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Abstract

This paper uses new annual datasets of globally-linked Input-Output (GIO) tables from 1997 to 2010 and explores how global chains, especially in Asia, have developed and changed during the period. Recent literatures on trade in value-added along production chains serve as a suitable tool for such investigation. However, we show that existing approach evidently underestimate the degree of procurement from foreign countries, and also illustrate that such variation is attributed to omission of the intermediate goods procurement effect in the model. To overcome this drawback, we propose a new analytical framework that incorporates both effects of value-added and intermediate inputs procurement. Our results show that Asia's (China, India, Indonesia, Japan, Korea, Malaysia, the Philippines, Taiwan and Thailand) procurement if value-added and intermediate goods to foreign countries has increased significantly from 23.5% in 2000 to 30.4% in 2010, while existing method underestimates such procurement by 9.6% in 2010. Furthermore, we demonstrate that the degree of economic integration in Asia is evidently lower than that in Europe, whereas, previous studies suggest more or less similar level of integration in two regions.

JEL classification: F15, D57
Keywords: Global production-chain, trade in value-added, trade in intermediate goods, economic integration, Asia, Global Input-Output table

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1. Introduction

Recent literatures (Johnson and Nogeura, 2012; Koopman *et al.*, 2012; OECD-WTO etc.) attempt to account multi-country production chains to reveal hidden structure of trade underlying gross trade by calculating value-added contents of export. In comparison to conventional gross trade statistics, these attempts successfully address "double-counting" problem of trade in intermediates and improves overstatement of domestic value-added contents of export. Further, because such data includes hidden and embodied trade patterns, data on value-added contents of trade are best suited for analyzing production chains, Shock transmissions, economic integration, international business cycle studies etc. However, data on value-added contents of export does not fully improve the understatement problem of foreign contents of export. We show that existing approach estimates embodied trade in value-added contents only and ignores embodied trade in intermediate goods and hence still understate foreign contents of export. Embodied trade in intermediate goods cannot be overseen because (1) more than half of the World's trade is intermediate goods trade, (2) extent of embodied trade in intermediate goods is not negligible, and most importantly (3) structure of trade in value-added and trade in intermediate goods are different. If such differences in embodied trade structures are addressed in the model, we expect relatively precise picture of the economic linkage among the countries. Therefore, we include both trades in value-added and intermediates in our calculation, which further improves the understatement problem of foreign contents. Such improvement becomes necessary because without knowing actual trade structures and economic linkages, the results may have very limited policy implications.

We compute global chains for value-added and intermediate goods, which includes both embodied trade in value-added and intermediate goods, using newly constructed annual globally linked input-output (hereafter, YNU-GIO[2]) tables for 1997 through 2010 with 35 production industries. The YNU-GIO table covers nine Asian (Japan, China, Korea, Taiwan, Malaysia, Thailand, Indonesia, Vietnam and India), twelve European (France, Germany, UK, Austria, Belgium, Finland, Ireland, Italy, Luxembourg, Netherlands, Portugal and Spain), three North American (USA, Canada and Mexico) and three other (Australia, Brazil and South Africa) countries (altogether 27 countries) endogenously and 62 countries (Hong Kong, the Philippines, Singapore, remaining 30 Asian countries, 16 European countries, 12 OPEC economies and Rest of

[2] YNU-GIO tables are constructed as a part of research project of Center for Economic and Social Studies (CESSA) at Department of Economics, Yokohama National University (YNU).

the World or ROW) exogenously.[3] We prefer using YNU-GIO over existing similar databases namely the Asian International Input-Output (henceforth, AIO) table published by Institute of Developing Economies-Japan External Trade Organization (IDE-JETRO) and the World Input-Output Database (WIOD) for our analysis because of following two reasons. First, the AIO table does not cover recent years (as of May 2013, the latest AIO table is for 2000) and major advanced economies, specifically, European countries, are not treated endogenously. Second, although WIOD is available up to 2009, it does not treat Malaysia and Thailand endogenously. We believe that without treating Malaysia and Thailand (at least) endogenously, Asian production chain cannot be justified because these countries have significant importance in Asian production chain.

The novelty of this paper is to account embodied trade in intermediate goods, which is ignored in previous studies and hence understates the foreign content of export. As embodied trade structure of value-added and intermediate goods are entirely different, our approach accounts both trade structure in a single framework, represents hidden trade structure underlying export better than existing approach and also provides relatively better measure of global chains. Moreover, we present results in annual series, starting from 1997 to 2010, to understand visually how global chains have changed each year. It is a major breakthrough in Input-Output related researches, because annual series of GIO tables are not available except WIOD. Further, availability of annual dataset opens the door for econometric analysis using the GIO tables in various research investigations.

Major findings of this paper are (1) extent of Asian contents in Asian export and world's export has increased significantly during 1997-2010 period implying substantial progress in regional and global integration, (2) level of regional integration in Asia is much more lower than that in Europe, which existing approach estimates to be in more or less same level, and finally (3) there exists structural economic diversity in Asian countries as well as in two major industry (electric machinery and transport equipment) covered by this paper, and hence Asian economic and monetary integration in near future appears to be a challenging task.

The rest of the paper is organized as follows. Section 2 discusses related literatures. Section 3 presents the analytical framework of this paper and also illustrates how and why existing approach understate foreign contents of export. Sections 4 and 5 provide datasets and results of the analysis respectively. Finally, Section 6 concludes the paper.

[3] See Appendix 1 for list of countries and industries covered by YNU-GIO table.

2. Literature survey

Recent trend of trade studies attempt to capture phenomenon that are not observable directly such as production fragmentation, trade in value-added, global chain of production, vertical specialization etc.[4] These research topics can be well addressed by using the IO framework (either single country or multi-country framework) because of its capability to address the production inducement effect in different stages of production process. Moreover, the IO model (in precise, the GIO model) is a convenient technique to reveal the extent of complicated economic linkage (among industries and among countries) and effect of inputs for production (intermediate inputs and value-added inputs) thus it provides a better measure of international linkage. Therefore, the GIO tables have been widely used in the field of international economics. For example, Koopman *et al.* (2012), Johnson and Noguera (2012), Ng(2010), Hasebe and Shrestha (2006), Hummels *et al.* (2001) etc. are a few studies that uses the GIO model.[5] Further, recently published database on trade in value-added (OECD-WTO) and World Input-Output database (WIOD) are two important breakthroughs on the GIO literature.

Hummels *et al.* (2001) and Ng (2010) use bilateral import matrices and the single country Leontief inverse matrix to compute the vertical specialization concept of the production and bilateral production fragmentation respectively. Their approaches do not fully address the international production linkage (because the single country Leontief inverse includes the intra-country production linkage only) and they also fail to account embodied trade in value-added associated with the production. Hasebe and Shrestha (2006) use the International IO table to examine the degree of economic integration in East Asia with respect to embodied trade in intermediate goods only. Again, the effect of trade in value-added is missing. Recent papers by Johnson and Noguera (2012) and Koopman *et al.* (2012) applied the international IO framework to estimate the value-added contents of bilateral trade and the value-added components of gross exports respectively. These estimations are capable to trace the direct and, most importantly, indirect transaction of goods that were either partially addressed or neglected so far. In another development, OECD-WTO published a new dataset for trade in value-added based on the international IO tables, which measures the actual

[4] Ferarrini (2013) maps global network production and vertical trade using the BACI dataset, which is based on the UN COMTRADE database. The paper emphasis on the visualization of production networks and vertical trade, but it does not account embodied trade underlying gross trade.

[5] In precise, Ng (2010) and Hummels *et al.* (2001) combines single country IO table and extend to multi-country framework using bilateral trade data.

contribution of trade to nations' value added sector.

In this paper, we show that the existing approach tend to underestimate the input procurement (value-added and intermediate goods) from foreign countries. For example, Figure 1 shows Chinese procurement (from different countries) associated with its finished goods export to the US in 2005.[6] The results based on existing method estimate that, for $170B export to the US, value-added contents of China, Japan, Korea and the US are $153.7B, $9.3B, $3.6B and $3.3B respectively. Note that the sum of procurements is equal to the amount of export, meaning that the existing method allocates direct export with respect to its procurement (i.e., domestic plus import from other countries). In other words, existing method estimates components of the direct export in terms of value-added contents and these estimates do not account for the production inducement (in intermediate goods sector) generated by the export. As we know that the production inducement is generated by active transaction of the intermediate goods mainly across border, existing method tends to include such inducement as domestic contents. Hence existing approach understates the extent of foreign contents (i.e., overstates the domestic contents). If we combine the effect of trade in value-added and intermediates (new method proposed in this paper) together, $170B Chinese finished goods export to the US generates production inducement of $291B (i.e., total impact of $461B). In addition to the value-added contents, the embodied intermediate goods contents of China, Japan, Korea and the US are $247.4B, $23.9B, $12.2B and $7.5B respectively. In this example, new method estimates Chinese procurement from Japan, USA and Korea as 7.2%, 3.4% and 2.3% respectively. It means that the existing method underestimates the impact of Chinese export to the US on Japanese economy by 1.7%, which is equivalent to $7.8B. Such difference in estimation will certainly affect the implication of the result. Therefore, further improvement on the existing modeling framework is highly recommended.

