is the RAS method, which performs iterative proportional adjustments from both row and column directions. This method is often adopted in practice because of its high computational efficiency and ease of implementation. The RAS method has characteristics of positive value preservation and structure preservation (maintaining zero cells).

The entropy method is a nonlinear optimization method based on information theory, formulated as a Kullback-Leibler information (relative entropy) minimization problem. This method seeks a solution that minimizes information-theoretical deviation from the original structure while satisfying constraints. The RAS method can be interpreted as a special case of the entropy method.

Quadratic programming is an optimization method with a quadratic objective function and linear constraints. When the objective function is convex, the local optimal solution satisfying the KKT conditions (Karush-Kuhn-Tucker conditions) coincides with the global optimal solution, allowing for efficient solution calculation. While it has the advantage of flexibly incorporating various constraints, there is also the challenge that computational volume increases as the problem size grows.

The Lagrangian multiplier method is a mathematical approach for solving constrained optimization problems, transforming the problem by incorporating constraints into the objective function. In application to input-output table balancing, it is formulated as a problem of minimizing deviation from original values under equality constraints of row and column sums. In this method, the characteristics of the solution change according to the design of the objective function; for example, if an objective function that minimizes relative change rates is chosen, the same proportion of change is evaluated equally regardless of the size of the initial values. On the other hand, if an objective function based on absolute differences is chosen, adjustment of cells with large values tends to dominate. Understanding these characteristics allows for appropriate selection and interpretation of balancing methods.

The feature of the least squares method is that it has a statistical theoretical foundation and can explicitly consider the variance-covariance structure of error terms for each input-output table cell. Specifically, differences in data reliability can be quantitatively expressed as a weight matrix, and correlations between cells, such as transactions within the same industry or between industries with specific input structures, can be explicitly modeled as a covariance matrix.

4.2 Data Characteristics and Method Selection

It is important to consider the characteristics of the target data when selecting a balance adjustment method. The RAS method is widely adopted for its high computational efficiency, but it has an important constraint: it cannot be applied to matrices containing negative values. Therefore, it is not suitable for balancing input-output tables that include negative values.

On the other hand, the entropy method can handle matrices with negative values while maintaining positive value preservation and structure preservation similar to the RAS method, and can flexibly incorporate more general constraints. Therefore, the entropy method may be a more appropriate choice for datasets containing negative values.

When using quadratic programming for balancing input-output tables, neither non-negativity nor zero cell structure is preserved, so values may appear in cells that were originally zero. Since it becomes difficult to interpret when values appear in cells marked as zero in input-output tables, constraints of non-negativity and zero cell structure should be added. However, adding these constraints further increases the computational load, which is problematic in practical input-output table balancing. With the Lagrangian multiplier method, in practice, a "saddle point problem" needs to be solved to find the optimal solution, and computational efficiency becomes an issue when there are many constraints. Also, unlike the RAS method, this method does not preserve relative relationships, so the choice depends on how much of the original data structure one wants to maintain.

When applying the least squares method to input-output tables, non-negative constraints on transaction values need to be considered, and adding these constraints significantly increases the computational load. However, this method becomes useful when there are differences in data reliability or when cell correlations need to be considered.

As a practical application example, considering computational load and other factors, the entropy method was adopted for constructing the NJIO, and the Lagrangian multiplier method was adopted when dividing the NJIO into exporting and non-exporting firms. Thus, it is important to select or combine appropriate methods according to the purpose and characteristics of the data being handled.

4.3 Overview of the Entropy Method Adopted in This Research

In this research, the entropy method was adopted as a balance adjustment method. The entropy method is based on information theory and is formulated as a minimization problem of relative entropy (Kullback-Leibler information). The basic idea of this method is to minimize information-theoretical deviation from the original matrix structure while satisfying constraints.

The entropy method has several important advantages in actual input-output table data processing. First, it can handle matrices containing negative values, ensuring practical flexibility. Also, by maintaining positive value preservation and structure preservation, data adjustment is possible without losing the essential features of the original matrix. Furthermore, it can flexibly incorporate multiple constraint conditions, allowing it to respond to diverse analytical needs. Compared to the RAS method, it provides a more general and versatile framework. In the actual application of this research, in addition to row and column sum constraints, it was possible to incorporate additional constraints on transactions between specific sectors, achieving more refined balance adjustment. The detailed mathematical formulation and implementation method of the entropy method are described in the technical notes in section 1 of Part II.

