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Abstract

An international input–output (IIO) table contains rich information and an analysis based on the IIO model is capable to include the indirect production effect generated by interactions among different industries and economies. However, availability of the IIO table for every five years with significant time lag limits extensive use of the table. To overcome such a problem, this study attempts to develop an algorithm to make a precise estimation of the latest IIO tables. This estimation approach not only enables us to conduct recent economic analysis, but also opens a door to use plentiful information contained in the IIO table in other discipline of economic studies.

Keywords: International input–output table estimation, data code conversion, RAS method and Trade–RAS method
JEL Classification: D57, F14

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1. Introduction

The international input–output (IIO) table contains extremely rich information on industrial level and country level transaction of intermediate and final goods. The IIO table serves as a data source for the IIO analysis, which is one of the best approaches to study the extent of interdependence among industries as well as countries because of its capability to quantify the indirect effect generated by interactions among industries and countries. Despite this analytical advantage, however, the IIO analysis has a serious drawback. Specifically, the IIO table is published every five years with a five- or six-year time lag, which makes the IIO approach inapplicable to empirical investigation especially when we focus on the recent period. To overcome such a drawback, this paper develops an algorithm to estimate an annual IIO table, i.e., an unpublished year IIO table, for East Asian economies.

A number of attempts have so far been made at estimating national and/or international input–output tables. As far as the Asian IIO table[1] is concerned, Takagawa and Okada (2004) estimated the 2000 Asian IIO table using the Trade–RAS method, and improved accuracy of estimation compared to the existing estimation procedures. Recently, Mori and Sasaki (2007) analyzed interdependence of production and income in Asia–Pacific region based on the estimated 2005 Asian IIO table that was obtained by the Takagawa and Okada (2004) method. In their estimation of the 2005 IIO table, however, both papers use a macro level trade data taken from IMF, *Direction of Trade Statistics*, and do not allow for the actual proportion of trade in intermediate and final goods. As far as relatively precise estimation of the IIO table is concerned, Takagawa and Okada (2004) admit that using of the trade data on both intermediate and final goods based on the commodity-breakdown trade statistics will certainly improve the quality of estimation.

The IIO table basically follows the IIO industrial classification that is different from United Nation's definition of industrial and commodity classifications. As a consequence, comparatively recent and easily available data with industrial and commodity classifications may not be directly used to construct the IIO table. Such data limitation makes the estimation complex and hence time lag is inevitable. If commonly accessible databases such as United Nations Industrial Development Organization's Industrial Statistics data (henceforth, UNIDO Indstat) classified by

[1] Asian IIO tables are officially published by Institute of Developing Economies, Japan External Trade Organization (IDE–JETRO), Japan for every five years. The most recent Asian IIO table refers to year 2000 (as of 2008/07/25).

International Standard Industrial Classification (ISIC) and United Nations' Commodity trade data (hereafter, UNComtrade) categorized by Standard International Trade Classification (SITC) or Harmonized System Classification (HS) or Classification by Broad Economic categories (BEC) could be converted into the IIO classification, a recent and precise estimation of the IIO table becomes possible.

Here it is important to mention that conversion of the industrial classification into the IIO classification is quite simple and straight forward, because both are classified by industries. However, the UNIDO Indstat database, an important resource for industrial data, does not distinguish the international transaction of industrial productions, which makes the estimation of IIO table not so straight forward. Recent and comprehensive data on international trade is available with the UNComtrade but challenge remains in converting the commodity coded data into the industry coded data. Another key advantage of using the UNComtrade data is that the transactions for the intermediate goods and final goods can be tracked easily as detail of the intermediate input transactions is basic feature of the Input–Output theory.