*** Figure 1 around here ***

Availability of recent and reliable GIO dataset is always a major issue. Beside the GIO constructed by individuals, AIO table (published by IDE-JETRO) and WIOD are two major GIO databases.[7] AIO tables are assumed to be suitable for the regional analysis in Asia because of its coverage of 9 Asian countries (China, Indonesia, Japan,

[6] Authors' estimation based on the four-country (China, Japan, Korea and USA) GIO table for Chinese export of finished manufacturing goods to the US.

[7] Single country IOs are available from different sources (for example, OECD, GTAP, central banks, statistical bureaus etc.)

Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand) and the USA. However, unavailability of recent table (2000 AIO table as of May 2013) and omission of European and other countries, analysis based on the AIO tables have very limited practical implications. On the other hand, WIOD (available for years 1995 to 2009) covers 40 economies of the world focused specifically on European nations. Among other countries, only six Asian economies (China, India, Indonesia, Japan, Korea and Taiwan) are included in the WIOD database.[8] Using the WIOD data in Asian context, compared to the AIO tables, effects of Malaysia and Thailand (for instance) are totally ignored. Asian economic analysis without these two countries (at least) does not reveal the true picture because these countries have significant importance in Asian production network.

3. Analytical framework

We basically follow globally linked input-output model, which is capable to address direct and indirect effects of production and in the meantime, it also supports multi-country framework to investigate the international linkages. Rest of this section describes the GIO model and develops a new method to estimate the international global chains. The new measure enables us to address both the effects intermediate inputs and value-added inputs simultaneously.

3.1 Globally linked Input-Output (three-country) Model

Let us assume that there are only three countries in the World and gross output (or equivalently gross input) of country *i* (or country *j*) is Y^i (Y^j). From the demand side notion, the gross input Y^j comprises domestically procured intermediate goods (Z^{jj}), imported intermediate goods (Z^{ij} for all $i \neq j$) and the value-added inputs[9] (V^j). On the other hand, from the supply side concept, the gross output (Y^i, which is equal to the gross input Y^j) consist of amount received by selling intermediate goods and final goods at domestic market (Z^{ii} and F^{ii}) and foreign market (Z^{ij} and F^{ij}) respectively. Such transactions of intermediate and final goods, value-added inputs and gross outputs subject to each country are efficiently captured in the globally linked IO Tables. One of the most important features of the GIO table is that it is the only database providing information on both domestic procurement and bilateral trade of the intermediate and final goods separately. This particular feature enables us to include

[8] See Table 2 in Section 4 for comparison of GIO datasets

[9] Primary components of the value-added inputs are compensation to employees, operating surpluses, and direct and indirect taxes. Total of the value-added inputs for any country may be regarded as a proxy for GDP of that country.

both intra- and inter-country effects of production in the analysis. Table 1 portrays a typical three-country single sector GIO table. The demand or input structures are characterized vertically and the supply or output structures are described horizontally in the table.

*** Table 1 around here ***

Here, Z^{ij} and F^{ij} are amount of intermediate and final goods supplied to country j from country i respectively. Note that, first suffix i represents source country and second suffix is the destination country. Transactions with same suffix (diagonal elements of intermediate and final goods blocks) denote the domestic procurement of intermediate and final goods, whereas that with different suffices (i.e., off diagonal elements) are bilateral trade of intermediate and final goods. V^j is value-added inputs associated with country j's production Y^j. Based on the GIO table in Figure 1, an intermediate input coefficient matrix (say, A) is defined as $A = \begin{bmatrix} A^{11} & A^{12} & A^{13} \\ A^{21} & A^{22} & A^{23} \\ A^{31} & A^{32} & A^{33} \end{bmatrix} = \begin{bmatrix} \frac{Z^{11}}{Y^1} & \frac{Z^{12}}{Y^2} & \frac{Z^{13}}{Y^3} \\ \frac{Z^{21}}{Y^1} & \frac{Z^{22}}{Y^2} & \frac{Z^{23}}{Y^3} \\ \frac{Z^{31}}{Y^1} & \frac{Z^{32}}{Y^2} & \frac{Z^{33}}{Y^3} \end{bmatrix}$; where, A^{ij}'s are intermediate input coefficients representing amount of country j's procurement of intermediate goods from country I to produce unit amount of output in country j. Note here again that vertical elements of matrix A represents intermediate input structure for production and horizontal elements describe distribution structure of production. Now, for a given input coefficient matrix A, vector of final goods produced in respective countries F and gross output vector Y, the input-output equation[10] is given in Equation 1.

$$\begin{bmatrix} Y^1 \\ Y^2 \\ Y^3 \end{bmatrix} = \left\{ \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} A^{11} & A^{12} & A^{13} \\ A^{21} & A^{22} & A^{23} \\ A^{31} & A^{32} & A^{33} \end{bmatrix} \right\}^{-1} \begin{bmatrix} F^1 \\ F^2 \\ F^3 \end{bmatrix} \qquad (1)$$

Here, $\begin{bmatrix} F^1 \\ F^2 \\ F^3 \end{bmatrix} = \begin{bmatrix} F^{11} + F^{12} + F^{13} \\ F^{21} + F^{22} + F^{23} \\ F^{31} + F^{32} + F^{33} \end{bmatrix}$ is the vector of final goods produced in respective countries. A simplified matrix representation of equation 1 is given below

[10] Without loss of generality, single sector GIO table can be extended to multi sector table with the same matrix equation by representing variables with corresponding matrix sizes.

$$Y = (I - A)^{-1} F$$

or

$$Y = LF \qquad (1a)$$

Where, I is an identity matrix and $L = (I - A)^{-1}$ is the Leontief inverse matrix. The Leontief inverse matrix, by its nature, captures the direct and induced effects[11] associated with final goods productions.

3.2 Global Chain based on the Leontief inverse

Let us denote final goods export of the country 1 E^1, and consider the following equation

$$\begin{bmatrix} L^{11} & L^{12} & L^{13} \\ L^{21} & L^{22} & L^{23} \\ L^{31} & L^{32} & L^{33} \end{bmatrix} \begin{bmatrix} E^1 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} = \begin{bmatrix} L^{11}E^1 \\ L^{21}E^1 \\ L^{31}E^1 \end{bmatrix} = \begin{bmatrix} y^{11} \\ y^{21} \\ y^{31} \end{bmatrix} \qquad (2)$$

Here, y^{i1} (i = 1, 2, 3) are the gross production of i^{th} country associated with production of final goods export of country 1 (i.e., E^1). In other words, equation 2 represents how country 1 procures inputs from various sources to produce its final goods export. In a similar manner, we can easily extend equation 2 as following to compute input contents for each country's export.

$$\begin{bmatrix} L^{11} & L^{12} & L^{13} \\ L^{21} & L^{22} & L^{23} \\ L^{31} & L^{32} & L^{33} \end{bmatrix} \begin{bmatrix} E^1 & 0 & 0 \\ 0 & E^2 & 0 \\ 0 & 0 & E^3 \end{bmatrix} = \begin{bmatrix} L^{11}E^1 & L^{12}E^2 & L^{13}E^3 \\ L^{21}E^1 & L^{22}E^2 & L^{23}E^3 \\ L^{31}E^1 & L^{32}E^2 & L^{33}E^3 \end{bmatrix} \qquad (3)$$

Equation 3 represents input contents associated with each country's export and it is a measurement of global chain based on the Leontief inverse (say, G_L), which can be rewritten in matrix form as,

$$G_L = L\hat{E} \qquad (3a)$$

Equation 3 provides a basic framework to study domestic and international trade of inputs which includes the inducement effect (usually, difficult to observe direectly) of production. The global chain based on the IO framework captures direct and induced effect of production, but it does not tell us about the extent of value-added

[11] See any of the Input-Output textbooks (for example, Miller and Blair, 2009) for the details.

contents, which are accounted as domestic contents. This is why conventional GIO model overstates the domestic contents of export.