4.4 Future Approaches

In this project, we used the entropy minimization method for balance adjustment, but we are considering introducing balance adjustment using quadratic programming, which can impose more flexible constraints, or using a hybrid method of quadratic programming and entropy. The application of quadratic programming to input-output table balancing problems is explained in detail in the technical notes in Part II.

5. Evaluation of the NJIO

This section evaluates the tables we've compiled. The evaluation methods examine the degree of consistency between the domestic input-output tables published by government agencies and the NJIO we've compiled, as well as checking the equilibrium relationships of input-output tables. First, we compare and evaluate the figures in the NJIO table with those in each country's tables. The evaluation extracts and clarifies the degree of error between each domestic table and NJIO for the following items: each component of final demand, total final demand, each component of value-added, total value-added, goods exports, service exports, total exports, goods imports, service imports, duties and import commodity taxes, and total imports. We first evaluate JIO, followed by NIO.

5.1 NJIO and JIO

The evaluation of the JIO was conducted based on the numerical comparison shown in Table 4. Regarding the consistency between the NJIO table and the JIO table, high agreement was observed in the main items. A 1.7% difference was observed in total final demand, with most of this difference attributed to a 3.0% deviation in private consumption expenditure. On the other hand, high concordance was confirmed in government consumption expenditure and gross fixed capital formation.

For value-added items, differences of 2.3% were observed in income/wages, capital depreciation, and net taxes, while the operating surplus showed only a slight difference of -0.5%. The total value added showed a difference of 1.8%, which is similar to the difference in total final demand. Operating surplus was used as an adjustment item to maintain constant total output in the process of compiling the NJIO, resulting in minimal error.

For trade-related items, goods exports showed a difference of 0.8%, service exports 5.6%, resulting in a total export difference of 2.0%. On the import side, the difference in goods imports was small at 0.2%, but service imports showed a somewhat larger deviation of 6.5%. There was no difference in import duties and import commodity taxes, and the total import difference was 1.2%.

Regarding the deviation in service trade between JIO and NJIO, one possible cause is that JIO only records amounts related to margins as cost commerce for items such as paintings/drawings (JIO code 9700021), antiques (JIO code 9700031), used tires (9700041), used cars (9700061), used ships (9700061), and other used goods (9700099), while NJIO does not handle JIO codes beginning with 97. Also, the deviation in service imports is due to the use of Taiwan's TTM rates when converting Japan's FOB-priced imports from Taiwan to producer prices. These removed TTM are moved to Taiwan's service trade, increasing aggregate service trade. While this amount doesn't have much impact on product imports due to their large aggregate value, service imports are only about 23% of product imports, so the movement of TTM has a significant impact.

Overall, while there are certain numerical deviations between NJIO and JIO, the differences are generally within acceptable ranges, and high consistency was confirmed in major items except for service trade. From these results, it can be concluded that the NJIO constructed in this project has sufficient reliability as a basic reference material reflecting Japan's industrial structure. However, for service trade items, since the deviation from the original data is somewhat large, caution is needed in analysis.

5.2 NJIO and NIO

Next, we check for errors in the NIO. The evaluation of the NIO is conducted based on the numerical comparison shown in the table 5. Regarding the consistency between the NJIO table and the NIO table, high agreement was observed in many major items. A difference of 0.8% was observed in total final demand, which is smaller than the 1.7% deviation in JIO. By item, a 1.3% difference was observed in private consumption expenditure, while government consumption expenditure showed -0.1% and gross fixed capital formation showed 0.3%, remaining small differences. Inventory changes showed a somewhat larger deviation of -6.8%, but due to their small overall scale, the impact on total final demand is limited.

For value-added items, negligible differences of -0.1% were observed in income/wages and capital depreciation, and the operating surplus also remained a small difference at 0.5%. On the other hand, a somewhat larger deviation of 7.9% was confirmed in net taxes, but the total value added showed a difference of 0.3%, indicating high overall consistency.