Under such research backgrounds, the current paper contributes to categorize the trade data by type end user (i.e., whether intermediate goods or capital goods or consumption goods.) Although UN provides information on relationship between the BEC coded trade data and the type of end user, insufficient number commodity categories in BEC (only 7 categories) restrict its use in estimating the IIO table. This paper summarizes a process to convert SITC Revision 3 (hereafter SITC3) data, which is structured with sufficient number of categories,[2] according to type of end user. In addition, the paper also formulates a rule to convert SITC3 coded commodity data into the ISIC3 coded industry data and hence into the IIO coded data. Development of such conversion rules allow us to create a foundation to use the recent and commonly available data while estimating the recent and yearly IIO tables Finally, we propose estimating single country IO tables at first and then the international IO table based on the IIO coded trade data and the existing IIO tables for further precision. Estimation of yearly and recent IIO tables not only enable us for recent economic and time series analysis of interdependence, but it also opens a door to use the *rich* IIO data in other discipline of economic studies.

The remainder of this paper is organized as follows. Sections 2 and 3 provide estimation framework and estimation algorithm respectively. Section 4 concludes the

[2] There are 10 sections, 67 divisions, 261 groups, 1033 subgroups and 3121 items in the SITC3 classification.

paper.

2. Estimation Framework

An IIO table contains the data on intra-industry transactions of intermediate goods (correspond to variable *z* in Figure 1) among the endogenous economies. Moreover, industry–wide final demand, export to exogenous economies, value–added inputs and total productions (denoted respectively by variables *f*, *e*, *v*, and *x* in Figure 1) are recorded for a given year. One can imagine how complicated and tiresome it is to compile an IIO table as the table with smallest possible dimension (as shown in Figure 1) requires 48 pieces of information. Because the above information is not available from a single source, official information on intra–industry transaction of intermediate goods does not exist at all. As a consequence, arrangement and estimation demand plenty of resources and hence the IIO tables are published every five years with significant time lag.

Insert Figure1 around here.

Figure 1 shows a typical layout of an IIO table and data sources for the estimation of the new table. The last column and row (total export and total import) in Figure 1 are, in fact, not a component of the IIO table, but these are obtained from the UN Comtrade database, which ultimately enables us to estimate intra–industry transactions of intermediate goods and final goods among the exogenous and endogenous economies. Here, it is important to mention that the UN Comtrade data covers international trade transactions only and also that we need to use the UNIDO Indstat database to estimate domestic transactions. The UNIDO Indstat database provides us with the information on the industrial productions (total input and output) and value added inputs as well. One may argue about a difference in classification system across different data sources. For example, the commodity classification in the UN Comtrade data entirely differs from the industry classification (ISIC) in the UNIDO Indstat database. Moreover, the IIO classification of the industries does not entirely conform to the ISIC classification. Such dissimilarity in data classification makes compiling the official IIO tables more complex and time consuming. To overcome this dissimilarity problem, we will propose the accurate conversion method of accurately converting from the commodity and industrial classifications into the IIO classification. A diagrammatic representation of the data sources, the flowchart of classification code conversion and the IIO estimation plan are given in Figure 2.

Insert Figure 2 around here.

Estimation of an IIO table requires differentiating between international trade and domestic transaction for both intermediate and final goods following the IIO classifications. The international trade data from the UN Comtrade database (coded in SITC3) should be first converted into BEC data that enables us to categorize the traded goods into either intermediate or final goods.[3] Second, the categorized data can be converted accurately into the ISIC3 code with reference to the conversion table provided by the Euro Stat homepage.[4] As far as domestic transactions are concerned, the UNIDO Indstat reports transactions of both intermediate and final goods based on the ISIC3 code. Finally, applying the conversion table in Kasahara (2005), the ISIC3 data can be converted into the IIO classification.

Once the data are converted into the IIO classification, the officially published IIO tables serve as the base year table to estimate the IIO tables for unpublished years. Estimation of single country IO tables and hence the IIO table follow the RAS and Trade–RAS methods respectively which are the well established estimation procedure.[5]

3. Estimation Algorithm

This section summarizes an algorithm to estimate the IIO table from the SITC3 coded commodity trade data that is obtained from the UN Comtrade database and the ISIC3 coded industry data that is taken from the UNIDO Indstat database.[6] To get a highly precise result of estimation, it is necessary to use the trade and industry data with maximum level of hierarchy. There are three principal steps to estimate the IIO table.