3.3 Global Chain for value-added: Existing method

Trade in value-added (for instance, OECD-WTO database, Johnson and Noguera, 2012 and Koopman *et al.*, 2012) literatures estimate domestic and traded value-added contents embodied in export. The global chains in value-added provides a better measure of economic linkages as it accounts both direct and indirect effects. In general, calculation of global chain for value-added (we assume it as *Gv*) associated with each country's export[12] uses following equation,[13]

$$Gv = \begin{bmatrix} \frac{V^1}{Y^1} & 0 & 0 \\ 0 & \frac{V^2}{Y^2} & 0 \\ 0 & 0 & \frac{V^3}{Y^3} \end{bmatrix} \begin{bmatrix} L^{11}E^1 & L^{12}E^2 & L^{13}E^3 \\ L^{21}E^1 & L^{22}E^2 & L^{23}E^3 \\ L^{31}E^1 & L^{32}E^2 & L^{33}E^3 \end{bmatrix} = \begin{bmatrix} Av^1 & 0 & 0 \\ 0 & Av^2 & 0 \\ 0 & 0 & Av^3 \end{bmatrix} L\hat{E} = \hat{A}vL\hat{E} \qquad (4)$$

Where, Av^j is the value-added input coefficient with respect to country *j*'s gross inputs such that $\sum_i A^{ij} + Av^j = 1$ and its diagonal matrix form is denoted as $\hat{A}v$.

Note that matrix of the value-added contents derived in equation 4 is combination of the value-added share '$\hat{A}vL$' and the final goods export $\hat{E}$. In particular, the value-added share '$\hat{A}vL$' captures the direct and indirect transactions of intermediate goods and it allocates respective value-added inputs to the country where the intermediate inputs are produced. In this sense, RHS of equation 4 provides a better measure of the value-added contents (domestic and bilateral trade in value-added) by taking account of source country of the intermediate inputs used for the production of the respective final goods.

Even though it is said that equation 4 provides a better measure and has been widely used for measurement of the value-added related questions recently, it does not accommodate the effect of intermediate inputs in reality. We show, in Appendix 2, that column sum of $\hat{A}vL\hat{E}$ is nothing but the amount of final goods export in respective countries. This particular fact implies that the term $\hat{A}vL\hat{E}$ allocates the amount of each country's final goods export $\hat{E}$ as domestic and imported value-added contents. In

[12] Here, we formulate an equation for global chain for value-added associated with final goods production. However, we can easily calculate the global chain embodied in export by replacing diagonal matrix of final goods with diagonal matrix of export in equation 4.

[13] Although, Johnson and Noguera (2012) do not formulate the value-added export in matrix notation, equations $va_{ij}(s) = r_i(s)y_{ij}(s)$ and $va_{ij} = \sum_s va_{ij}(s)$ (here, notations follow Johnson and Noguera, 2012) given in definition 1 (page 226) are equivalent to equation 4 in matrix form.

other words, global chain in value added accounts each country's amount of final goods export and embodied trade in intermediate goods is completely ignored. Example in Section 2 illustrate that production inducement in intermediate goods sector is accounted as domestic contents and thus still overstates the domestic contents of export. Therefore, calculating global chains with respect to trade in value-added only (as in existing literatures) is not sufficient enough. To overcome this important drawback we propose a new measure of global chain that integrates effect of both the value-added inputs and intermediate inputs.

3.4 Global Chain for value-added and intermediates: New method

Having said that the global chain based on the Leontief inverse accounts both direct and indirect effects, and the existing approaches only account the effect of value-added in reality, We propose a new measure of the global chain (say, G) that is capable to capture both direct and indirect effects, global chain of value-added (as in existing literatures) and global chain for intermediate goods additionally. We combine both effects of value-added and intermediate goods to obtain the new measure of the global chain given in the following matrix equation.

$$G = G_{int} + G_v = AL\hat{E} + \hat{A}vL\hat{E} \qquad (5)$$

Here, $G_{int} = AL\hat{E}$ is the global chain for intermediate goods that describes source country of intermediate goods associated with the production of final goods. Further, equation 5 can be written as $G = L\hat{E} - L\hat{E} + AL\hat{E} + \hat{A}vL\hat{E}$ and on arranging we finally get

$$G = L\hat{E} - \hat{E} + \hat{A}vL\hat{E} = G_L - \hat{E} + G_v \qquad (6)$$

And using relationship ($uG_v = u\hat{E}$) derived in Appendix 2, we have,

$$uG = uG_L \qquad (7)$$

On the one hand, Equations 6 illustrates relationship between new and two of existing measures of global chain based on the IO theory. The new approach subtracts the direct effect of the final goods export $\hat{E}$ (considered as domestic contents) from global chain based on the Leontief inverse (G_L) and adds an equivalent value-added contents G_v. As a consequence, our approach accounts both direct and induced effect of production in the model and hence it improves the misstatement problem.

Equation 7 indicates that the results obtained from new method and the global

chain based on the Leontief inverse have same characteristic from the backward linkage point of view. In other words, both results track the source country of both intermediate and value-added inputs associated with final goods production. In summary, the newly proposed measure of global chain improves disadvantage of overestimating the domestic procurements in G_L, by replacing $\hat{E}$ with G_v.

Finally, we calculate the global chain for value-added and intermediate goods using equation 5 and summarize the extent of global chains in Asia, Europe and North America using annual datasets of YNU-GIO tables from 1997 to 2010.

4. Globally linked Input-Output data sets: YNU-GIO tables

We use annual YNU-GIO tables to explore how global chains, especially in Asia, have developed and changed. The annual dataset from 1997 to 2010 covers 27 endogenous countries, 62 exogenous countries and 35 industries. The YNU-GIO database covers not only major Asian economies but also a number of advanced economies such as the US and other European countries as an endogenous country. It also includes as many economies as possible (mainly from Asia, Europe and oil producing countries) as an exogenous country.[14] Table 2 provides a comparison of YNU-GIO dataset with two major GIO datasets AIO and WIOD.

*** Table 2 around here ***

We preferred to use the YNU-GIO table because of following two reasons. First, AIO is outdated and major advanced economies (precisely, European countries) are not covered in AIO database. Next, WIOD's coverage of Asian economies is insufficient. As it is explained in Section 2 also, Asian regional production chain cannot be justified without treating Malaysia and Thailand (at least) endogenously.

We discussed our analytical framework on the basis of three-country GIO table without exogenous countries[15] in Section 3. However, the essential feature of the model does not differ much by inclusion of the exogenous countries. The only difference is that it is not possible to compute global chains with respect to export of exogenous countries, because input structures of the exogenous countries are not

[14] See Sato and Shrestha (2013) for details of the YNU-GIO tables.

[15] Exogenous countries in GIO tables are countries for which input structures of production (both intermediate and value-added inputs) are not available. Although, effects of production in exogenous countries are ignored, their supplies of intermediate goods to the endogenous countries are accounted exogenously in the model.

available.

5. Results

We calculate the extent of global chains for value-added and intermediate goods with respect to export of 27 endogenous countries covered by the YNU-GIO tables using equation 5. The result for global chains for any endogenous country consists of its sources of procurement to produce final goods exported by that country. Figure 2 summarizes procurement structure of Asia, Europe, N. America and all endogenous countries from foreign countries in 2000, 2005 and 2010. Gray and black bars in the figure shows foreign contents in regional export calculated from existing and new method respectively. Evident under estimation of foreign contents by existing method in Figure 2 means that the extent of export shock transmission to foreign countries is low and that to domestic economy is high. In other words, the degree of economic linkage with foreign countries, based on existing method, is understated. In Asia, share of foreign contents has increased significantly from 23.5% in 2000 to 30.4% in 2010, whereas, the share has decreased form 37.1% to 32.7% during the period in N. America. Moreover, in contrast to the result based on existing method, level of procurement from foreign countries in Europe is far higher than that in Asia. Such difference in results can be attributed to the fact that the existing method does not address the embodied trade in intermediate goods in the model. Therefore, we claim that the existing approach alone is not sufficient to explain the international transmission channels of economic shock and hence, it justifies our approach to include both embodied trades in value-added and intermediate goods to figure out better picture of economic linkages across countries.

*** Figure 2 around here ***

We present regional global chain of value-added and intermediate goods (based on new method) and global chain of value added (based on existing method) in Figures 3 from 1997 to 2010. Global chain results are aggregated by three regions (Asia, Europe, N. America and all countries) according to their source of procurement from Asia, Europe and N. America to illustrate regional linkages. Figure 3 shows general upward trend of Asian procurements in manufacturing industry. In particular, not only regional procurement in Asia has increased (12.6% in 1997 to 18.8 in 2010) significantly, Asian procurement to other regions has also increased during the period. Such increase indicates growing Asian regional economic integration and Asia’s emergence as a

major procurement source (both intermediate goods and value-added) for the World production also. Asian emergence can be explained by the fact that share of Asian procurement to all countries is the highest (13.4%, which is 1.3% higher than European procurement) in 2010. Moreover, share of regional and Asian contents in N. American export shows almost same level in 2010. In contrast, existing method evaluates the regional contents much higher than the Asian contents. The difference in results by two methods can be attributed to the fact that existing method accounts trade in value-added only and ignore effect of trade in intermediate goods, which is a major component of Asian procurements.