Table 4. Difference between NJIO and original JIO

million US dollar

	NJIO	Original JIO	Difference	Diff.%
Domestic Final Demand				
Private Consumption Expenditure	2,875,329	2,790,357	84,972	3.0%
Government Consumption Expenditure	808,303	808,303	0	0.0%
Gross Fixed Capital Formation	1,254,554	1,254,564	-10	0.0%
Changes in stock	-1,321	-1,335	13	-1.0%
Final Demand Total	4,936,865	4,851,889	84,976	1.7%
Value added				
Income and wages	2,567,310	2,508,716	58,594	2.3%
Operating Surplus	937,157	941,996	-4,839	-0.5%
Capital Depreciation	1,058,050	1,033,902	24,148	2.3%
Net taxes	309,694	302,626	7,068	2.3%
Value-Added Total	4,872,211	4,787,240	84,971	1.8%
Export				
Commodity exports	555,101	550,495	4,607	0.8%
Exports of services	192,646	182,082	10,564	5.6%
Total Exports	747,748	732,577	15,171	2.0%
Import				
Commodity imports	596,528	595,191	1,337	0.2%
Imports of services	135,256	126,735	8,521	6.5%
Import duties and commodity taxes	74,601	74,601	0	0.0%
Import + duties&imp.com.taxes	806,385	796,527	9,858	1.2%

Source: prepared by authors.

For trade-related items, goods exports showed a difference of 0.9%, service exports 0.1%, resulting in a total export difference of 0.8%. On the import side, goods imports showed a somewhat larger difference of -2.8%, and service imports showed a significant deviation of 14.4%. However, import duties and import commodity taxes remained a small difference at -0.6%, and total imports achieved perfect agreement at 0.0%.

The large deviation in Taiwan's service imports (14.4%) is consistent with the explanation for the JIO. That is, the main factor is thought to be the use of Taiwan's TTM rates when converting Japan's FOB-priced imports from Taiwan to producer prices and moving the removed margins to Taiwan's service trade. Also, the -2.8% difference in goods imports may be related to this margin adjustment process.

Overall, the differences between NJIO and NIO are even smaller than those of the Japanese table, with the differences in total final demand (0.8%) and total value added (0.3%) being minimal. Since high consistency was confirmed in most items except for service imports, it can be concluded that the NJIO constructed in this project also has sufficient reliability as a basic reference material reflecting Taiwan's industrial structure. For service imports, analysis should proceed considering that the structural differences are due to the handling method of commercial and transport margins.

Table 5. Difference between NJIO and original NIO

million US dollar

	NJIO	Original NIO	Difference	Diff.%
Domestic Final Demand				
Private Consumption Expenditure	276,378	272,873	3,505	1.3%
Government Consumption Expenditure	76,777	76,842	-64	-0.1%
Gross Fixed Capital Formation	114,823	114,426	397	0.3%
Changes in stock	-338	-362	24	-6.8%
Final Demand Total	467,641	463,779	3,861	0.8%
Value added				
Income and wages	270,918	271,169	-252	-0.1%
Operating Surplus	158,755	158,031	724	0.5%
Capital Depreciation	83,543	83,621	-78	-0.1%
Net taxes	18,808	17,385	1,424	7.9%
Value-Added Total	532,024	530,206	1,819	0.3%
Export				
Commodity exports	287,734	285,111	2,623	0.9%
Exports of services	66,241	66,206	35	0.1%
Total Exports	353,975	351,318	2,657	0.8%
Import				
Commodity imports	236,164	242,850	-6,686	-2.8%
Imports of services	47,560	41,170	6,391	14.4%
Import duties and commodity taxes	10,370	10,433	-64	-0.6%
Import + duties&imp.com.taxes	294,094	294,453	0	0.0%

Source: prepared by authors.

5.3 Equilibrium Relationships

We also evaluate the equilibrium relationships of the input-output tables. In input-output tables, theoretically, "Final Demand (FD) + Exports (EX) - Imports (IM)" should match "Total Value-Added," and this equilibrium relationship serves as an important indicator of the basic consistency of the input-output table.

