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Abstract

Firms that are expanding their cross-border activities, such as vertical specialization trade, outsourcing, and fragmentation productions, have brought dramatic changes to the global economy during the last two decades. In an attempt to understand the evolution of the interaction among countries or country groups, many trade-statistics-based indicators have been developed. However, most of these statistics focus on showing the direct trade-specific-relationship among countries, rather than considering the roles that intercountry and interindustrial production networks play in a global economy. This paper uses the concepts of trade in value added as measured by the input–output tables of OECD and IDE-JETRO to provide alternative indicators that show the evolution of regional economic integration and global value chains for more than 50 economies. In addition, this paper provides thoughts on how to evaluate comparative advantages on the basis of value added using an international input–output model.

Keywords: Trade in value added, value chain, vertical specialization, comparative advantage
JEL classification: C6, F4, O18

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Measuring Global Value Chains and Regional Economic Integration: An International Input–Output Approach*

Bo MENG[1], Yong FANG[2], and Norihiko YAMANO[3]

Abstract

Firms that are expanding their cross-border activities, such as vertical specialization trade, outsourcing, and fragmentation productions, have brought dramatic changes to the global economy during the last two decades. In an attempt to understand the evolution of the interaction among countries or country groups, many trade-statistics-based indicators have been developed. However, most of these statistics focus on showing the direct trade-specific-relationship among countries, rather than considering the roles that intercountry and interindustrial production networks play in a global economy. This paper uses the concepts of trade in value added as measured by the input–output tables of OECD and IDE-JETRO to provide alternative indicators that show the evolution of regional economic integration and global value chains for more than 50 economies. In addition, this paper provides thoughts on how to evaluate comparative advantages on the basis of value added using an international input–output model.

Keywords: global value chains, trade in value added, comparative advantage, input–output

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1. Introduction

The increasing presence of global value chains (GVCs) has been considered one of the most important features of rapid economic globalization. The representative phenomena relating to the context of GVCs include "vertical specialization," "fragmentation production," "outsourcing," and "global supply chains." Despite the use of different terms or "language" to explain these phenomena or having just a partial perspective of these phenomena, all of them indicate the same fact: a higher volume of intermediate goods, such as parts and components, is produced in subsequential stages or processes across different countries, and then exported to other countries for further production. This phenomenon is explained by the so-called second unbundling (Baldwin, 2011). Namely, lower communication costs resulting from the information and communication technology (ICT) revolution has enabled the international unbundling of factories and offices, which means that tasks can also be traded globally. The production systems of Apple's products (Linden et al., 2009; Dedrick et al., 2010; and Xing and Detert, 2010) and Boeing's Dream 787 commercial airplane (Carson, 2007) are the most famous and widely quoted examples to explain the rapid spread of GVCs.

In contrast, given the current difficulties and challenges faced by the WTO after the Doha Round negotiation, the discussion on regional economic integration and regional trade agreements (RTAs), as well as their effects, has received much more attention from both academia and the government (Murray, 2011; Neffke and Boschma, 2011; and Sierra, 2011). Such movement is primarily attributable to the fact that the trade pattern in the 21st century—the second unbundling—requires new disciplines that go far beyond the WTO's current rulebook. In other words, "developing nations wanted the offshored industrial jobs and technology, rich-nation firms wanted access to lower-cost labour. Both pushed for disciplines to underpin the trade-investment-services-IP nexus. The result was 'deep' regional trade agreements and unilateral pro-business reforms by developing nations" (Baldwin, 2012). The interaction among countries within the same region and the interdependence in regional trade and production networks have very important implications for economic development as well as for international business activity locations.

Given the importance of understanding the mechanism and structure of regional integration, a number of studies have been conducted in this field using different approaches and data sources. One study is the politically based approach that employs macrodata to analyze the influence of harmonized laws and regulations (Suder, 2008; Murray, 2010; and Cherry, 2011). The other approaches focus on the economic effects from the integration of countries or economies through normalized economic agreements such as FTA, EPA, and RATs (Dunning, 2007; Hiratsuka and Kimura, 2008; Volz, 2011; and Batra, 2012). In addition, the data sources used in the previous studies vary according to different model requirements and analytical purposes. For example, UNCTAD (2009), Pula and Peltonen (2009), and Suder et al. (2011) used FDI and trade statistics to show the economic rationale of regional integration; Rugman and Verbeke (2004) and Piekkari et al. (2010) utilized firm-based data, such as foreign MNE sales, to analyze regional integration from a firm's perspective. However, just a few studies concentrated on the structural change of production networks, supply chains, and industry clusters using international input–output (I–O) data when considering the effects of regional economic integration (Hoen, 2002; Shrestha and Hasebe, 2006; and Kuroiwa and Heng, 2008).

The main objective of this study is to apply the newly developed I–O-based GVC indicators[1] to show the structural change in the ongoing regional economic integration for regions such as NAFTA, Europe, and Asia from the viewpoint of production networks and international spillover effects. Comparing and measuring the process and degree of regional economic integration for different regions can provide very constructive opinions for future policy design concerning the economic development of the Asian region.

The remainder of this paper is organized as follows. Section 2 uses trade data to show the evolution of global trade structure and the role of trade in intermediate goods. Section 3 first explains how to use the I–O framework to measure GVCs. Second, the relationship between the concepts of value added in trade (VAiT) and trade in value added (TiVA) is discussed. Then, an alternative measurement of the comparative advantage based on the newly defined individual linkage of TiVA is proposed. In addition, this section shows how to use the I–O framework to measure "who produces intermediate goods for whom." In Section 4, the features and changing pattern of regional economic integration and GVCs are discussed on the basis of the calculation results of the measurement proposed in Section 3. Section 5 presents concluding remarks.

2. Evolution of global trade and the role of trade for intermediate goods

This section uses the up-to-date OECD bilateral trade database (BTDIxE, 1988–2010) to show the historical evolution of the global trade structure at both industrial level (ISIC 3.0 with 37 sectors) and end-use category level (primarily separated as intermediate goods, final consumption goods, and capital goods). In addition, to understand the role of different categories and countries in the growth of global trade, the movement of "trade hubs" (supply and demand centers) by the end-use category is presented.

2.1 Historical evolution of international non-fuel merchandise trade

Using the OECD BTDIxE database[2], the historical evolution of trade in goods by different end-use categories is clearly illustrated in Figure 1. The chart makes apparent that the entire evolution from 1995 to 2010 is divided into three main phases. In the first phase, during 1995–2002, total trade in goods showed slow growth and reached a slight peak in 2000. In the second phase, 2002–2008, world trade significantly increased compared with that in the first phase. In the third phase, 2008–2010, world trade was heavily damaged from the financial crisis and the ensuing world economic crisis, but showed a rapid, V-shaped recovery from 2009.

A comparison of movement of trade by category clearly shows that trade in intermediate goods is considered the main driving power of the world's total trade in goods. Particularly during the crisis, trade in intermediate goods seemed to show very sensitive patterns of change that can explain the main source

[1]For recent I–O-based GVC indicators, refer to Hummels et al. (2001), Kuroiwa, (2006), Escaith (2008), Koopman et al. (2008, 2010), Uchida and Inoamata (2009), Yang et al. (2009), Timmer (2010), Johnson and Noguera (2011), Fukasaku et al. (2011), Meng et al. (2011), Ahmad et al. (2011), Abdul et al. (2011), Stehrer (2012), and Backer and Yamano (2012).

[2]Note that goods such as passenger cars, personal computers, packed medicaments, and personal phones may be used by firms as intermediate inputs and capital formation, or are directly consumable by households. Therefore, in the OECD BTDIxE database, these items are treated as an individual category.

of the V-shaped recovery of total trade. The movement of intermediate goods also clearly reflects increased globalization and the development of fragmented production in manufacturing sectors. However, calculations of the share of each category in total trade (Figure 2) clearly confirm that all categories remained very stable over the last 15 years. This fact indicates that, at the absolute level, the contribution of different categories to total trade is stable; however, given the differences in their shares and growth rates, the relative contribution by category may indicate a different pattern.