It is important to note that the results based on existing method show more or less same level of respective regional contents in Asia and Europe in Figure 3 meaning that the degree of regional integration in Asia and Europe are more or less same. However, it is true that, Asia has not achieved European level of regional integration yet. Our results (in terms of regional contents in export) confirm lower degree of economic integration in Asia compared to Europe.

*** Figure 3 around here ***

So far, we discussed regional global chain in manufacturing industry. Use of GIO table allows us to carry out industry-specific analysis also. Although there are 35 industries in YNU-GIO table, we pick up two major industries, namely electric machinery and transport equipment industry, for our study. Figures 4 and 5 illustrate results of regional global chain based on existing and new method in electric machinery and transport equipment industries respectively. Electric machinery industry in Asia procured 26.8% of its procurement from its regional partners in 2010 compared to Europe's 20.4% of procurement from Europe. On the other hand, in transport equipment industry the extents of regional procurement in Asia and Europe are 12.7% and 28.0% respectively in 2010. It means, Asia is highly integrated regionally compared to Europe in electric machinery sector, whereas, opposite is true in transport equipment industry. Asia has emerged as major source for procurement, specifically in electric machinery industry, after 2000. Among others, China's entry in global production network in the beginning of 21st century helped Asia to become a major procurement source for the World's export.

*** Figure 4 around here ***

*** Figure 5 around here ***

Finally, we present detailed country-specific results of global chain for value-added and intermediate goods. Tables 3, 4 and 5 provides region- and country-specific global chain results for 2000, 2005 and 2010 in manufacturing, electric machinery and transport equipment industries respectively. We mentioned that economic integration in Asia has increased significantly during 1997-2010 based on the regional analysis. However, if we carefully look at Tables 3, 4 and 5 (country-specific results,) we find that there exists dissimilar procurement structure in Asia. For example, in manufacturing industry, Malaysia's procurement from foreign countries is 62.4% in 2010 and that for Japan and china are 14.9% and 29.1% (see Table 3) respectively. Such differences in procurement structure lead to asymmetric shock transmission patterns across regional members. As a consequence, implementation of common economic policy becomes difficult in Asia. On the other hand, in European case, member countries have more or less similar procurement structure compared to Asia.

In electric machinery industry (see Table 4), all countries procurement ratio from China has increased to 5.1% in 2010 from 1.6% in 2000. In a similar manner, Chinese procurement to Europe and N. America also increased significantly from 1.3% and 2.2% in 2000 to 5.2% and 6.8% in 2010 respectively. These numbers explain that China has become a major source of procurement for the World's electric machinery production.

In transport industry (see Table 5), Japan shows very unique procurement structure. Japanese transport industry's procurement form foreign countries is the lowest (12.0% in 2010) compared to Korea's 34.7%, Germany's 34.0% and 27.4% for the US. Once export shock hits Japanese transport industry, the shock does not transmit to foreign countries, but most of the shocks are absorbed with in the country.

6. Concluding remarks

Recent works by Johnson and Noguera (2012), Koopman *et al.* (2012) and OECD-WTO attempt to estimate embodied trade associated with export to reveal hidden structure of trade in value-added underlying gross trade flow. Compared to conventional trade data and conventional GIO analysis, such approach improves overstatement of domestic contents of exports problem to some extent. However, we show that results based on the existing method account embodied trade in intermediate goods as domestic contents and hence the understatement problem of foreign contents in export still remains. Such misstatement in international trade linkages may limit

practical implication of the results.

We also compute embodied trade associated with export using newly constructed YNU-GIO tables to reveal hidden structure of trade. The main difference is that we calculate embodied trade in terms of both value-added and intermediate goods, whereas recent literatures take account of embodied trade in terms of value-added only. Overlooking embodied intermediate inputs trade (as in recent literatures) will definitely understate foreign contents of export, because trade in intermediate inputs accounts more than half of international trade. Although, results based on existing method show similar level of regional integration in Europe and Asia, it is well-known fact that Asia has not achieved European level of regional integration yet. Our results on regional procurement in Asia and Europe confirm the higher level of European integration compared to Asian level.

Based on the results of manufacturing industry, regional and global chains in Asia and Asian contents in European, North American and the World's export has increased significantly during 1997-2010 period. It means that Asian economies demonstrate significant progress in both regional and global integration. Industry-specific results for two major industries (electric machinery and transport equipment) in Asia also show similar trend. However, the level of regional contents of electric machinery industry is comparatively higher than that of transport equipment industry. Very low foreign procurement ratio (7.4% in 2000 and 12.0% in 2010, see Table 5) and large share of finished goods export of Japanese transport equipment industry are two major factors that explain relatively low level of regional integration in Asian transport equipment sector. Moreover, we also illustrate that country-specific global chain structures in Asia is comparatively diverse than that in Europe. In particular, Japan has very low share of foreign procurements (although it increased significantly from 2000), whereas Malaysia has very low domestic contents. Finally we conclude that existence of economic diversity remains as a major issue for Asian economic and monetary integration, even though regional and global chain in Asia has expanded significantly during 1997-2010 period.

This paper can be extended in following ways. First, detailed country- and industry-specific analysis will be more informative. Second, use of more recent (for example, 2012 or 2011) GIO tables enables us to understand new developments in global chains in recent years. And finally, inclusion of more Asian economies (for instance, Singapore, the Philippines etc.) endogenously in the GIO table will useful to extend the analysis. These are left for future work.

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Tables and Figures

Figure 1: China's procurement for its final goods export to USA, Billion USD in 2005 (Procurement in percent)

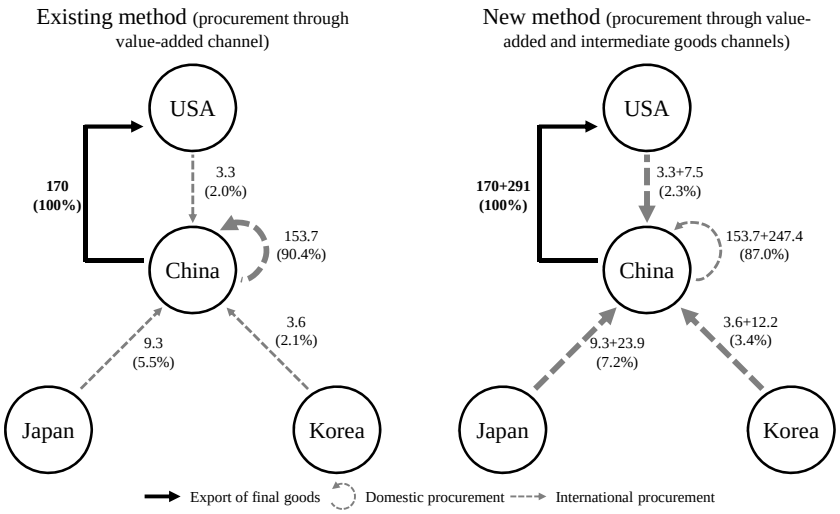

Figure 2: Comparison of procurement from foreign countries (2000-2005-2010, percent)

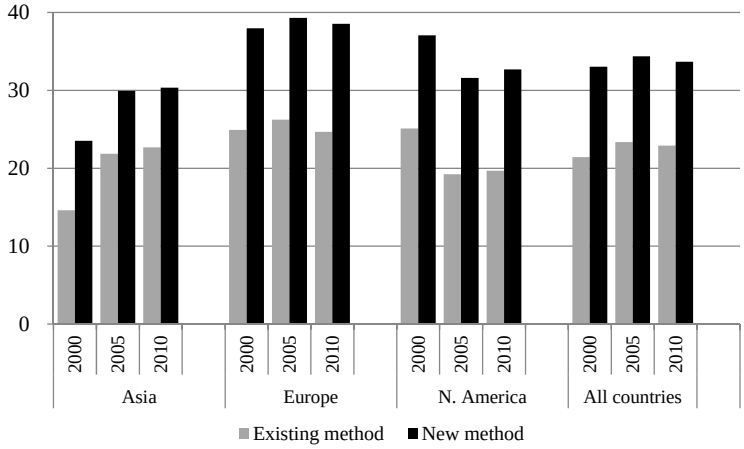

Figure 3: Regional global chain of value-added and intermediate goods

(Manufacturing industry, 1997-2010, percent)