(1) Converting the trade and industry data into the IIO classification

- Construct bilateral export and import vectors (the size of the vectors will be

[3] UNSD homepage (http://unstats.un.org/unsd/cr/registry/regdnld.asp?Lg=1) lists the conversion tables between different classifications. Moreover, http://comtrade.un.org/kb/Article.aspx?id=10180 provides relationship between BEC and type of goods (i.e., intermediate, capital, and consumption goods). Both homepages were accessed on 2008/07/16. The detail of the conversion tables are omitted in this paper, which is either available at the above URL links or upon request.

[4] http://ec.europa.eu/eurostat/ramon/relations/index.cfm?TargetUrl=LST_LINK&StrNomRelCode=SITC%20REV.%203%20-%20ISIC%20REV.%203&StrLanguageCode=EN (access: 2008/07/16)

[5] See any of input–Output texts (for example, Miller and Blair, 1985; United Nations, 1999; Takagawa and Okada, 2004) for details of the RAS and Trade–RAS methods.

[6] We use the information taken from the UN Service trade data and UNIDO Demand–Supply Balance database as well. However, these databases are note mentioned here because they serve as secondary information.

equal to the number of commodity classifications) for each pair of endogenous countries corresponding to the target year (data source: the UN Comtrade database in 4-5 digit SITC3 code)

- Estimate an actual proportion of trade in intermediate and final goods i.e. separate the total export and import vectors according to its use either as intermediate or final goods
- Convert the SITC3 coded data into the IIO codes[7]
- Get domestic transaction data, industry–wide total production (i.e., total input/output) and value–added data for endogenous countries from the UNIDO Indstat in ISIC3 code
- Convert the ISIC coded data into the IIO codes (refer to Kasahara, 2005)

(2) Estimating the single country IO table

- Construct the base year single country IO tables corresponding to each endogenous country (data source: published IIO tables)
- Use the RAS method to estimate the single country IO tables based on the based year IO tables and the data converted into the IIO codes that is taken from the UNIDO Indstat

(3) Estimating the IIO table

- Breakdown the IIO coded country–wide export and import vectors, corresponding to the intermediate goods, into industry–wide transactions on the basis of existing IIO relationship (i.e., expand the export vector horizontally and the import vector vertically)
- Apply the Trade–RAS method to get the estimated IIO table for a target year

Here it is important to note that the annual data on recent trade and industry are available from the UN Comtrade and the UNIDO Indstat, respectively, which enables us to make precise estimation of the unpublished-year IIO tables based on the estimation algorithm proposed in this paper.

4. Concluding Remarks

This paper attempts to develop an estimation algorithm to precisely estimate an

[7] Appendix 1 shows the code conversion table. The table has been summarized into 2 digit level of SITC and ISIC code. However, a detail conversion table is available upon request. Refer to UNSD homepage for details of the 2 digit level SITC3 and ISIC3 codes. Appendix 2 provides details of AIIO code.

unpublished-year IIO data. Most importantly, it formulates a conversion rule that converts the SITC3 data code into the ISIC3 data code and finally into the IIO data code. Moreover, it summarizes categorization of international commodity trade into trade in intermediate and final goods, which is a key component of the IIO table. Such conversion rules allow us to utilize the comprehensive and recent trade data available from UN Comtrade in estimating an unpublished-year IIO table. Estimated IIO tables can be used not only for a time series analysis of economic interdependence but also for other fields of economic research that need rich information contained in the IIO table.

This study reviews the data code conversion process and existing IIO estimation procedures (i.e., RAS and Trade–RAS methods). The proposed algorithm is expected to estimate the yearly IIO tables with significant degree of precision. However, an application of the algorithm to the estimation of IIO tables is left for the next phase of the research.