To provide detailed information on contribution by category, we calculate the relative contribution of different categories to the growth in total trade in goods by considering together the absolute share of an individual category in total trade and its growth rate (for the detailed calculation method, see Appendix 1). The calculation results of relative contribution by category are shown in Figure 3. Clearly, trade in intermediate goods represents the dominant contribution to growth in total trade for both periods (1996–2002 and 2002–2008), followed by household consumption and capital goods. A review of shares by different category over time shows significant changes. Intermediate goods enhanced their presence from 40.43% to 57.01%, indicating that the increasing performance of these goods was the primary reason for the rapid growth of global trade after 2002. Compared to the relatively stable tendency for household consumption goods, the contribution from capital goods almost doubled over time from 9.6% to 16.5%, making capital goods the second main source of the rapid growth of total trade in goods during 2002–2008. In contrast, contributions from all other categories such as passenger cars, packed medicaments, and personal computers declined over time.

Several factors may help explaining the above dynamic changes in global merchandise trade. First, the continuous reduction in international trade costs, including tariff and non-tariff costs, is one of the most important factors. In particular, note that during the last 20 years, tariffs on intermediate goods such as parts and components have usually been lower than those on final goods (Miroudot, 2009). Such lower tariffs boosted the volume and diversity of parts and components exchanged all over the world. The second factor is the active cross-border movement of capital, such as foreign direct investment (FDI), which has played an important role in the expansion of trade in intermediate goods (Miroudot, 2009). Simultaneously, related to the first and second factors, the increasing fragmentation of value chains, particularly the so-called intrafirm trade, could spread globally and has led to an increase in trade flows of intermediate goods (Yi, 2003). Finally, domestic-market-oriented economic reforms undertaken in certain developing economies such as China should also be considered a very important factor because their domestic economic reforms provide significant opportunities for countries or multinational enterprises to locate there and to be involved in global production networks.

Similarly, the country-specific contribution rate can be computed from the supply (export) and demand (import) sides[3]. On the supply side, the top 30 contributors are listed in Table 1. For both periods, without considering the contribution from the rest of the world, the top 30 countries/regions account for more than 90% of the total contribution. As per a review of country-specific contributions, China shows the

[3]Note that trade data can be collected in two ways. One is from export statistics and the other is from import statistics. In principle, because import statistics follow the "rule of origin," the so-called "mirror statistic problem" (a country's exports may not equal its partner's imports) caused by re-export can supposedly be avoided using import data, to some extent. Therefore, in this paper, the trade data (export or import) used are both from C.I.F.-price-based import statistics.

largest figure, followed by Germany and the United States. Japan also enhanced its presence over time from 1.54% to 5.36%. This fact indicates that China, Germany, the United States, Japan, and France have played roles as the most important exporters in the rapid increase in global trade. On the other hand, a similar pattern is found in Table 2, namely that these main countries also make dominant contributions to the growth of global trade as importers. However, significantly more dynamic changes are found from the demand side than from the supply side. For example, the United States lost its dominant role and went from 34.59% to 9.15%; China's figure also declined, from 14.23% to 9.61% over the two periods. The lost shares by the United States and China were taken up by other economies, making the distribution of country-specific contributions much flatter across countries. In particular, the fact that the contribution from the rest of the world increased rapidly from 5.54% to 12.88% over the two periods may be considered evidence that an increasing number of smaller economies have been involved in the global trade system.

2.2 Global trade hubs: supply and demand centers

This section focuses on evaluating the movement of global trade hubs using the so-called "dominant links" (Fukasaku et al., 2011) of trade flows in goods by different end-use categories. As a dominant link, a country's exports in goods to a particular partner country exceeding a given threshold percentage of that country's total imports are considered. The current exercise uses 10% as the threshold when exploring trade nodes. If a relatively large number of countries' imports depend on exports (supply of goods for foreign use) of a specific country, this country may be considered the supply center in global trade. Similarly, if a large number of countries' exports depend on imports (domestic demand for goods produced outside) of a specific country, this country may be considered the demand center.

Given the bilateral trade data for 65 countries/regions by end-use categories, the supply and demand centers are easily identified (Figure 4). Obviously, larger industrialized economies are expected to be identified as dominant trade partners for smaller ones in respective regions, as differentiation and specialization take place around these larger economies. Closely analyzing Figure 4, some features are summarized as follows. (1) Germany maintains the leading position as the trade center for both supply and demand during the last 15 years. For example, more than 35 countries heavily depend on Germany's supply of intermediate goods. Simultaneously, more than 25 countries heavily depend on Germany's demand of intermediate goods. The most important feature for Germany is that its leading position can be maintained very stably over time. (2) The United States is one of the most important trade centers, but its presence has decreased rapidly in the last 15 years. For example, more than 25 countries shipped over 10% of their exports of intermediate goods to the United States in 2000. However, this figure for the United States declined to 10 in 2010. (3) Compared to the United States, China showed very different changes. In particular, China's supply power increased dramatically after its accession of the WTO in 2001. This situation can be easily confirmed by analyzing the supply of final consumption goods. In 1995, just 10 countries had relatively high dependence on China's products of final goods. However, in 2010, more than 45 countries had more than 10% of their imports from China, reflecting why the country is called the "world factory." The increasing presence of China's supply power is also seen with intermediate and capital goods. In 2010, China was the largest supply center for final consumption goods and the second largest supply center for intermediate and capital goods. In contrast, the country was also the second largest demand center for intermediate goods. Not surprisingly, China has been deeply involved in global supply chains by using a significant volume of imported intermediate goods to

produce goods for export throughout the world. However, unlike Germany, China is not yet an important demand center for final consumption goods relative to its supply power. Several reasons explain this phenomenon. The first reason is that China's purchasing power related to foreign consumption goods is still low because of its relatively low per capita income. The second reason is that a high percentage of domestic demand for consumption goods from China's domestic consumers is satisfied by the country's domestic supply because of relatively low prices and large production capacity for these domestic goods. (4) Japan's movement is similar to Germany's, but its presence has decreased slowly over time.

In general, China, to some extent, has taken the place of the United States and Japan in global merchandise trade. The United States lost its position as a leading supply and demand center in terms of trade in goods primarily because its economic (supply and demand) structure became more service-oriented or service-specialized. The United Kingdom also rapidly lost its supply and demand power in global trade for a very similar reason. For Japan, the same reason noted previously caused a transfer of some of its production capacity to neighboring countries, such as China, through FDI to capture lower labor costs and for other market-related reasons.

3. Input–output-based measure of global value chains

In the previous section, trade data provide us with a global and intuitive view for understanding the evolution of the trade structure. However, obtaining detailed information on how countries are linked to each other through GVCs is difficult. To measure the participation degree of a specific country in GVCs and the linkages among countries and country groups within GVCs, a preferable method is to utilize I–O tables. An I–O-based measurement can capture not only direct linkages, such as trade flow, but also indirect linkages, such as the spillover effect and the feedback effect among countries though international production networks.

3.1 Concept and measurement of value added in trade in a single national I–O framework

VAiT is simply defined as "domestic value added embodied in trade (export or import)"[4]. If "trade" noted here indicates a home country's exports, VAiT measures the home country's domestic value added embodied in its exports. In turn, if "trade" indicates the home country's imports, the VAiT indicates its partner country's domestic value added embodied in the home country's imports.