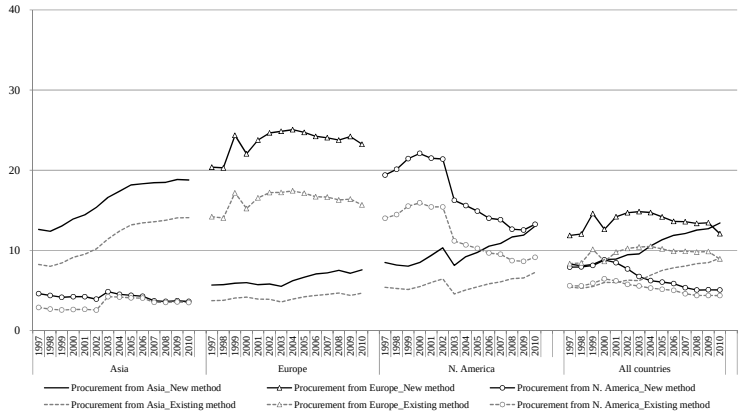

Figure 4: Regional global chain of value-added and intermediate goods

(Electric machinery industry, 1997-2010, percent)

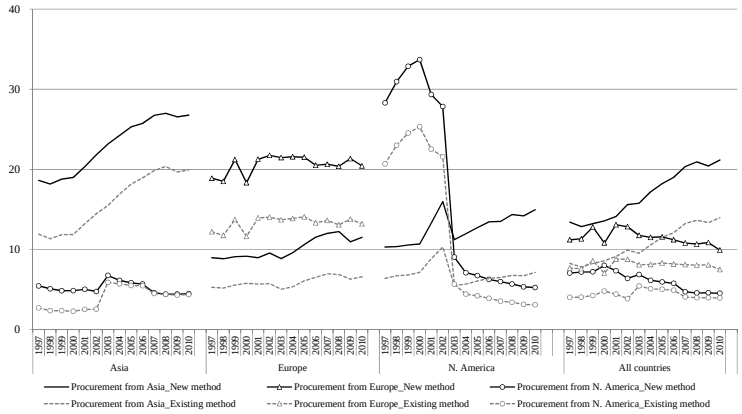

Figure 5: Regional global chain of value-added and intermediate goods

(Transport equipment industry, 1997-2010, percent)

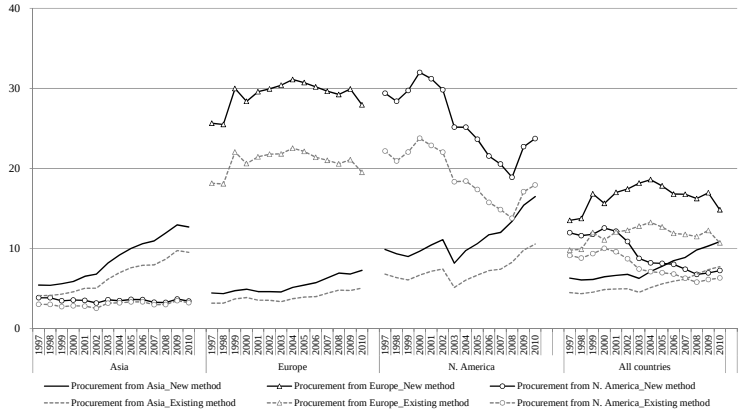

Table 1: Layout of a typical GIO table

		Intermediate goods			Final goods			Gross output
		Country1	Country2	Country3	Country1	Country2	Country3	
Intermediate goods	Country1	Z^{11}	Z^{12}	Z^{13}	F^{11}	F^{12}	F^{13}	Y^{1}
	Country2	Z^{21}	Z^{22}	Z^{23}	F^{21}	F^{22}	F^{23}	Y^{2}
	Country3	Z^{31}	Z^{32}	Z^{33}	F^{31}	F^{32}	F^{33}	Y^{3}
Value-added inputs		V^{1}	V^{2}	V^{3}				
Gross input		Y^{1}	Y^{2}	Y^{3}				

Table 2: Comparison of YNU-GIO, WIOD and AIO data sets

	YNU-GIO	**WIOD**	**AIO**
Endogenous countries	27 countries	40 countries	10 countries
Asia	9 countries JPN, CHN, KOR, TWN, MAL, THL, IDN, VTM, IND	6 countries JPN, CHN, KOR, TWN, IDN, IND	9 countries JPN, CHN, KOR, TWN, MAL, THL, IDN, SGP, PHL
North America	3 countries USA, CAN, MEX	3 countries USA, CAN, MEX	1 country USA
Europe	12 countries FRA, GER, UK, EU9*	27 countries EU27	-
Others	3 countries AUS, BRA, SAF	4 countries AUS, BRA, RUS, TUR	-
Exogenous countries	62 economies HK, PHL, SGP, Asia30, Eur16, OPEC12 and ROW	-	3 economies HK, EU27 (?), and ROW
Period (Availability)	1997 - 2010	1995 - 2009	1985, 1990, 1995 and 2000^{+} ($^{+}$ Latest table)
Sectors	35 industries	35 industries	78 industries (max)

*EU9: AUT, BEL, FIN, IRE, ITA, LUX, NLD, POR and ESP

Table 3: Global Chain for value-added and intermediates goods
(Manufacturing industry, 2000-2005-2010, percent)

2000		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
Procurement from	Domestic	**76.5**	91.0	81.6	62.4	55.0	31.5	64.6	79.6	55.9	90.3	**62.0**	67.5	70.6	50.8	40.8	59.6	30.5	70.3	43.0	50.5	53.5	52.4	67.0	**62.9**	81.3	42.3	39.5	**67.0**
	Foreign	**23.5**	9.0	18.4	37.6	45.0	68.5	35.4	20.4	44.1	9.7	**38.0**	32.5	29.4	49.2	59.2	40.4	69.5	29.7	57.0	49.5	46.5	47.6	33.0	**37.1**	18.7	57.7	60.5	**33.0**
	Asia	**13.9**	3.5	12.3	20.7	28.7	45.2	22.6	10.8	36.4	3.5	**6.0**	4.7	5.4	4.1	6.8	9.7	12.4	3.9	3.1	8.0	4.7	4.8	8.1	**8.5**	8.5	7.4	10.2	**8.9**
	China	**1.5**	1.0	0.0	4.0	2.3	3.1	3.0	1.8	3.6	1.0	**1.0**	0.9	0.9	0.7	1.0	1.7	1.2	0.9	0.4	1.3	0.5	0.8	1.1	**1.4**	1.4	1.1	1.7	**1.2**
	Europe	**2.7**	1.3	2.7	5.2	5.7	9.4	4.5	2.8	3.6	2.8	**22.0**	19.2	15.7	36.8	42.4	23.1	26.2	17.3	47.3	24.6	36.1	35.3	15.6	**4.8**	4.4	5.5	5.1	**12.6**
	N. America	**4.2**	2.8	2.1	7.4	7.7	10.4	5.4	3.9	2.2	1.4	**6.4**	5.7	5.0	5.8	6.8	4.9	23.3	3.8	4.3	11.1	2.6	4.2	7.1	**22.1**	4.3	42.8	43.5	**8.8**
	USA	**3.8**	2.5	1.8	6.8	7.2	9.8	4.9	3.3	2.0	1.1	**5.7**	5.2	4.5	5.2	5.9	4.6	22.1	3.4	4.0	10.1	2.3	3.6	6.0	**18.9**	0.0	41.0	41.7	**7.7**
	OPEC	**0.5**	0.4	0.2	1.0	1.2	0.4	0.5	0.5	0.5	0.5	**0.3**	0.3	0.2	0.2	0.3	0.1	0.1	0.4	0.2	0.4	0.3	0.6	0.2	**0.3**	0.2	0.3	0.2	**0.4**
	ROW	**2.2**	1.1	1.0	3.3	1.7	3.1	2.5	2.4	1.4	1.6	**3.3**	2.7	3.2	2.2	2.8	2.5	7.4	4.2	2.0	5.4	2.7	2.7	2.0	**1.4**	1.2	1.7	1.6	**2.4**