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Appendix 1: Code Conversion Table

SITC3	ISIC3	AIIO
S3-00	I3-01	5
S3-01	I3-01, I3-15	5, 14
S3-02	I3-01, I3-15	5, 14-16
S3-03	I3-05, I3-15	7, 13

SITC3	ISIC3	AIIO
S3-04	I3-01, I3-15	1-4, 12, 15, 16
S3-05	I3-01, I3-15	1-4, 12, 15, 16
S3-06	I3-01, I3-15	2-4, 12, 14-16
S3-07	I3-01, I3-15, I3-37	3, 4, 15, 16, 76
S3-08	I3-01, I3-15, I3-37	1-4, 13-15, 76
S3-09	I3-01, I3-15	5, 15, 16
S3-11	I3-15	16
S3-12	I3-01, I3-16, I3-37	1-4, 17, 76
S3-21	I3-01, I3-15, I3-37	5, 14, 76
S3-22	I3-01, I3-15	1-4, 15
S3-23	I3-01, I3-02, I3-24, I3-25, I3-37	1-4, 6, 29, 37, 76
S3-24	I3-02, I3-20, I3-24, I3-37	6, 24, 26, 30
S3-25	I3-21, I3-37	27, 76
S3-26	I3-01, I3-15, I3-17, I3-24, I3-36, I3-37	1-5, 14, 15, 18, 19, 29, 60, 76
S3-27	I3-11, I3-14, I3-24, I3-26, I3-36, I3-37	8, 11, 30, 31, 38, 60, 76
S3-28	I3-12, I3-13, I3-24, I3-27, I3-37	9, 10, 30, 42, 76
S3-29	I3-01, I3-02, I3-05, I3-15	1-7, 13, 74
S3-32	I3-10, I3-23	11, 34
S3-33	I3-11, I3-23, I3-24, I3-26	8, 30, 34, 40
S3-34	I3-11, I3-23, I3-40	8, 34, 61
S3-35	I3-40	61
S3-41	I3-15, I3-17	14, 15, 18, 19
S3-42	I3-15	12, 15
S3-43	I3-01, I3-15, I3-24	5, 15, 30, 33
S3-51	I3-15, I3-24	16, 30, 32, 33
S3-52	I3-23, I3-24, I3-26, I3-40	30, 31, 40, 61
S3-53	I3-24	30, 33
S3-54	I3-24	32
S3-55	I3-24	33
S3-56	I3-24	31
S3-57	I3-24, I3-37	29, 76
S3-58	I3-25	35
S3-59	I3-15, I3-24, I3-26, I3-37	12, 14, 15, 30, 31, 33, 38, 40, 76
S3-61	I3-18, I3-19	21-23
S3-62	I3-25	36, 37
S3-63	I3-02, I3-20	6, 24, 26
S3-64	I3-21, I3-22	14, 15
S3-65	I3-17, I3-18, I3-21, I3-24, I3-25, I3-26, I3-36	11, 14, 16, 20, 22, 36
S3-66	I3-05, I3-14, I3-24, I3-26, I3-36	4, 8, 16, 21-23, 36
S3-67	I3-27	24
S3-68	I3-27	42
S3-69	I3-27, I3-28, I3-29	42, 43, 53
S3-71	I3-23, I3-28, I3-29, I3-31, I3-34, I3-35	30, 44, 45, 48, 55, 57, 58
S3-72	I3-22, I3-29, I3-30	28, 45-48, 50
S3-73	I3-29	46-48
S3-74	I3-38, I3-29, I3-31, I3-33	43-48, 52-54, 59
S3-75	I3-30	50
S3-76	i3-32, I3-33	49, 52, 54, 59