For Japan's case, JIO extracted from the NJIO shows an equilibrium difference of 6,017 million dollars (difference rate 0.1%), which is negligible and indicates high consistency. Meanwhile, the original JIO shows an even smaller difference of 699 million dollars (difference rate 0.0%), achieving almost perfect equilibrium. Even the JIO extracted from the NJIO table remains at a slight difference of 0.1%, and it can be evaluated that the constructed NJIO table captures the structure of the Japanese economy almost accurately.

For Taiwan's case, the NIO extracted from the NJIO table shows an equilibrium difference of -4,503 million dollars (difference rate -0.8%). The original NIO shows a difference of -9,562 million dollars (difference rate -1.8%). It is noteworthy that the structural consistency of the Taiwan table improved and the difference rate improved through the adjustment techniques in the NJIO table construction process. This demonstrates the effectiveness of the methodological approach when integrating different data sources.

Overall, a high equilibrium relationship is confirmed in both cases for the JIO, and for the NIO, the data extracted from the NJIO table shows good results in terms of equilibrium relationship. The fact that the NJIO table constructed in this study exhibits good equilibrium relationships indicates that it meets the theoretical consistency requirements of an input-output table at a high level.

Thus, from the perspective of equilibrium relationships as well, it was confirmed that the NJIO table is a highly reliable dataset that appropriately reflects the economic structures of Japan and Taiwan. The fact that the consistency of the input-output table is ensured by the NJIO table construction method can be considered an important achievement for international input-output analysis.

Table 6. Equilibrium Relationship

million US dollar

	FD + EX - IM	Value-Added total	Difference	Diff.%
JIO from NJIO	4,878,228	4,872,211	6,017	0.1%
JIO	4,787,939	4,787,240	699	0.0%
NIO from JNIO	527,521	532,024	-4,503	-0.8%
NIO	520,644	530,206	-9,562	-1.8%

Source: prepared by authors.

6. Extended NJIO by Export Status

In this project, we constructed an extended NJIO based on export status. The extended table was compiled by dividing an 86-sector table integrated into 22 sectors, using census data from both Japan and Taiwan[6].

6.1 Overview of Extended NJIO by Export Status

The structure of the extended NJIO is shown in Figure 2. Here, we explain the newly introduced concepts of exporting firms and non-exporting firms (or domestic firm). The definitions distinguishing whether a firm is an exporting firm, or a domestic firm are as follows: An exporting firm refers to a firm that exports even a small portion of its produced goods, while a domestic firm is one that does not export at all. In this context, “domestic firm” refers to firms that serve only the domestic market and does not indicate ownership structure. In the extended table, the production of each manufacturing sector is divided into exporting firms and domestic firms. This separation is not applied to primary and service industries.

Figure 2: The schematic image of the 2016 Japan-Taiwan International Input-Output Table