2005		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
Procurement from	Domestic	**70.1**	85.5	72.1	62.7	45.1	39.9	53.5	82.7	50.4	87.6	**60.7**	67.1	68.3	52.4	41.9	52.3	29.3	68.0	36.2	52.4	50.8	54.9	64.0	**68.4**	81.4	48.9	45.5	**65.6**
	Foreign	**29.9**	14.5	27.9	37.3	54.9	60.1	46.5	17.3	49.6	12.4	**39.3**	32.9	31.7	47.6	58.1	47.7	70.7	32.0	63.8	47.6	49.2	45.1	36.0	**31.6**	18.6	51.1	54.5	**34.4**
	Asia	**18.1**	6.9	17.1	21.2	36.5	37.6	30.8	10.4	41.3	5.4	**6.6**	4.7	6.2	4.1	6.7	12.3	12.0	5.0	3.8	11.0	5.4	5.6	8.1	**9.7**	8.1	8.5	18.7	**11.3**
	China	**3.1**	3.6	0.0	6.8	7.8	9.8	8.0	3.0	11.3	2.3	**2.1**	1.5	1.9	1.2	1.8	4.0	5.0	2.1	0.7	3.6	1.1	1.8	2.4	**3.2**	2.5	2.7	7.3	**2.6**
	Europe	**3.9**	2.3	4.9	5.2	6.0	8.2	5.0	2.3	3.5	2.7	**24.7**	21.3	18.8	37.1	42.6	27.3	34.9	20.3	53.7	26.1	38.4	32.6	19.7	**4.9**	4.5	5.4	5.8	**14.2**
	N. America	**4.4**	2.8	3.3	6.6	9.1	11.4	6.0	2.5	2.3	1.5	**4.9**	4.4	3.9	3.8	5.7	5.5	19.7	2.9	3.6	6.3	2.1	3.3	5.8	**14.9**	4.2	34.7	27.5	**6.0**
	USA	**3.9**	2.5	2.8	6.0	8.5	10.8	5.6	2.1	1.9	1.2	**4.4**	3.9	3.5	3.3	5.0	5.0	18.9	2.5	3.3	5.8	1.8	2.7	5.0	**11.7**	0.0	33.1	26.0	**5.2**
	OPEC	**0.8**	0.8	0.7	1.3	1.4	0.6	0.8	0.4	0.8	0.4	**0.4**	0.4	0.2	0.2	0.5	0.2	0.2	0.7	0.3	0.5	0.5	0.8	0.2	**0.4**	0.4	0.4	0.3	**0.6**
	ROW	**2.7**	1.7	1.9	2.9	2.0	2.3	3.9	1.8	1.8	2.4	**2.7**	2.1	2.6	2.4	2.6	2.5	4.0	3.0	2.4	3.6	2.8	2.9	2.2	**1.7**	1.5	2.1	2.2	**2.3**

2010		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
Procurement from	Domestic	**69.6**	85.1	70.9	64.5	45.5	37.6	54.5	87.8	46.2	85.3	**61.5**	65.7	68.6	53.7	42.3	57.0	35.9	67.7	48.7	53.5	52.1	56.3	63.7	**67.3**	80.5	46.6	43.3	**66.3**
	Foreign	**30.4**	14.9	29.1	35.5	54.5	62.4	45.5	12.2	53.8	14.7	**38.5**	34.3	31.4	46.3	57.7	43.0	64.1	32.3	51.3	46.5	47.9	43.7	36.3	**32.7**	19.5	53.4	56.7	**33.7**
	Asia	**18.8**	7.6	17.4	21.9	40.3	38.6	31.4	8.9	44.2	7.2	**7.6**	5.7	7.0	5.2	8.5	9.5	8.3	7.1	3.9	11.9	6.5	7.0	8.9	**13.0**	9.5	12.1	25.9	**13.4**
	China	**3.4**	4.0	0.0	8.9	12.6	11.2	9.3	2.6	17.2	3.5	**3.2**	2.5	3.0	2.1	3.0	4.5	3.6	3.5	1.3	4.5	2.2	3.2	3.4	**5.9**	4.0	4.5	13.9	**3.6**
	Europe	**4.1**	2.0	5.5	4.5	4.2	8.8	4.6	0.9	3.5	2.5	**23.2**	21.0	17.9	35.1	40.0	26.3	35.2	18.7	41.3	24.0	35.9	29.7	19.6	**4.5**	4.0	4.7	5.8	**12.1**
	N. America	**3.6**	2.5	3.2	4.9	5.9	11.5	4.6	1.1	3.0	1.7	**4.3**	4.8	3.4	2.7	5.6	3.7	16.3	2.6	3.1	5.5	2.0	3.1	5.2	**13.2**	4.3	34.2	22.7	**5.0**
	USA	**3.2**	2.2	2.7	4.4	5.5	11.0	4.2	0.9	2.6	1.5	**3.9**	4.3	3.0	2.4	4.9	3.3	15.6	2.3	2.8	4.9	1.6	2.6	4.5	**9.8**	0.0	31.5	21.2	**4.2**
	OPEC	**0.9**	0.8	0.8	1.1	2.3	0.7	1.0	0.3	1.0	1.4	**0.5**	0.5	0.3	0.3	0.6	0.2	0.2	0.8	0.3	0.6	0.6	1.0	0.3	**0.3**	0.3	0.3	0.3	**0.7**
	ROW	**2.9**	2.0	2.3	3.1	1.8	2.8	3.8	0.9	2.2	1.8	**2.9**	2.2	2.9	3.0	3.0	3.3	4.1	3.1	2.7	4.5	2.9	2.9	2.4	**1.6**	1.4	2.1	2.0	**2.5**

Table 4: Global Chain for value-added and intermediate goods
(Electric machinery industry, 2000-2005-2010, percent)

2000		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
	Domestic	**70.0**	90.2	76.9	50.7	49.6	25.3	46.1	75.8	39.6	81.4	**63.3**	66.9	72.8	56.4	44.7	60.5	33.7	63.0	44.1	55.3	44.7	55.5	66.2	**48.7**	82.1	40.5	23.1	**65.1**
	Foreign	**30.0**	9.8	23.1	49.3	50.4	74.7	53.9	24.2	60.4	18.6	**36.7**	33.1	27.2	43.6	55.3	39.5	66.3	37.0	55.9	44.7	55.3	44.5	33.8	**51.3**	17.9	59.5	76.9	**34.9**
Procurement from	Asia	**19.0**	4.5	14.9	31.3	33.6	49.9	39.4	13.7	51.0	4.6	**9.2**	7.5	8.9	6.6	10.2	13.4	14.8	5.2	3.9	7.4	7.9	7.6	10.7	**10.7**	7.6	10.5	14.1	**13.6**
	China	**1.9**	1.4	0.0	5.3	2.5	2.9	2.9	1.8	4.2	1.1	**1.3**	1.1	1.0	0.9	1.3	2.5	1.4	1.1	0.4	1.2	1.0	1.3	1.4	**2.2**	1.6	2.8	2.3	**1.6**
	Europe	**3.5**	1.4	4.2	6.1	6.4	10.7	5.3	4.5	4.8	6.3	**18.3**	18.1	11.5	31.2	37.5	19.4	30.7	22.1	44.9	19.5	41.1	30.0	13.9	**5.1**	4.1	5.6	5.6	**10.8**
	N. America	**4.9**	2.5	2.6	8.9	7.4	11.1	7.3	3.8	2.4	1.7	**6.1**	4.9	4.0	3.7	5.4	4.8	16.9	4.9	5.0	9.7	3.7	4.2	7.4	**33.7**	4.4	41.8	55.0	**8.0**
	USA	**4.5**	2.2	2.3	8.3	6.9	10.7	7.0	3.3	2.1	1.4	**5.4**	4.3	3.7	3.3	4.8	4.5	16.0	4.3	4.7	8.8	3.3	3.7	6.0	**30.4**	0.0	38.3	53.0	**7.2**
	OPEC	**0.4**	0.3	0.3	0.6	1.0	0.3	0.2	0.5	0.5	0.6	**0.2**	0.2	0.1	0.2	0.2	0.1	0.2	0.4	0.2	0.2	0.3	0.5	0.1	**0.2**	0.3	0.2	0.3	**0.3**
	ROW	**2.3**	1.1	1.1	2.4	1.9	2.6	1.6	1.7	1.8	5.4	**3.0**	2.5	2.6	1.9	2.1	1.8	3.8	4.4	2.0	7.9	2.2	2.3	1.6	**1.6**	1.5	1.6	1.8	**2.2**