SITC3	ISIC3	AIIO
S3-77	I3-25, I3-26, I3-29, I3-31, I3-32, I3-33	35, 39, 40, 46-48, 51-54, 59
S3-78	I3-29, I3-34, I3-35	47, 55, 56, 58
S3-79	I3-35	57, 58
S3-81	I3-25, I3-26, I3-28, I3-29, I3-31	35, 39, 40, 43, 53, 54
S3-82	I3-17, I3-36	22, 25, 35
S3-83	I3-19	23
S3-84	I3-17, I3-18, I3-25	20-22, 35, 37
S3-85	I3-19	23
S3-87	I3-33, I3-36	52, 59, 60
S3-88	I3-19, I3-24, I3-31, I3-33, I3-74, I3-92	23, 33, 54, 59, 74
S3-89	I3-17, I3-20, I3-21, I3-22, I3-24, I3-25, I3-28, I3-29, I3-33, I3-36, I3-74, I3-92	22, 26-28, 33, 35, 43, 47, 52, 59, 60, 74
S3-91	-	76
S3-93	-	76
S3-96	I3-36	60
S3-97	I3-27, I3-37	42, 76

Appendix 2: AIIO Classification Details

AIIO	Classification detail
1	Paddy
2	Other grain
3	Food crops
4	Non-food crops
5	Livestock and poultry
6	Forestry
7	Fishery
8	Crude petroleum and natural gas
9	Iron ore
10	Other metallic ore
11	Non-metallic ore and quarrying
12	Milled grain and flour
13	Fish products
14	Slaughtering, meat products and dairy products
15	Other food products
16	Beverage
17	Tobacco
18	Spinning
19	Weaving and dyeing
20	Knitting
21	Wearing apparel
22	Other made-up textile products
23	Leather and leather products
24	Timber
25	Wooden furniture
26	Other wooden products
27	Pulp and paper
28	Printing and publishing
29	Synthetic resins and fiber
30	Basic industrial chemicals
31	Chemical fertilizers and pesticides
32	Drugs and medicine
33	Other chemical products
34	Refined petroleum and its products
35	Plastic products
36	Tires and tubes
37	Other rubber products
38	Cement and cement products
39	Glass and glass products
40	Other non-metallic mineral products
41	Iron and steel
42	Non-ferrous metal
43	Metal products
44	Boilers, Engines and turbines
45	General machinery
46	Metal working machinery
47	Specialized machinery
48	Heavy Electrical equipment
49	Television sets, radios, audios and communication equipment
50	Electronic computing equipment
51	Semiconductors and integrated circuits
52	Other electronics and electronic products

AIIO	Classification detail
53	Household electrical equipment
54	Lighting fixtures, batteries, wiring and others
55	Motor vehicles
56	Motor cycles
57	Shipbuilding
58	Other transport equipment
59	Precision machines
60	Other manufacturing products
61	Electricity and gas
62	Water supply
63	Building construction
64	Other construction
65	Wholesale and retail trade
66	Transportation
67	Telephone and telecommunication
68	Finance and insurance
69	Real estate
70	Education and research
71	Medical and health service
72	Restaurants
73	Hotel
74	Other services
75	Public administration
76	Unclassified