To ease an explanation of VAiT, we model a closed economy with just two countries (r and s) and n sectors for each country. In the first step, only the information on country r's national I–O table with a separate import matrix is assumed to be known (Figure 5). In this single national I–O framework, country r's total value added is given in the following form on the basis of the traditional I–O theory.

$$
\begin{aligned}
\mathrm{VA}^{\mathrm{r}} &= \mathbf{v}^{\mathrm{r}} \cdot (\mathrm{I} - \mathbf{A}^{\mathrm{rr}})^{-1} \cdot \mathbf{fd}^{\mathrm{r}} \\
&= \mathbf{v}^{\mathrm{r}} \cdot \mathbf{L}^{\mathrm{rr}} \cdot (\mathbf{fd}^{\mathrm{rr}} + \mathbf{ex}^{\mathrm{rs}}) \\
&= \mathbf{v}^{\mathrm{r}} \cdot \mathbf{L}^{\mathrm{rr}} \cdot \mathbf{fd}^{\mathrm{rr}} + \mathbf{v}^{\mathrm{r}} \cdot \mathbf{L}^{\mathrm{rr}} \cdot \mathbf{ex}^{\mathrm{rs}}, \qquad (1)
\end{aligned}
$$

[4]For a detailed discussion concerning the relationship between VAiT and TiVA, refer to Stehrer (2012).

where VA^r represents country r's total value added (scalar), $\mathbf{v}^r$ represents a (1 × n) row vector of value added ratios (the share of domestic value added in total input) by sector for country r, $\mathbf{A}^{rr}$ represents the (n × n) matrix of country r's domestic input coefficients, $\mathbf{fd}^r$ represents the (n × 1) column vector of country r's total final demand, $L^{rr} = (I - \mathbf{A}^{rr})^{-1}$ represents country r's domestic Leontief inverse in a single national I–O framework, $\mathbf{fd}^{rr}$ represents the column vector of country r's domestic final demand, and $\mathbf{ex}^{rs}$ represents the (n × 1) vector of exports from country r to country s. Because this economy has just two countries, $\mathbf{ex}^{rs}$ naturally represents the total exports of country r.

Clearly, a country's total value added is expressed in two parts, namely the value added embodied in the domestic final demand ($\mathbf{v}^r \cdot \mathbf{L}^{rr} \cdot \mathbf{fd}^{rr}$) and the value added embodied in the total exports ($\mathbf{v}^r \cdot \mathbf{L}^{rr} \cdot \mathbf{ex}^{rs}$). The second part is tentatively considered a measurement of the VAiT for country r when a single national I–O table is available for use. In addition, in a single national I–O framework, the following equation always holds:

$$(\mathbf{v} + \mathbf{u} \cdot \mathbf{M}) \cdot \mathbf{L} = \mathbf{u}, \tag{2}$$

where $\mathbf{u}$ represents a 1 × n unity vector and $\mathbf{M}$ represents the n × n matrix constructed by intermediate import coefficients. Multiplying country r's export vector with both sides of the previous equation yields

$$\mathbf{v}^r \cdot \mathbf{L}^{rr} \cdot \mathbf{ex}^{rs} + \mathbf{u} \cdot \mathbf{M}^r \cdot \mathbf{L}^{rr} \cdot \mathbf{ex}^{rs} = \mathbf{u} \cdot \mathbf{ex}^{rs}. \tag{3}$$

Note that the second term on the left-hand side of Eq. (3) indicates the "import contents of export" (Hummel et al., 2001). Clearly, a country's domestic value added embodied in its exports is measured by the difference in its total exports ($\mathbf{u} \cdot \mathbf{ex}^{rs}$) and the import contents of its exports. In other words, if country r does not need any intermediate imports for the production of exports, the measuring result of VAiT for country r should be the same figure for exports.

In addition, if end-use based international trade statistics are available, country r's total exports are separated into intermediate and final products, as follows:

$$\mathbf{ex}^{rs} = \mathbf{fd}^{rs} + \mathbf{imd}^{rs}, \tag{4}$$

where $\mathbf{fd}^{rs}$ and $\mathbf{imd}^{rs}$ represent, respectively, country r's exports of final goods and intermediate goods shipped to country s (n × 1 column vector). By still using the single national I–O framework, country r's VAiT in terms of its final and intermediate goods exports is defined as follows:

$$VAiTF^r = \mathbf{v}^r \cdot \mathbf{L}^{rr} \cdot \mathbf{fd}^{rs} \tag{5}$$
$$VAiTI^r = \mathbf{v}^r \cdot \mathbf{L}^{rr} \cdot \mathbf{imd}^{rs}, \tag{6}$$

where $VAiTF^r$ and $VAiTI^r$ represent the value added embodied in country r's exports of final goods ($\mathbf{fd}^{rs}$) and intermediate goods ($\mathbf{imd}^{rs}$), respectively.

3.2 Measuring the trade in value added in an international I–O framework

Adopting the single national I–O framework to measure VAiT enables easy measurement of $VAiTI^r$

because country r's intermediate goods exports are treated as an exogenous variable. An important question arises. Namely, if an international I–O framework is given, intermediate goods exports should be considered an endogenous variable; in this situation, how is the VAiT measured for intermediate goods? To answer this question, the single national I–O framework of a closed economy used in Figure 5 is expanded to a two-country international I–O framework (Figure 6) in which the trade of intermediate goods between these two countries is treated as an endogenous variable. On the basis of the traditional international I–O theory, the total value added is given as follows:

$$\mathbf{va} = \mathrm{diag}(\mathbf{v}) \cdot \mathbf{L} \cdot \mathbf{fd}, \tag{7}$$

$$\mathbf{va} = \begin{pmatrix} \mathbf{va}^{r} \\ \mathbf{va}^{s} \end{pmatrix},\ \mathbf{v} = (\mathbf{v}^{r}, \mathbf{v}^{s}),\ \mathbf{L} = \begin{pmatrix} \mathbf{L}^{rr} & \mathbf{L}^{rs} \\ \mathbf{L}^{sr} & \mathbf{L}^{ss} \end{pmatrix} = \left[\mathbf{I} - \begin{pmatrix} \mathbf{A}^{rr} & \mathbf{A}^{rs} \\ \mathbf{A}^{sr} & \mathbf{A}^{ss} \end{pmatrix}\right]^{-1},\ \mathbf{fd} = \begin{pmatrix} \mathbf{fd}^{rr} \\ \mathbf{fd}^{sr} \end{pmatrix} + \begin{pmatrix} \mathbf{fd}^{rs} \\ \mathbf{fd}^{ss} \end{pmatrix},$$

where $\mathbf{va}^{r}$ represents the (n × 1) column vector representing country r's value added by sector, $\mathbf{v}^{r}$ represents the (1 × n) row vector of value added ratio by sector for country r, $\mathbf{L}$ represents the international Leontief inverse constructed by the submatrix $\mathbf{L}^{rs}$, $\mathbf{A}^{rs}$ represents the (n × n) matrix of international input coefficients from country r to country s, and $\mathbf{fd}^{rs}$ represents the (n × 1) column vector for country s's final demand for goods and services produced in country r. Following the definition of TiVA proposed by Johnson and Noguera (2009), formulating country r's value added exported to country s is easy, and is shown as follows:

$$\mathrm{TiVA}^{rs} = (\mathbf{u}, \mathbf{u}) \cdot \mathrm{diag}(\mathbf{v}^{r}, \mathbf{0}) \cdot \begin{pmatrix} \mathbf{L}^{rr} & \mathbf{L}^{rs} \\ \mathbf{L}^{sr} & \mathbf{L}^{ss} \end{pmatrix} \cdot \begin{pmatrix} \mathbf{fd}^{rs} \\ \mathbf{fd}^{ss} \end{pmatrix}, \tag{8}$$

$$\mathrm{TiVA}^{rs} = \mathbf{v}^{r}(\mathbf{L}^{rr} \cdot \mathbf{fd}^{rs} + \mathbf{L}^{rs} \cdot \mathbf{fd}^{ss}). \tag{9}$$