				Intermediate Demand (A)								Final Demand (F)				
				Japan				Taiwan				Japan	Taiwan	R.O.W	Statistical Discrepancy	Total Output
				(AJ)	(AJD)	(AJE)	(AJ)	(AN)	(AND)	(ANE)	(AN)	(FJ)	(FN)	(LW)	(QL)	(XX)
		code		001-006	007-020	007-020	021-087	001-006	007-020	007-020	021-087	001-004	001-004	001	001	600
	Japan	(AJ)	001-006	A^{JJ}	A_{DD}^{JJ}	A_E^{JJ}	A^{JJ}	A^{JN}	A_D^{JN}	A_E^{JN}	A^{JN}	F^{JJ}	F^{JN}	L^{JW}	Q^J	X^J
		(AJD)	007-020	A_D^{JJ}	A_{DD}^{JJ}	A_{DE}^{JJ}	A_D^{JJ}					F_D^{JJ}			Q_D^J	X_D^J
		(AJE)	007-020	A_E^{JJ}	A_{ED}^{JJ}	A_{EE}^{JJ}	A_E^{JJ}	A_E^{JN}	A_{ED}^{JN}	A_{EE}^{JN}	A_E^{JN}	F_E^{JJ}	F_E^{JN}	L_E^{JW}	Q_E^J	X_E^J
		(AJ)	021-087	A^{JJ}	A_D^{JJ}	A_E^{JJ}	A^{JJ}	A^{JN}	A_D^{JN}	A_E^{JN}	A^{JN}	F^{JJ}	F^{JN}	L^{JW}	Q^J	X^J
	Taiwan	(AN)	001-006	A^{NJ}	A_D^{NJ}	A_E^{NJ}	A^{NJ}	A^{NN}	A_D^{NN}	A_E^{NN}	A^{NN}	F^{NJ}	F^{NN}	L^{NW}	Q^N	X^N
		(AND	007-020					A_D^{NN}	A_{DD}^{NN}	A_{DE}^{NN}	A_D^{NN}		F_D^{NN}		Q^N	X^N
		(ANE)	007-020	A_E^{NJ}	A_{ED}^{NJ}	A_{EE}^{NJ}	A_E^{NJ}	A_E^{NN}	A_{ED}^{NN}	A_{EE}^{NN}	A_E^{NN}	F_E^{NJ}	F_E^{NN}	L_E^{NW}	Q_E^N	X_E^N
		(AN)	021-087	A^{NJ}	A_D^{NJ}	A_E^{NJ}	A^{NJ}	A^{NN}	A_D^{NN}	A_E^{NN}	A^{NN}	F^{NJ}	F^{NN}	L^{NW}	Q^N	X^N
Freight and Insurance		(BF)	001	BA^J	BA_D^J	BA_E^J	BA^J	BA^N	BA_D^N	BA_E^N	BA^N	BF^J	BF^N			
R.O.W		(CW)	001-087	C^{WJ}	C_D^{WJ}	C_E^{WJ}	C^{WJ}	C^{WN}	C_D^{WN}	C_E^{WN}	C^{WN}	F^{WJ}	F^{WN}			
Duties and Import Commodity Taxes		(DT)	001	DA^J	DA_D^J	DA_E^J	DA^J	DA^N	DA_D^N	DA_E^N	DA^N	DF^J	DF^N			
Value Added		(VV)	001-004	V^J	V_D^J	V_E^J	V^J	V^N	V_D^N	V_E^N	V^N					
Total Inputs		(XX)	600	X^J	X_D^J	X_E^J	X^J	X^N	X_D^N	X_E^N	X^N					

Source: prepared by authors.

Similar to regular international IO, each cell shows the input structure of industries in each country. For example, the second column from the left shows the input structure of Japanese domestic firms for domestically produced primary products (services). A_D^{JJ} represents the input structure of Japanese domestic firms for domestically produced goods by Japanese domestic firms. Also, A_{ED}^{JJ} represents the input structure of Japanese domestic firms for domestically produced goods by Japanese exporting firms. On the other hand, A_D^{NJ} represents the input structure of Japanese domestic firms for imported primary products (services) from Taiwan's primary product (service) sectors. A_{ED}^{NJ} shows the input structure of Japanese domestic firms for imports from Taiwan's exporting firms.

All transaction amounts compiled in this way are shown in producer prices from the country of origin. International freight and insurance paid by Japanese domestic firms for these import transactions are all recorded in row vectors. ${C_D}^{WJ}$represents the input structure of Japanese domestic firms for imported goods and services from the rest of the world, shown in CIF prices. Import duties and import commodity taxes and import commodity taxes imposed on all Japanese domestic firms are recorded in row vector${DA_D}^{J}$.

Looking at the intersection of the second row and ninth column, from the left side of the table, we can see the composition of manufactured goods flowing to the final demand sectors of Japanese non-exporting firms. For example, ${F_D}^{JJ}$ shows the inflow of Japanese domestic firms to the final demand for domestically produced goods. Since domestic firms do not export, there is no inflow in the next cell of ${F_D}^{JJ}$.

Since they do not export, there is no L_D. ${L_E}^{WJ}$ represents exports from Japanese firms to other regions. ${Q_D}^{J}$ indicates statistical discrepancies, and ${X_D}^{J}$ shows the total output of Japanese domestic firms.

6.2 Methodology to split JNIO by Export Status

In this project, we used the Lagrangian method to split the input-output tables. There are various methods for splitting input-output tables, such as simply using CT division ratios, using the RAS method, or using quadratic programming. We chose the Lagrangian method because when using the RAS method, the divided values are not confined to the target sector but spread to other sectors, making it impossible to completely restore the divided table to the original table.