2005		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
	Domestic	**60.3**	81.1	62.5	56.6	37.8	36.9	46.0	74.7	37.9	81.5	**59.5**	68.3	66.9	57.9	50.0	48.4	37.2	61.2	42.2	53.1	35.9	46.6	60.1	**75.3**	82.1	54.1	28.4	**61.8**
	Foreign	**39.7**	18.9	37.5	43.4	62.2	63.1	54.0	25.3	62.1	18.5	**40.5**	31.7	33.1	42.1	50.0	51.6	62.8	38.8	57.8	46.9	64.1	53.4	39.9	**24.7**	17.9	45.9	71.6	**38.2**
Procurement from	Asia	**25.3**	10.8	23.8	26.6	43.8	38.0	38.0	16.6	50.5	8.0	**10.6**	6.5	11.3	6.3	9.2	18.3	8.7	6.8	5.2	10.3	7.6	12.6	12.4	**12.7**	10.4	14.2	32.6	**18.2**
	China	**3.9**	6.1	0.0	7.1	8.9	8.8	7.1	4.8	11.0	3.1	**3.0**	2.1	2.8	1.7	2.6	5.9	2.3	2.7	1.0	2.9	1.9	3.9	3.5	**3.8**	2.9	4.5	11.9	**3.6**
	Europe	**5.1**	2.7	6.8	5.0	6.3	9.3	5.4	4.4	5.3	4.0	**21.5**	19.1	14.7	30.1	34.0	23.8	35.6	25.0	46.5	26.8	50.6	32.9	18.1	**3.8**	3.3	5.1	7.1	**11.6**
	N. America	**5.8**	3.0	4.2	8.6	9.7	13.5	7.1	2.8	3.0	2.1	**5.9**	3.9	5.0	3.4	4.5	7.0	15.6	3.7	3.8	6.6	3.2	4.4	7.4	**6.7**	3.0	24.3	29.0	**5.9**
	USA	**5.3**	2.6	3.6	8.0	9.2	12.8	6.6	2.5	2.7	1.8	**5.3**	3.5	4.7	3.0	4.1	6.4	14.8	3.3	3.4	6.1	2.8	3.7	6.3	**4.0**	0.0	22.6	27.4	**5.1**
	OPEC	**0.8**	0.7	0.7	1.0	0.8	0.5	0.6	0.4	0.9	0.5	**0.3**	0.3	0.2	0.2	0.3	0.2	0.2	0.6	0.2	0.3	0.5	0.6	0.2	**0.3**	0.3	0.3	0.5	**0.5**
	ROW	**2.7**	1.8	2.0	2.1	1.7	1.8	2.9	1.1	2.4	3.9	**2.2**	2.0	2.0	2.2	2.0	2.3	2.7	2.7	2.1	2.9	2.3	2.8	1.9	**1.2**	1.0	2.0	2.5	**2.0**

2010		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
	Domestic	**59.7**	80.6	61.3	61.7	37.9	31.7	38.8	75.7	34.5	79.4	**60.8**	67.7	71.1	57.5	50.2	50.1	37.2	57.9	61.5	52.6	39.9	51.8	58.9	**74.9**	80.9	56.0	27.5	**61.5**
	Foreign	**40.3**	19.4	38.7	38.3	62.1	68.3	61.2	24.3	65.5	20.6	**39.2**	32.3	28.9	42.5	49.8	49.9	62.8	42.1	38.5	47.4	60.1	48.2	41.1	**25.1**	19.1	44.0	72.5	**38.5**
Procurement from	Asia	**26.8**	11.9	24.2	26.1	49.2	40.7	45.9	19.3	53.0	11.5	**11.5**	7.7	11.0	7.6	10.3	16.1	10.7	10.8	5.4	13.0	10.6	14.7	15.7	**15.0**	12.0	16.5	41.5	**21.2**
	China	**4.8**	6.6	0.0	10.1	15.7	11.3	12.3	5.8	18.5	5.2	**5.2**	3.6	5.1	3.2	4.8	7.6	4.7	5.9	2.0	5.7	4.9	7.2	6.1	**6.8**	5.1	7.1	22.0	**5.1**
	Europe	**5.4**	2.3	7.6	4.1	4.1	10.5	5.3	2.0	5.0	3.2	**20.4**	19.1	12.4	29.3	32.2	25.8	35.4	24.2	28.6	24.9	43.9	26.5	17.1	**3.5**	3.1	4.4	6.8	**9.9**
	N. America	**4.5**	2.4	3.9	4.8	6.1	14.4	6.6	1.8	4.1	1.9	**4.4**	3.1	3.0	2.6	4.5	4.8	13.6	3.3	2.6	5.7	2.6	3.5	6.1	**5.2**	2.7	20.4	21.6	**4.5**
	USA	**4.0**	2.1	3.3	4.3	5.7	13.8	6.1	1.6	3.6	1.7	**4.0**	2.8	2.8	2.2	3.9	4.4	12.7	3.0	2.4	5.2	2.2	3.0	5.3	**2.7**	0.0	18.8	20.2	**3.8**
	OPEC	**0.9**	0.8	0.8	1.0	1.3	0.5	0.8	0.4	1.0	1.3	**0.3**	0.3	0.2	0.2	0.3	0.2	0.2	0.7	0.2	0.4	0.6	0.8	0.3	**0.3**	0.2	0.3	0.5	**0.7**
	ROW	**2.8**	2.0	2.3	2.4	1.4	2.3	2.6	0.9	2.4	2.6	**2.5**	2.1	2.2	2.8	2.5	3.0	2.8	3.1	1.7	3.4	2.4	2.7	2.0	**1.2**	1.0	2.5	2.1	**2.2**

Table 5: Global Chain for value-added and intermediates goods
(Transport equipment industry, 2000-2005-2010, percent)

2000		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
Procurement from	Domestic	**86.2**	92.6	86.6	69.5	67.0	44.1	43.8	85.0	45.7	87.2	**57.3**	61.9	69.4	31.6	28.1	55.4	29.7	64.4	44.1	43.7	38.2	39.0	63.0	**50.9**	75.4	33.1	39.5	**62.9**
	Foreign	**13.8**	7.4	13.4	30.5	33.0	55.9	56.2	15.0	54.3	12.8	**42.7**	38.1	30.6	68.4	71.9	44.6	70.3	35.6	55.9	56.3	61.8	61.0	37.0	**49.1**	24.6	66.9	60.5	**37.1**
	Asia	**5.9**	2.2	7.7	14.4	15.7	34.3	40.4	9.2	43.2	3.3	**4.9**	4.3	3.9	4.4	7.7	4.9	13.9	4.8	2.2	7.7	6.6	5.2	6.3	**9.7**	11.1	8.5	9.6	**6.5**
	China	**1.1**	0.7	0.0	2.4	2.1	2.3	2.1	0.9	5.2	0.9	**0.8**	0.7	0.8	0.7	0.8	0.7	1.2	1.0	0.3	1.1	0.5	0.7	0.9	**1.2**	1.5	0.9	1.4	**1.0**
	Europe	**1.7**	1.2	2.8	4.8	5.2	7.8	6.7	2.5	5.5	4.3	**28.4**	23.0	18.0	48.9	54.7	30.3	34.0	21.7	47.3	37.0	49.2	48.8	21.3	**5.7**	6.2	5.2	5.9	**15.7**
	N. America	**3.6**	2.7	1.8	6.4	9.1	8.4	5.2	2.3	2.7	1.3	**6.4**	8.1	5.5	12.7	6.9	6.2	19.2	5.2	4.4	8.0	3.1	4.1	7.0	**32.0**	5.7	51.6	43.2	**12.6**
	USA	**3.2**	2.4	1.4	5.8	8.5	7.8	4.8	1.7	2.4	1.1	**5.7**	7.4	4.9	11.4	6.0	5.7	18.1	4.7	4.0	7.3	2.8	3.6	6.0	**28.5**	0.0	49.6	41.1	**11.2**
	OPEC	**0.5**	0.3	0.3	1.0	1.3	0.6	0.5	0.2	0.6	0.6	**0.2**	0.2	0.2	0.2	0.2	0.1	0.2	0.3	0.1	0.2	0.3	0.5	0.2	**0.2**	0.2	0.2	0.2	**0.3**
	ROW	**2.1**	1.0	1.0	3.9	1.7	4.8	3.3	0.8	2.3	3.3	**2.7**	2.4	3.0	2.2	2.4	3.0	3.0	3.5	1.8	3.3	2.6	2.5	2.3	**1.4**	1.4	1.4	1.6	**2.1**