Because the above concept represents country r's value added induced by country s's final demands, this type of measure is called demand-based TiVA. According to Miller and Blair (1985), each submatrix in the international Leontief inverse can be expressed using the submatrix of input coefficients as follows:

$$\mathbf{L}^{rr} = (\mathbf{I} - \mathbf{A}^{rr})^{-1}[\mathbf{I} + \mathbf{A}^{rs} \cdot \mathbf{C}^{-1} \cdot (\mathbf{I} - \mathbf{A}^{rr})^{-1}]$$
$$\mathbf{L}^{rs} = (\mathbf{I} - \mathbf{A}^{rr})^{-1} \cdot \mathbf{A}^{rs} \cdot \mathbf{C}^{-1}$$
$$\mathbf{L}^{sr} = \mathbf{C}^{-1} \cdot \mathbf{A}^{sr} \cdot (\mathbf{I} - \mathbf{A}^{rr})^{-1}$$
$$\mathbf{L}^{ss} = \mathbf{C}^{-1}$$
$$\mathbf{C} = \mathbf{I} - \mathbf{A}^{ss} - \mathbf{A}^{sr} \cdot (\mathbf{I} - \mathbf{A}^{rr})^{-1} \cdot \mathbf{A}^{rs}.$$

Using previous equations, TiVA^{rs} is rewritten as follows:

$$\begin{aligned}
\mathrm{TiVA}^{rs} &= \mathbf{v}^{r}(\mathbf{L}^{rr} \cdot \mathbf{fd}^{rs} + \mathbf{L}^{rs} \cdot \mathbf{fd}^{ss}) \\
&= \mathbf{v}^{r}(\mathbf{I} - \mathbf{A}^{rr})^{-1}[\mathbf{I} + \mathbf{A}^{rs} \cdot \mathbf{C}^{-1} \cdot (\mathbf{I} - \mathbf{A}^{rr})^{-1}]\mathbf{fd}^{rs} + \mathbf{v}^{r} \cdot [(\mathbf{I} - \mathbf{A}^{rr})^{-1} \cdot \mathbf{A}^{rs} \cdot \mathbf{C}^{-1}]\mathbf{fd}^{ss} \\
&= \mathbf{v}^{r}(\mathbf{I} - \mathbf{A}^{rr})^{-1}[\mathbf{fd}^{rs} + \mathbf{A}^{rs} \cdot \mathbf{C}^{-1} \cdot \mathbf{A}^{sr} \cdot (\mathbf{I} - \mathbf{A}^{rr})^{-1} \cdot \mathbf{fd}^{rs} + \mathbf{A}^{rs} \cdot \mathbf{C}^{-1} \cdot \mathbf{fd}^{ss}] \\
&= \mathbf{v}^{r}(\mathbf{I} - \mathbf{A}^{rr})^{-1}\mathbf{fd}^{rs} + \mathbf{v}^{r}(\mathbf{I} - \mathbf{A}^{rr})^{-1} \cdot \mathbf{A}^{rs}(\mathbf{L}^{sr} \cdot \mathbf{fd}^{rs} + \mathbf{L}^{ss} \cdot \mathbf{fd}^{ss}) \\
&= \mathrm{VAiTF}^{rs} + \mathrm{VAiTI}^{*rs}.
\end{aligned} \tag{10}$$

Obviously, TiVA^{rs} is expressed through two types of VAiT. The first one, VAiTF^{rs}, exactly represents country r's value added embodied in its exports of final goods shipped to country s when the single national I–O model is used (Eq. (5)). The second one, VAiTI^{*rs}, is defined as the cross-border value

added in terms of trade in intermediate goods. A close analysis of the definition of $VAiTI^{*rs}$ clearly shows that this part can be further separated into two: the value added induced by the trade in intermediate goods shipped from country r to country s caused by the feedback effect ($\mathbf{L}^{sr} \cdot \mathbf{fd}^{rs}$) and the spillover effect ($\mathbf{L}^{ss} \cdot \mathbf{fd}^{ss}$). Therefore, using this measurement, the contribution of trade in final and intermediate goods is separately evaluated within the international I–O model.

Furthermore, at the product (sector) level, the induced value added in country r's specific sector j by country s's consumption on a specific final product i can be regarded as "an individual TiVA linkage," which is defined as follows:

$$TiVA_{ij}^{rs} = \mathbf{v}_j^r(\mathbf{L}^{rr} \cdot \mathbf{fd}_i^{rs} + \mathbf{L}^{rs} \cdot \mathbf{fd}_i^{ss}). \quad (11)$$

On the basis of the above definition, country r's export of sector j's value added to country s ($TiVA_{\cdot j}^{rs}$) and country r's export of value added to country s in terms of the consumption of a specific final product i ($TiVA_{i\cdot}^{rs}$) is measured, respectively, as follows:

$$TiVA_{\cdot j}^{rs} = \sum_i TiVA_{ij}^{rs}, \quad (12)$$
$$TiVA_{i\cdot}^{rs} = \sum_j TiVA_{ij}^{rs}. \quad (13)$$

In other words, $TiVA_{\cdot j}^{rs}$ shows how country r's value added created in sector j fulfills country s's total final demand; $TiVA_{i\cdot}^{rs}$ represents how country s's final demand for product i is fulfilled by country r's value added created in all sectors.

3.3 TiVA-based indicator for measuring revealed comparative advantage

The concept of revealed comparative advantage (RCA) is primarily based on the theory of Ricardian comparative advantage. RCA represents the relative advantage or disadvantage of a certain country in international economics for a certain class of goods or services. The most widely used indicator of RCA (Béla Balassa, 1965) is given as follows:

$$RCA_i^r = \frac{EX_i^r / EX^r}{\sum_r EX_i^r / \sum_r EX^r}, \quad (14)$$

where EX_i^r represents country r's exports of goods i and EX^r represents the total exports of country r. When all countries' exports just include their domestic contents, the previous RCA is considered a reasonable indicator of a comparative advantage. However, as previously mentioned, when a larger volume of intermediate imports are embodied in exports, this indicator may lose its original interpretability. Using the concept of sector-level or product-level TiVA proposed in this paper, a country's comparative advantage can be remeasured in the following two ways:

$$RCA_{\cdot j}^r = \frac{TiVA_{\cdot j}^r / TiAV^r}{\sum_r TiVA_{\cdot j}^r / \sum_r TiVA^r} \quad (15)$$

$$RCA_{i\cdot}^r = \frac{TiVA_{i\cdot}^r / TiAV^r}{\sum_r TiVA_{i\cdot}^r / \sum_r TiVA^r}, \quad (16)$$

where

$\mathrm{TiVA}^{r}_{\cdot j} = \sum_s \mathrm{TiVA}^{rs}_{\cdot j}$,
$\mathrm{TiVA}^{r}_{i\cdot} = \sum_s \mathrm{TiVA}^{rs}_{i\cdot}$,
$\mathrm{TiAV}^{r} = \sum_s \mathrm{TiVA}^{rs} = \sum_j \mathrm{TiVA}^{r}_{\cdot j} = \sum_i \mathrm{TiVA}^{r}_{i\cdot}$.

In this definition, $\mathrm{RCA}^{r}_{\cdot j}$ represents the comparative advantage of country r's sector j in GVCs, and $\mathrm{RCA}^{r}_{i\cdot}$ shows country r's entire comparative advantage in providing value added to fulfill other countries' final demand on product i.

3.4 Measuring "who produces intermediate products for whom"

The previous section proposed TiVA-based indicators to measure spatial economic interdependence. These indicators are based on the international I–O model. In this model, both final demand item and value added item are treated as exogenous variables; trade in intermediate goods and services among countries is treated as an endogenous variable. Therefore, how a country's final demand affects other country's value added through trade in intermediate products can be determined. However, this indicator cannot show in detail the role that intermediate trade plays in international production networks. By still using an international I–O model, we propose a simple method to measure the role of intermediate trade in production networks.