Specifically, this project used both CT division ratios and total value-added division ratios for the splitting process. We derived the division ratios for items within the value-added component using the Lagrangian method to match the total value-added ratio. Additionally, we determined the ratios for each sector of intermediate inputs to equal the CT division ratios while considering the division ratios of the value-added group. A detailed explanation of the division method can be found in Section 2 of Part 2 Technical Notes.

Conclusion

In this paper, we explain compilation procedure of standard NJIO and extension of NJIO based on export status. Our NJIO provides a detailed sectoral classification of 86 sectors and an extended table based on 22 export status sectors, capturing the ICT industry in more detail than tables published by other international organizations. The detailed sectoral classification presented in this framework facilitates comprehensive examination of the intricate GVC configurations in the ICT industry, which holds strategic importance for both Japan and Taiwan.

In the evaluation of the compiled NJIO, high consistency with the domestic input-output tables of Japan and Taiwan was confirmed. In particular, for Japan, the differences were limited to 1.7% in total final demand and 1.8% in total value added, while for Taiwan, the differences were even smaller at 0.8% in total final demand and 0.3% in total value added. Although slightly larger differences were observed in service trade, these are considered to be due to differences in the processing methods of transportation and trade margins and the handling of goods. The evaluation of equilibrium relationships also showed that the theoretical consistency of the table was ensured at a high level.

As methodological contributions of this research, we adopted a balance adjustment method using entropy minimization, which handles matrices containing negative values. Additionally, by reflecting the trade structure using BEC classification, we more accurately reflect the characteristics of each country's import structure. Furthermore, a feature of this research is that we utilize all observations included in the census data to more comprehensively capture the actual state of industries.

The results of this research will be published as version 1 at this stage, but we aim for further improvements in the future. Future challenges include the following.

1. More careful linking work can more accurately reflect the relationships between industrial sectors.
2. Using more detailed data, including surveys on overseas business activities (METI, 2017), can improve the accuracy and granularity of the analysis.
3. It is also a consideration to perform statistical processing of outliers in census data aggregation to more clearly understand representative trends in industrial structure.

In terms of methodology, another important task involves introducing division methods using quadratic programming to compare and verify against the methods adopted in this research. Furthermore, as an extension based on firm characteristics, the addition of divisions based on firm size (large firms, small and medium-sized firms) and ownership structure (domestic firms, foreign firms, etc.), and even the possibility of multidimensional division combining these elements should be explored. By overcoming these challenges, we aim to develop and release a more enriched version 2 in the future.

We expect that these research results will not only serve as a foundation for detailed analysis of the interdependent relationship between the industrial structures of Japan and Taiwan, but also help evaluate the inter-company dependencies including Taiwan's semiconductor industry of increasing geopolitical importance, important nodes in the industrial structure, and vulnerabilities in the supply chain, supporting policy planning and corporate strategy for effective risk management and sustainable industrial development.

References

Cadestin, C., De Backer, K., Desnoyers-James, I., Miroudot, S., Ye, M., & Rigo, D. (2018). Multinational enterprises and global value chains: The OECD analytical AMNE database. *OECD Trade Policy Papers*, No. 211. OECD Publishing.

Fortanier, F., Miao, G., Kummritz, V., & Langhammer, R. (2020). Accounting for firm heterogeneity in global value chains. *Journal of International Business Studies*, 51(3), 432-453.

Inomata, S., Tokoyama, M., Kuwamori, H., & Meng, B. (2006). Compilation of the Asian International Input-Output Table. *Asian International Input-Output Table 2000: Volume 1: Explanatory Notes.* I.D.E. Statistical Data Series, No. 82. Chiba: IDE-JETRO.

Koopman, R., Wang, Z., & Wei, S. J. (2014). Tracing value-added and double counting in gross exports. *American Economic Review*, 104(2), 459-494.

Kuwamori, H., Tamamura, C., & Sano, S. (2017). Overview of the Asian International Input-Output Table: compilation procedures and characteristics. In H. Kuwamori & C. Tamamura (Eds.), *Compilation of Asian International Input-Output Tables: Foundations and Extensions (in Japanese)*. IDE Research Series No. 632. Chiba: IDE-JETRO.