2005		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
Procurement from	Domestic	**79.7**	88.4	78.1	67.0	57.8	53.1	49.6	74.9	38.5	82.8	**56.7**	61.2	67.2	35.9	25.3	42.4	38.5	63.8	38.1	47.6	28.0	43.6	60.7	**57.4**	76.8	38.9	42.1	**63.5**
	Foreign	**20.3**	11.6	21.9	33.0	42.2	46.9	50.4	25.1	61.5	17.2	**43.3**	38.8	32.8	64.1	74.7	57.6	61.5	36.2	61.9	52.4	72.0	56.4	39.3	**42.6**	23.2	61.1	57.9	**36.5**
	Asia	**10.0**	4.6	11.4	17.2	23.5	30.1	36.9	19.4	50.0	6.1	**5.5**	4.8	4.2	4.5	9.1	5.9	12.2	5.7	4.0	7.4	9.2	5.8	7.0	**10.6**	9.6	9.7	17.8	**7.8**
	China	**3.0**	2.2	0.0	5.7	5.5	6.1	4.0	2.9	13.8	2.2	**1.6**	1.5	1.3	1.2	2.0	1.6	2.7	2.3	0.5	2.2	1.2	1.8	2.0	**3.2**	2.6	3.0	6.5	**2.3**
	Europe	**2.9**	2.1	4.4	5.7	5.2	6.5	5.3	2.3	4.4	4.5	**30.7**	25.6	22.3	50.5	58.2	44.6	33.6	23.3	52.6	36.7	57.1	43.9	24.3	**6.0**	5.9	5.7	6.9	**17.8**
	N. America	**3.7**	2.8	3.1	5.3	10.0	5.8	3.2	1.7	2.5	2.6	**4.4**	6.1	3.5	6.6	4.9	4.4	13.2	4.0	2.9	5.7	2.5	3.3	5.3	**23.7**	5.6	43.3	30.4	**8.2**
	USA	**3.2**	2.5	2.7	4.8	9.3	5.4	2.8	1.5	2.2	2.4	**3.9**	5.4	3.1	5.7	4.4	3.8	12.2	3.5	2.6	5.0	2.1	2.8	4.6	**19.9**	0.0	41.2	28.6	**7.0**
	OPEC	**0.9**	0.7	0.8	1.3	1.5	0.8	0.6	0.2	1.2	0.5	**0.3**	0.3	0.2	0.2	0.3	0.2	0.2	0.6	0.2	0.3	0.5	0.6	0.2	**0.3**	0.4	0.3	0.3	**0.5**
	ROW	**2.8**	1.5	2.1	3.4	2.0	3.7	4.4	1.5	3.4	3.5	**2.4**	2.0	2.5	2.3	2.1	2.6	2.2	2.6	2.2	2.2	2.7	2.7	2.4	**2.0**	1.8	2.1	2.5	**2.3**

2010		Procured to																										
		Asia	JPN	CHN	KOR	TWN	MAL	THL	IDN	VTM	IND	**Europe**	FRA	GER	AUT	BEL	FIN	IRE	ITA	LUX	NLD	POR	SPN	UK	**N. America**	USA	CAN	MEX	**All countries**
Procurement from	Domestic	**76.8**	88.0	77.2	65.3	57.6	47.2	48.1	82.5	35.2	80.9	**57.4**	59.5	66.0	34.9	22.7	54.5	40.9	63.7	82.0	50.3	29.3	43.5	58.6	**52.0**	72.6	33.0	39.3	**64.1**
	Foreign	**23.2**	12.0	22.8	34.7	42.4	52.8	51.9	17.5	64.8	19.1	**42.6**	40.5	34.0	65.1	77.3	45.5	59.1	36.3	18.0	49.7	70.7	56.5	41.4	**48.0**	27.4	67.0	60.7	**35.9**
	Asia	**12.7**	5.3	11.6	19.9	27.1	35.3	39.0	14.2	45.2	8.4	**7.3**	6.5	5.8	6.1	13.7	7.1	13.5	8.0	1.0	11.2	7.3	7.6	9.5	**16.5**	13.1	15.1	25.3	**10.9**
	China	**3.8**	2.6	0.0	8.1	8.3	9.0	6.4	1.9	16.6	4.1	**2.8**	2.8	2.3	2.1	3.5	3.1	5.0	4.0	0.3	4.0	2.4	3.2	3.5	**6.8**	4.9	5.3	12.6	**3.9**
	Europe	**3.1**	1.8	4.9	5.0	5.3	6.5	4.7	1.4	6.6	3.8	**28.0**	23.7	21.9	53.0	56.5	30.8	30.1	21.5	15.0	29.9	58.4	42.7	23.5	**5.6**	5.4	5.2	6.7	**14.8**
	N. America	**3.4**	2.6	2.9	5.1	5.7	6.7	3.2	0.9	8.2	2.9	**4.5**	8.0	3.4	3.4	4.5	4.0	13.0	3.6	0.8	6.0	2.2	2.9	5.6	**23.7**	6.9	44.6	26.2	**7.3**
	USA	**3.0**	2.3	2.4	4.5	5.2	6.2	2.8	0.8	7.6	2.6	**4.0**	7.3	3.0	2.9	4.0	3.5	12.0	3.2	0.7	5.4	1.8	2.4	4.9	**19.0**	0.0	40.6	24.5	**6.1**
	OPEC	**0.9**	0.7	0.9	1.0	2.6	1.0	0.9	0.2	1.5	1.4	**0.3**	0.3	0.2	0.2	0.3	0.2	0.3	0.7	0.1	0.4	0.4	0.7	0.3	**0.3**	0.3	0.3	0.3	**0.5**
	ROW	**3.1**	1.6	2.6	3.6	1.7	3.3	4.1	0.8	3.3	2.6	**2.5**	2.0	2.7	2.3	2.3	3.4	2.3	2.6	1.1	2.3	2.4	2.6	2.5	**1.8**	1.6	1.8	2.2	**2.4**

Appendices

Appendix 1: List of Countries and industries covered by YNU-GIO Tables

Endogenous country list:

Asia:

01	Japan (JPN)	04	Taiwan (TWN)	07	Indonesia (IDN)
02	China (CHN)	05	Malaysia (MAL)	08	Vietnam (VTM)
03	Korea (KOR)	06	Thailand (THL)	09	India (IND)

North America (N. America):

01	USA (USA)	02	Canada (CAN)	03	Mexico (MEX)

Europe:

01	France (FRA)	05	Belgium (BEL)	09	Luxembourg (LUX)
02	Germany (GER)	06	Finland (FIN)	10	Netherlands (NLD)
03	UK (UK)	07	Ireland (IRE)	11	Portugal (POR)
04	Austria (AUT)	08	Italy (ITA)	12	Spain (ESP

Others:

01	Australia (AUS)	02	Brazil (BRA)	03	South Africa (SAF)

Exogenous country list:

Asia:

01	Hong Kong	03	the Philippines
02	Singapore	04	Rest of Asia

Europe:

01	Russia	02	Rest of European Union

Oil producing countries (OPEC):

01	Algeria	05	Iraq	09	Qatar
02	Angola	06	Kuwait	10	Saudi Arabia
03	Ecuador	07	Libya	11	UAE
04	Iran	08	Nigeria	12	Venezuela

Rest of the World (ROW)

Industry list:

01	Agriculture, hunting, forestry and fishing
02	Mining and quarrying
03	Food products, beverages and tobacco
04	Textiles, textile products, leather and footwear
05	Wood and products of wood and cork
06	Pulp, paper, paper products, printing and publishing
07	Coke, refined petroleum products and nuclear fuel
08	Chemicals and pharmaceuticals
09	Rubber and plastics products
10	Other non-metallic mineral products
11	Basic metals
12	Fabricated metal products
13	Machinery and equipment
14	Office, accounting and computing machinery
15	Electrical machinery and apparatus

16 Radio, television and communication equipment
17 Medical, precision and optical instruments
18 Motor vehicles, trailers and semi-trailers
19 Other transport equipment
20 Other manufacturing
21 Electricity, Gas and Water supply
22 Construction
23 Wholesale and retail trade; repairs
24 Hotels and restaurants
25 Transport
26 Post and telecommunications
27 Finance and insurance
28 Real estate activities
29 Renting of machinery and equipment
30 Computer and related activities
31 Research and development
32 Other Business Activities
33 Public administration, social security and defense
34 Education
35 Health, social work and other services

Appendix 2: Global chain for value-added and Export

Based on the notations used in the paper, column sum of the global chain for value-added (i.e., $G_v = u\hat{A}vL\hat{E}$) is amount of final goods export in respective countries. In matrix symbol, it is equivalent to prove

$$uG_v = u\hat{E}$$

where $u = \begin{pmatrix} 1 & 1 & 1 \end{pmatrix}$ is a row vector of ones.

Proof:
In IO theory, sum of total inputs (i.e., intermediate and value added inputs) is equal to unity. Therefore, we have,

$$u = uA + u\hat{A}v$$

where A is the intermediate input coefficient matrix and $\hat{A}v$ is the diagonal matrix of value added input coefficient.
Using this identity we can rewrite the column sum of the value-added content matrix as

$$uG_v = u\hat{A}vL\hat{E} = \left(u - uA\right)L\hat{E} = u\left(I - A\right)L\hat{E}$$

We also know that $L = \left(I - A\right)^{-1}$, it follows

$$uG_v = u\hat{E}$$

It proves that the column sum of value added transfer matrix subject to final goods export is equal to amount of the final goods production in respective countries.