Given the same two-country I–O model as shown in Figure 6, according to the demand-driven I–O model, the intermediate transaction from country r to country s ($\mathbf{IMD}^{rs}$: a matrix representing country r's export of intermediate goods and services to country s) is formulated as follows:

$$\mathbf{u}\cdot\mathbf{IMD}^{rs} = \mathbf{u}\cdot\mathbf{A}^{rs}\cdot(\mathbf{L}^{sr}\cdot\mathbf{fd}^{rr} + \mathbf{L}^{sr}\cdot\mathbf{fd}^{rs} + \mathbf{L}^{ss}\cdot\mathbf{fd}^{sr} + \mathbf{L}^{ss}\cdot\mathbf{fd}^{ss}). \quad (17)$$

Rearranging the above equation yields

$$1=\frac{\mathbf{u}\cdot\mathbf{A}^{rs}\cdot\mathbf{L}^{sr}\cdot\mathbf{fd}^{rr}}{\mathbf{u}\cdot\mathbf{IMD}^{rs}}+\frac{\mathbf{u}\cdot\mathbf{A}^{rs}\cdot\mathbf{L}^{sr}\cdot\mathbf{fd}^{rs}}{\mathbf{u}\cdot\mathbf{IMD}^{rs}}+\frac{\mathbf{u}\cdot\mathbf{A}^{rs}\cdot\mathbf{L}^{ss}\cdot\mathbf{fd}^{sr}}{\mathbf{u}\cdot\mathbf{IMD}^{rs}}+\frac{\mathbf{u}\cdot\mathbf{A}^{rs}\cdot\mathbf{L}^{ss}\cdot\mathbf{fd}^{ss}}{\mathbf{u}\cdot\mathbf{IMD}^{rs}}$$
$$= a + b + c + d. \quad (18)$$

Obviously, a, b, c, and d provide information on how intermediate exports from country r to country s end up or contribute to a country's final demand. This information can assist in answering the question "who produces what for whom?," and shows the spatial economic interdependence among countries from the viewpoint of the relationship between intermediate and final products. The following equation provides the general form for calculating how trade in intermediate products directly and indirectly contributes to different types of final demand across countries through international supply chains.

$$\mathrm{WP}^{RS}_{rs} = \mathbf{u}\cdot\mathbf{A}^{RS}\cdot\mathbf{L}^{Sr}\cdot\mathbf{fd}^{rs}/\mathbf{u}\cdot\mathbf{IMD}^{RS}, \quad (18')$$

where WP^{RS}_{rs} shows the contribution rate of induced trade in intermediate products shipped from country R to S by country s's final demand for country r's products in a total intermediate transaction from country R to country S. When changing our viewpoint, the following indicator can also provide

alternative information on the aspect of "who produces intermediate goods for whom":

$$WP_{rs}^{*RS} = \mathbf{u} \cdot \mathbf{A}^{RS} \cdot \mathbf{L}^{Sr} \cdot \mathbf{fd}^{rs} / \sum_S \sum_R \mathbf{u} \cdot \mathbf{A}^{RS} \cdot \mathbf{L}^{Sr} \cdot \mathbf{fd}^{rs}, \quad (18)$$

where WP_{rs}^{*RS} shows the contribution rate of induced trade in intermediate products from country R to S by country s's final demands for country r's products in the total induced global trade through the same final demands.

If more attention is paid to international transactions (without considering the domestic trade in intermediate and final products), the following two indicators can provide an understanding of how intercountry trade in intermediate products is induced by intercountry trade in final products:

$$IWP_{rs}^{RS} = \frac{\mathbf{u} \cdot \mathbf{A}^{RS} \cdot \mathbf{L}^{Sr} \cdot \mathbf{fd}^{rs}}{\sum_{r \neq s} \sum_{s \neq r} \mathbf{u} \cdot \mathbf{A}^{RS} \cdot \mathbf{L}^{Sr} \cdot \mathbf{fd}^{rs}}, (R \neq S) \quad (19)$$

$$IWP_{rs}^{*RS} = \frac{\mathbf{u} \cdot \mathbf{A}^{RS} \cdot \mathbf{L}^{Sr} \cdot \mathbf{fd}^{rs}}{\sum_{R \neq S} \sum_{S \neq R} \mathbf{u} \cdot \mathbf{A}^{RS} \cdot \mathbf{L}^{Sr} \cdot \mathbf{fd}^{rs}}, (r \neq s) \quad (20)$$

where IWP_{rs}^{RS} shows the contribution rate of country r's export of final products to country s in the inducement of international trade in intermediate products shipped from country R to S. IWP_{rs}^{*RS} shows the share of induced international trade in intermediate products shipped from country R to S in the total inducement of international intermediate trade in terms of country s's final demand on the products made in country r.

4. Empirical results in measuring GVCs and regional economic integration

This section applies the indicators proposed in Section 3 to the 1995 and 2005 international I–O table constructed using the OECD's and IDE-JETRO's I–O tables and OECD bilateral trade data. To facilitate showing the evolution of GVCs and regional economic integration, the global economy is simply divided into several groups such as EUROPE, EU15, the rest of EUROPE, NAFTA, South America, ASIA, East Asia, ASEAN, the rest of ASIA, and the rest of the world[5].

4.1 Trade in value added share across regions

Table 3 shows the share of bilateral TiVA in total cross-border TiVA for 1995 and 2005. Through the columns, each figure shows how a specific region's domestic final demand contributes to (impacts) other regions' value added creation. In other words, the figure seen column-wise is considered the imported value of a specific region added from other regions, and each figure seen row-wise shows how a specific region exports value added to the other regions. Obviously, for most regions or subregions, the intraregional value added transactions account for a relatively large share compared with the interregional figure. Focusing just on the intraregional transaction shows that EUROPE accounts for almost 22.7% in the global TiVA, followed by ASIA at 11.7% and NAFTA at 7.0% in 1995. This figure decreased for

[5]Appendix 2 shows the detailed members in different country groups.

most regions but increased for some developing countries groups except ASEAN between 1995 and 2005. Clearly, the intra and interregional value chains for different country groups show very different presence. This is mainly due to the difference of the position, participation degree and role that regions play in the global value chains.

When looking at the interregional TiVA, certain interesting features are summarized as follows. (1) EU15 lost the potential for both TiVA import (see figure column-wise) and TiVA export (see figures row-wise) from/to other regions except for the rest of EUROPE, clearly indicating that EU15's relative presence in GVCs decreased, but its linkage with the rest of EUROPE in terms of TiVA strengthened. (2) NAFTA lost its potential for TiVA export but enhanced its TiVA import over time, which also represents the increasing value added gain in developing economies through TiVA from NAFTA. (3) The rest of EUROPE showed a rapidly increasing tendency for both TiVA import from and TiVA export to other regions. Although the absolute share in global TiVA from the rest of EUROPE is still small, the region's remarkable performance clearly illustrates how it benefited from the EUROPE's ongoing regional integration. (4) In general, ASEAN lost its TiVA import and export potential over time in global GVCs. Recalling the concept of TiVA, even if a country is large or has significant dependence on foreign trade, it is not guaranteed to get much more TiVA because TiVA depends on the scale of trade, the value added ratio, and the country's position in international production networks. (5) East Asia enhanced TiVA exports to EUROPE, NAFTA, especially to the rest of EUROPE, and the rest of ASIA. (6)The presence of the rest of EUROPE, the rest of ASIA, and the rest of the world in global TiVA shows a strong increasing trend, which is considered clear evidence that the distribution of TiVA at the worldwide level has become much flatter and more diverse.