Melitz, M. J. (2003). The impact of trade on intra-industry reallocations and aggregate industry productivity. *Econometrica*, 71(6), 1695-1725.

METI (2016). 2016 Input-Output Tables. Ministry of Economy, Trade and Industry, Japan

METI (2017). Basic Survey on Overseas Business Activities. Ministry of Economy, Trade and Industry, Japan.

MIC (2019). 2015 Input-Output Tables. Ministry of Internal Affairs and Communications, Japan.

Piacentini, M., & Fortanier, F. (2015). Firm heterogeneity and trade in value added. *OECD Statistics Working Papers*, 2015/23. OECD Publishing. https://doi.org/10.1787/5js6dnkvzrzs-en

Uchida, Y. (Ed.) (2023). *International Input Output Table, Japan-Taiwan 2016*. IDE Statistical Data Series No. 102. Chiba: IDE-JETRO.

Uchida, Y., Noda, Y., Nakamura, J., Lin, H., & Hsu, S. (2023). Compilation for the 2016 Japan-Taiwan International Input-Output Table. In Y. Uchida (Ed.), *International Input Output Table, Japan-Taiwan 2016* (pp. 24-51). IDE Statistical Data Series No. 102. Chiba: IDE-JETRO.

United Nations. (2018). *Classification by Broad Economic Categories, rev.5*. Statistical Papers, Series M No.53, Rev.5. United Nations.

[*] Claude was used as a supplementary tool during the writing process of this paper to proofread the text, organize the structure, and improve the expression. The author is responsible for all content and analysis results.

[1] Since Taiwan is assigned the letter "N" for coding convenience, the Taiwan-Japan table is referred to as the NJIO rather than the TJ table.

[2] The six international input-output tables published by the Institute of Developing Economies are as follows:

IDE (1982), *International Input-Output Table for ASEAN Countries, 1975*. I.D.E. Statistical Data Series, No. 39, Tokyo: Institute of Developing Economies.

IDE (1992), *Asia International Input-Output table 1985*. I.D.E. Statistical Data Series, No. 65, Tokyo: Institute of Developing Economies. IDE. 1998. *Asia International Input-Output table 1990*. I.D.E. Statistical Data Series, No. 81, Tokyo: Institute of Developing Economies.

IDE-Japan External Trade Organization (JETRO) (2001), *Asian International Input-Output Table 1995*. I.D.E. Statistical Data Series, No. 82, Chiba: IDE-JETRO.

IDE-JETRO (2006a), *Asian International Input-Output Table 2000: Volume 1. Explanatory Notes*. I.D.E. Statistical Data Series, No. 89, Chiba: IDE-JETRO. IDE-JETRO. 2006b. *Asian International Input-Output Table 2000: Volume 2. Data*. I.D.E. Statistical Data Series, No. 90, Chiba: IDE-JETRO.

IDE-JETRO (2013), *Asian International Input-Output Table 2005,* IDE Statistical Data Series No. 98, Chiba: IDE-JETRO.

[3] Ministry of Internal Affairs and Communications (2020), 2015 Input-Output Tables: Comprehensive Explanation Edition p.65

[4] OECD, "International Transport and Insurance Costs of Merchandise Trade (ITIC)," 2023.02.12. https://www.oecd.org/en/data/datasets/international-transport-and-insurance-costs-of-merchandise-trade-itic.html

[5] Since the ITIC dataset was provided in HS2007 classification at the time of data collection, this project uses CIF-FOB margins from HS2007.

[6] For Japan's division, we used the "2016 Economic Census-Activity Survey" and the "2017 Census of Manufactures" (aggregated through secondary use application) from the Ministry of Economy, Trade and Industry. Although the table is for 2016, we used the 2015 census data, assuming no significant differences in economic structure between 2015 and 2016. For Taiwan, the data source is directly from the 2016 industry and services census database. The Directorate General of Budget, Accounting and Statistics (DGBAS) of Executive Yuan, R.O.C.(Taiwan) handles census and survey in every five years.