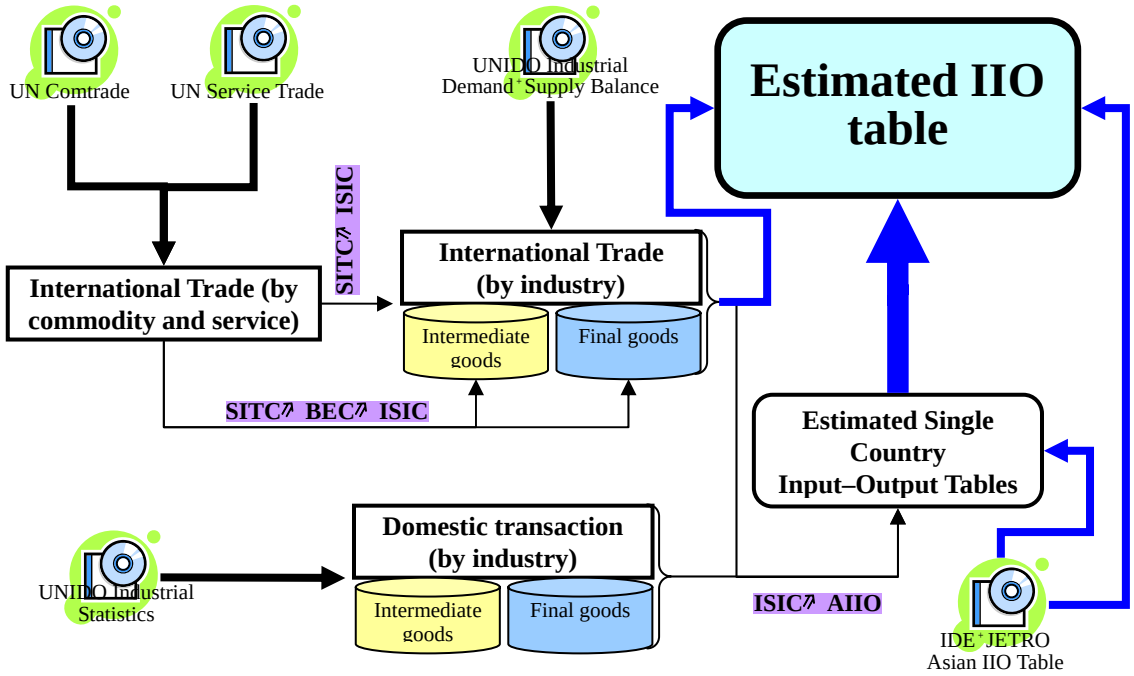
Figure 1: An IIO table layout and data sources for the estimation

		Country 1		Country 2		Final Demand		Export	Total	Total
		Sect 1	Sect 2	Sect 1	Sect 2	Con 1	Con 2	(exo)	Output	Export
Country 1	Sect 1	z_{11}^{11}	z_{12}^{11}	z_{11}^{12}	z_{12}^{12}	f_1^{11}	f_1^{12}	e_1^1	x_1^1	ex_1^1
	Sect 2	z_{21}^{11}	z_{22}^{11}	z_{21}^{12}	z_{22}^{12}	f_2^{11}	f_2^{12}	e_2^1	x_2^1	ex_2^1
Country 2	Sect 1	z_{11}^{21}	z_{12}^{21}	z_{11}^{22}	z_{12}^{22}	f_1^{21}	f_1^{22}	e_1^2	x_1^2	ex_1^2
	Sect 2	z_{21}^{21}	z_{22}^{21}	z_{21}^{22}	z_{22}^{22}	f_2^{21}	f_2^{22}	e_2^2	x_2^2	ex_2^2
Country 3 (exo)	Sect 1	z_{11}^{31}	z_{12}^{31}	z_{11}^{32}	z_{12}^{32}	f_1^{31}	f_1^{32}			
	Sect 2	z_{21}^{31}	z_{22}^{31}	z_{21}^{32}	z_{22}^{32}	f_2^{31}	f_2^{32}			
Value Added		v_1^1	v_2^1	v_1^2	v_2^2					
Total Input		x_1^1	x_2^1	x_1^2	x_2^2					
Total Import		m_1^1	m_2^1	m_1^2	m_2^2					

Notes on sources of data:

Total export and import:	UN Comtrade database (do not appear in the final IIO table)
Total input and output:	UNIDO Industrial Statistics database
Value added:	UNIDO Industrial Statistics database
Domestic transactions:	UNIDO Industrial Statistics database, IDE–JETRO Asian IIO table (estimates)
International trades:	estimates based on above data

Figure 2: Data Sources, Classification Code Conversion and Estimation Plan



Notes:
SITC: Standard International Trade Classification
BEC: Classification by Broad Economic Categories
ISIC: International Standard Industrial Classification of All Economic Activities
AIIO: Asian International Input–Output Table classification
Thick black arrow: data form different sources
Thin black arrow: data classification code conversion
Blue arrow: estimation process