4.2 TiVA at the country level

Figure 7 shows the TiVA at country level for 2005. The main features of Figure 7 are summarized as follows. (1) The main sources of both TiVA import and TiVA export for most countries originate from the intraregional TiVA. Not surprisingly, because the cost of organizing production networks depends on geographic distance, a neighbor country should always be the first choice when looking for trade patterns if other conditions remain unchanged. This feature also reflects the magnitude of a country's degree of participation in GVCs. (2) A comparison of TiVA import and TiVA export clearly shows that most countries export more value added to NAFTA than their imports from NAFTA. This phenomenon occurs partly because some of the United States's production capacity for merchandized goods has moved to developing economies through FDI. (3) In addition, NAFTA has a relatively close relationship in terms of TiVA with ASIA countries compared with EUROPE, which is clearly reflected in the strong connections among the production networks in the Asia-Pacific region (ASIA and NAFTA). (4) ASIA shows a similar or relatively large performance in EUROPE's value chain system compared with NAFTA.

4.3 TiVA in terms of final and intermediate products

As noted in the previous section, an I–O-based decomposition technique can separately measure the TiVA from the contribution of trade in intermediate and final products. Tables 4 and 5 show the shares of interregional and intraregional TiVA in total TiVA for intermediate and final products, respectively. The key findings are summarized as follows. 1) The TiVA in terms of trade in intermediate products accounts for more than 60% of total international TiVA, and this presence increased between 1995 and 2005 (from

62.1% to 66.2%). This increase indicates that trade in intermediate goods played an increasing and dominant role in the value added creation system through international production networks. 2) Except for the rest of EUROPE and the rest of ASIA, the TiVA for most regions related to trade in final products decreased rapidly both interregionally and intraregionally. In contrast, except for ASIA's TiVA imports and NAFTA's TiVA exports to ASIA, the presence of GVCs for most regions increased rapidly from both inter and intraregional aspects concerning the TiVA in terms of trade in intermediate products. This phenomenon clearly implies that the ongoing regional integration is primarily driven by the expansion of intraregional trade in intermediate goods with respect to value creation and distribution, especially for the rest of EUROPE and the East Asia region. 3) Although the ASIA area showed an overall increase in the presence of intraregional TiVA in terms of intermediate products, the linkages between ASEAN and East Asia decreased between 1995 and 2005. ASEAN and East Asia are linked through international trade, but their interaction with respect to TiVA showed lower performance. Confirming the difference in the performance of regional integration between EUROPE and ASIA is easy by analyzing the interaction between EU15 – the rest of EUROPE relationship and East Asia – ASEAN relationship.

4.4 Who produces intermediate products for whom?

As shown in previous sections, international trade statistics provide a very direct image of the evolution of the global trade structure. The concept of TiVA is proposed to measure the degree of regional integration using both direct and indirect linkages. However, all of these measurements provide a kind of "final" image of regional economic integration, rather than showing the step-by-step interaction among countries within a target region. Using the measure proposed in Section 3.4 captures a more detailed image of regional economic integration.

Figures 8 and 9 show the type of bilateral trade in final products that induces international trade in intermediate products. In other words, these figures provide detailed information on who produces intermediate products for whom. For example, when France imported goods and services from Germany in 1995, the induced international trade in intermediate products was concentrated in Europe area, which surrounded certain trade hubs such as the United Kingdom, Belgium, The Netherlands, and Luxembourg. In addition, this trade in final goods and services that occurred within Europe (between France and Germany) also had a relatively large effect on Japan and the United States. Namely, France's import of a larger volume of final products from Germany induced a larger volume of international trade of intermediate products produced in Japan and the United States. Comparing this situation with that of 2005 easily confirms very dramatic changes. For example, France's imports of final goods and services from Germany caused a higher volume of international trade in intermediate products within Europe, especially between EU15 and the rest of EUROPE, clearly indicating the evolution of ongoing regional integration within the EUROPE. In addition, in contrast to the situation in 1995, the fact that France's imports from Germany had a more significant effect on China's exports of intermediate products to countries throughout the world, especially to intra-East Asia trade, also provides the additional information on worldwide production networks that deepening regional integration causes shifts in simultaneous interregional relationships. Another example is the effect of Japan's imports of final goods and services from China (Figure 12). Obviously, in 1995, when Japan imported final products from China, the East Asia region tended to import a higher volume of intermediate products from NAFTA, the EUROPE, and East Asia. However, in 2005, the situation changed and international trade within ASIA became much flatter. Simultaneously, the induced interregional trade in intermediate products between

ASIA and EUROPE decreased.

4.5 Alternative measurement of revealed comparative advantage

As explained in the previous section, the traditional indicator of comparative advantage proposed by Balassa (1965) is only based on international trade data. The increasing vertical specialization in trade and fragmentation of production in international production networks prevents this measure from providing significant information because a country's exports tend to embody a higher percentage of other countries' contents (value added). Using the newly proposed measure of RCA based on the concept of TiVA enables the calculation of a new ranking of RCA across countries. The primary results for selected industries are shown in Tables 6 and 7 and easily confirm that the new measure of TiVA-based RCA provides very different information compared with that provided by traditional measures. For example, according to the traditional indicator for exports of office, accounting, and computing machinery, China ranked ninth in 1995. However, TiVA-based RCA for China indicates a lower ranking, precisely reflecting the fact that almost half of the exports of office, accounting, and computing machinery products made in China are processed goods with a large share of imported content. Therefore, the traditional RCA indicator may overestimate the relative ranking of China in terms of its comparative advantage. The figure for 2005 shows that the difference in China's ranking from these two measures narrowed, possibly implying that China exported a higher volume of domestic content or gained more value added by exporting office and computing machinery goods. In other words, China may have achieved a kind of industrial upgrade in its production of computing machinery. Alternatively, multinational enterprises in China may have increased their local procurement rate. In contrast, Mexico's traditional RCA- and TiVA-based RCA rankings in the motor vehicles, trailers, and semi-trailers sector are the highest. The fact that Mexico ranks first is no surprise considering the fact that the country's primary export goods are motor-related products, the majority of which are shipped to the United States. Japan and Germany maintained their RCA for both measurements. The TiVA-based RCA of Korea is much higher than its traditional RCA and is close to Germany and Japan, implying that evaluating only the export of motor-vehicle-related products without considering the value added creation potential of Korea's motor sector may underestimate Korea's true performance in this sector in GVCs.

5 Conclusion

International I–O tables have been considered a very useful source of data for analyses of production networks, international fragmentation production, GVCs, etc. This paper uses the new I–O-based concept, TiVA, to measure the evolution of GVCs and regional economic integration. Compared with the traditional measure based on international trade statistics, the TiVA-based measure provides a more detailed image of countries' positions and degrees of participation in international production networks from both direct and indirect perspectives. In addition, using the I–O-based decomposition technique, the TiVA measurement can be separated by the factor of trade in final and intermediate goods, helping us understand how intermediate goods function and driving the evolution of regional economic integration. Furthermore, we redefine the indicator of RCA using the concept of TiVA. Compared to the traditional trade-statistics-based indicator, this new indicator can provide a more reasonable measure of a country's comparative advantage because the potential of a country's value added export is fully considered. In addition, on the basis of the traditional international I–O model, induced international trade in intermediate goods is identified by different trade transactions in final goods. Therefore, capturing more

detailed information on who produces what for whom is possible, and additional information on regional economic integration that may be masked by traditional trade statistics becomes available.

The primary findings of the empirical analysis are summarized as follows. 1) EUROPE has been a high-level integrated region in terms of its high intraregional TiVA. In addition, the emergence of the rest of EUROPE has resulted in very dynamic effects on the EUROPE's regional integration. The deepening and strengthening of the interaction between EU15 and the rest of EUROPE has been the most important feature of the ongoing regional integration of the EUROPE. 2) In contrast, ASIA as a whole shows a slight decreasing presence of regional integration in terms of intraregional TiVA. When tracing a more detailed interaction within ASIA, the intraregional interaction for ASEAN shows decreasing, but East Asia shows increasing performance; however, the interregional dependency in terms of TiVA between the two regions shows a decreasing tendency compared to EU15 and the rest of EUROPE. 3) The contribution from trade in intermediate goods accounted for 66% of the total international TiVA in 2005, clearly implying that the deepening regional integration is primarily driven by the expansion in intraregional trade in intermediate goods with respect to value creation and distribution. 4) The structural change as measured by the induced international trade in intermediate goods through selected bilateral trade in final goods clearly confirms that integrated production networks within the EUROPE and ASIA were enhanced through trade in intermediate products between 1995 and 2005.

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Figure 1 Evolution of global trade in goods

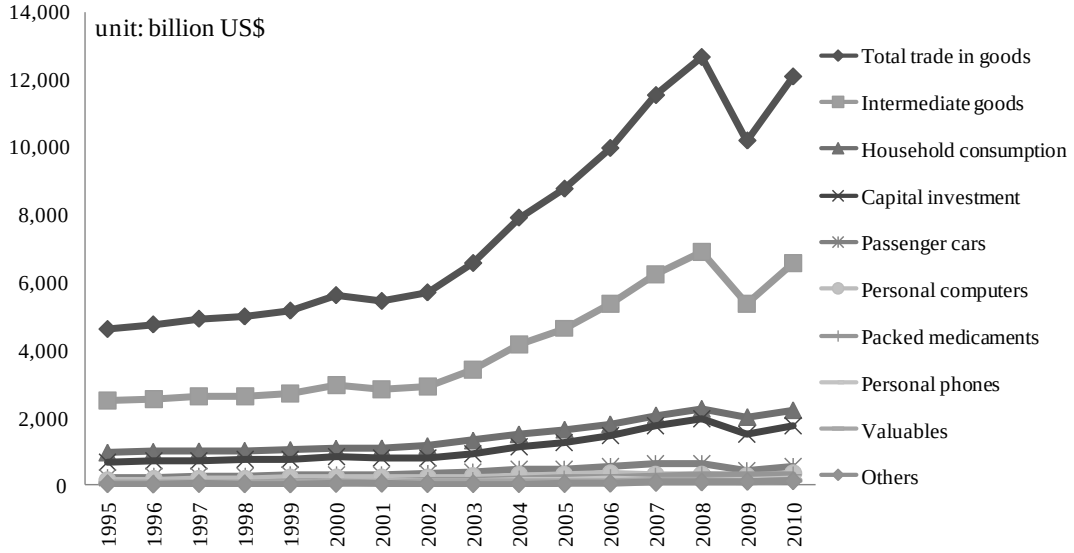

Figure 2 Categories' share of global trade

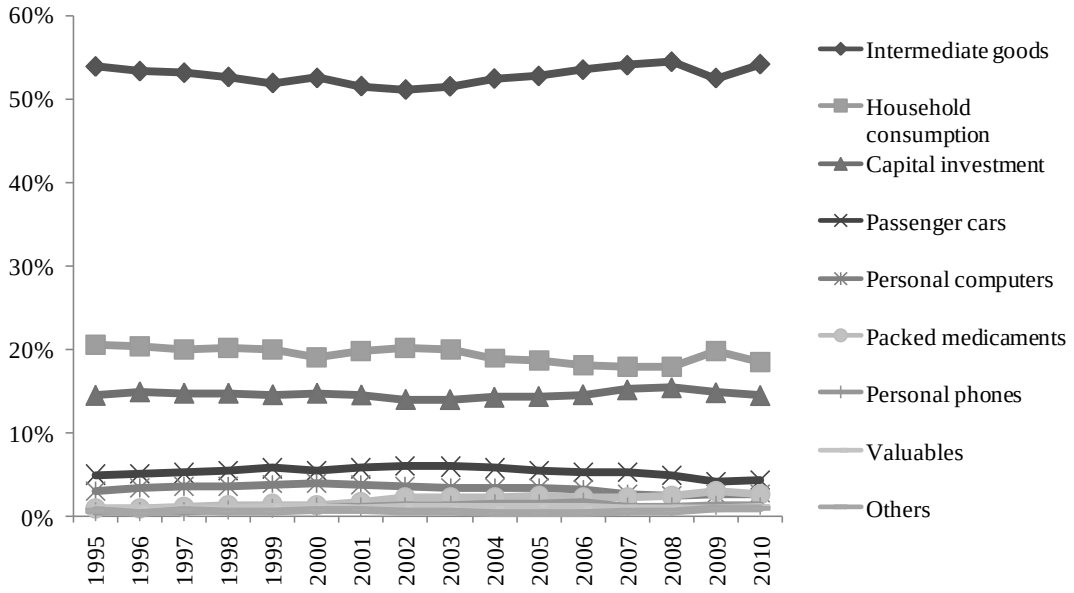

Figure 3 Relative contributions to growth in total trade by end-use category

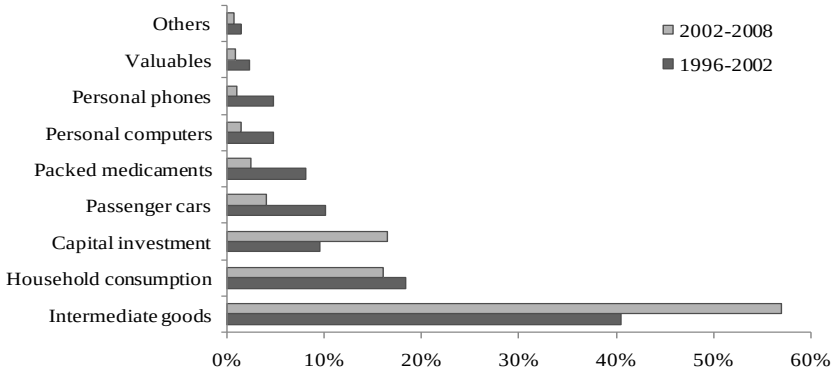

Table 1 Contribution by country to growth in world trade (in terms of export)

Rank		1996-2002	2002-2008	Rank		1996-2002	2002-2008
1	China	24.84%	17.86%	16	Thailand	1.42%	1.64%
2	Germany	8.30%	11.52%	17	Canada	3.96%	1.58%
3	USA	5.80%	6.91%	18	India	1.24%	1.54%
4	Rest of world	4.28%	5.60%	19	Poland	1.69%	1.53%
5	Japan	1.54%	5.36%	20	Mexico	6.97%	1.46%
6	France	2.89%	4.05%	21	Malaysia	2.46%	1.39%
7	Italy	0.14%	3.57%	22	Sweden	-0.10%	1.36%
8	Korea	4.90%	3.50%	23	Czech Rep.	1.90%	1.32%
9	Netherlands	1.66%	3.09%	24	Austria	1.44%	1.28%
10	Belgium, Luxembourg	0.63%	2.45%	25	Australia	-0.10%	1.23%
11	Chinese Taipei	3.47%	2.26%	26	Singapore	-0.11%	1.11%
12	United Kingdom	0.61%	2.23%	27	Ireland	6.68%	1.00%
13	Spain	2.37%	2.01%	28	Russian Federation	0.56%	0.94%
14	Brazil	1.14%	1.94%	29	Turkey	1.46%	0.92%
15	Switzerland	0.06%	1.87%	30	Indonesia	1.13%	0.87%
					Sum	93.23%	93.39%

Table 2 Contribution by country to growth in world trade (in terms of import)

Rank	Country name	1996-2002	2002-2008	Rank	Country name	1996-2002	2002-2008
1	Rest of world	5.54%	12.88%	16	India	1.38%	2.28%
2	China	14.23%	9.61%	17	Poland	1.81%	2.14%
3	USA	34.59%	9.15%	18	Singapore	-1.99%	1.98%
4	Germany	5.93%	8.33%	19	Mexico	8.62%	1.84%
5	France	2.43%	4.86%	20	Turkey	0.60%	1.55%
6	Netherlands	0.17%	3.68%	21	Brazil	-0.89%	1.55%
7	United Kingdom	6.52%	3.67%	22	Australia	0.73%	1.53%
8	Italy	3.43%	3.59%	23	Czech Rep.	1.53%	1.48%
9	Japan	-1.65%	3.55%	24	Switzerland	0.48%	1.43%
10	Belgium, Luxembourg	4.05%	3.41%	25	Austria	0.43%	1.42%
11	Russian Federation	0.47%	3.17%	26	Thailand	-1.03%	1.35%
12	Spain	3.85%	3.01%	27	Sweden	0.15%	1.31%
13	Hong Kong SAR of China	0.93%	2.87%	28	Chinese Taipei	0.76%	1.21%
14	Korea	-0.26%	2.77%	29	Indonesia	-1.70%	1.19%
15	Canada	5.49%	2.28%	30	Malaysia	-0.13%	1.00%
					Sum	96.47%	100.09%

Figure 4 Evolution of global trade hubs

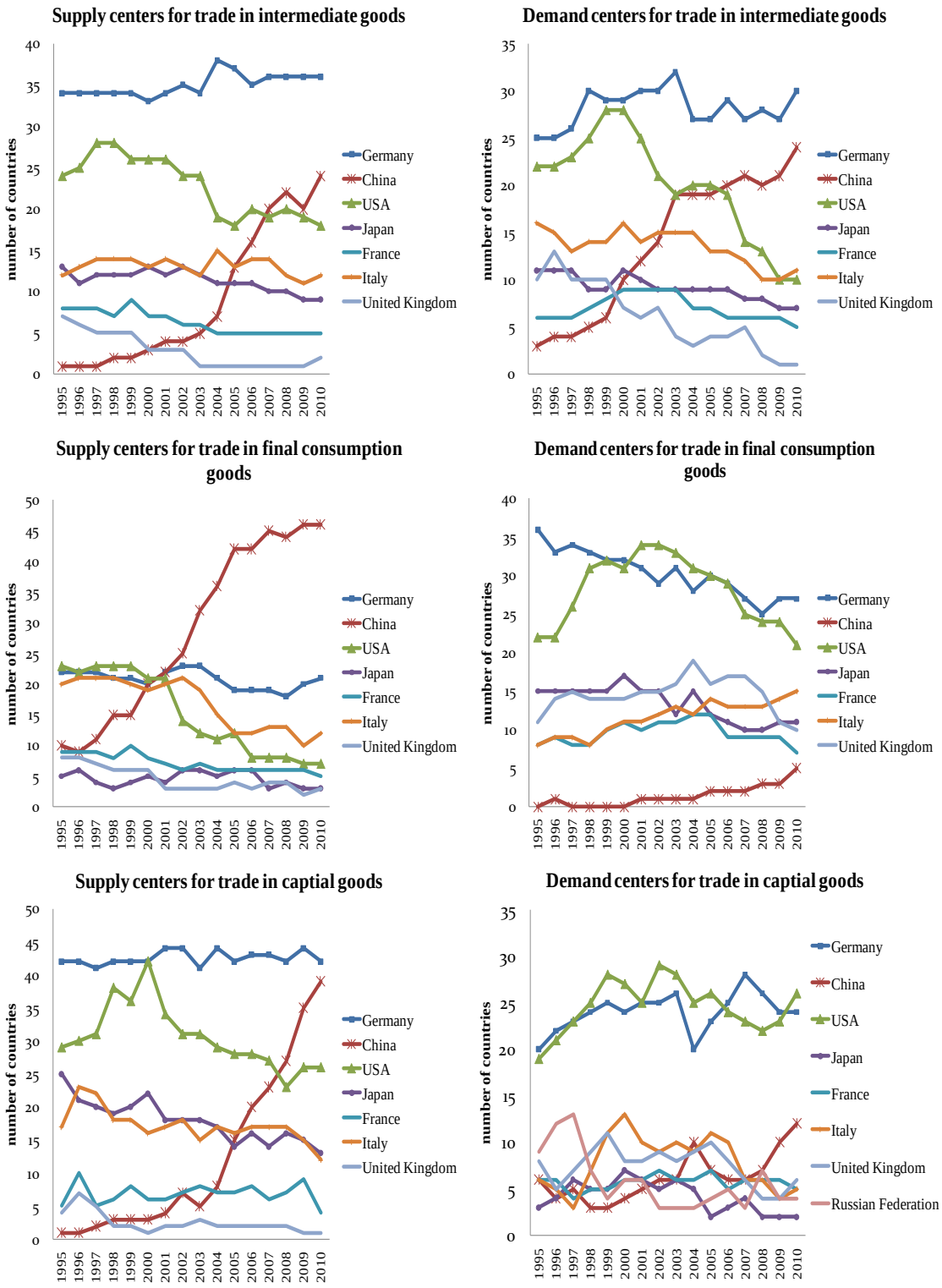

Figure 5 Single national I–O framework

	country r	country r	export to country s	total output
country r	$\mathbf{IMD}^{rr}$	$\mathbf{fd}^{rr}$	$\mathbf{ex}^{rs}$	$\mathbf{x}^{r}$
country s	$\mathbf{IMD}^{sr}$	$\mathbf{fd}^{sr}$		
value added	$\mathbf{va}^{r}$			
total input	$\mathbf{x}^{r}$			

Figure 6 International I–O framework (two-country case)

	country r	country s	country r	country s	total output
country r	$\mathbf{IMD}^{rr}$	$\mathbf{IMD}^{rs}$	$\mathbf{fd}^{rr}$	$\mathbf{fd}^{rs}$	$\mathbf{x}^{r}$
country s	$\mathbf{IMD}^{sr}$	$\mathbf{IMD}^{ss}$	$\mathbf{fd}^{sr}$	$\mathbf{fd}^{ss}$	
value added	$\mathbf{va}^{r}$	$\mathbf{va}^{s}$			
total input	$\mathbf{x}^{r}$	$\mathbf{x}^{s}$			

Table 3 TiVA share across regions (%)

Bilateral TiVA share in total TiVA for 1995 (%)												
1995		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**22.7**	21.6	1.1	4.6	0.7	5.2	1.2	3.4	0.6	5.1	38.3
	EU15	21.8	**20.8**	1.0	4.6	0.6	5.1	1.2	3.3	0.6	4.9	37.0
	Rest of EUROPE	0.9	0.8	**0.1**	0.1	0.0	0.1	0.0	0.1	0.0	0.2	1.3
NAFTA		3.8	3.7	0.1	**7.0**	0.7	5.7	1.0	4.2	0.6	1.5	18.7
South America		0.5	0.5	0.0	0.4	**0.3**	0.5	0.1	0.4	0.0	0.3	2.1
ASIA		4.5	4.3	0.1	7.1	0.4	**11.7**	3.3	7.6	0.9	2.0	25.7
	ASEAN	0.7	0.7	0.0	0.8	0.0	2.4	**0.7**	1.6	0.1	0.3	4.3
	East Asia	3.4	3.3	0.1	6.0	0.3	8.3	2.4	**5.2**	0.6	1.5	19.5
	Rest of ASIA	0.3	0.3	0.0	0.3	0.0	1.1	0.2	0.7	**0.1**	0.2	1.9
ROW		6.8	6.3	0.4	3.4	0.4	3.6	0.5	2.7	0.4	**1.1**	15.2
World		38.2	36.4	1.8	22.6	2.5	26.7	6.1	18.2	2.5	10.0	100.0
Bilateral TiVA share in total TiVA for 2005 (%)												
2005		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**20.2**	18.5	1.8	4.8	0.4	3.9	0.5	2.6	0.8	4.6	33.9
	EU15	18.7	**17.2**	1.5	4.6	0.4	3.7	0.5	2.5	0.8	4.2	31.7
	Rest of EUROPE	1.5	1.3	**0.3**	0.2	0.0	0.1	0.0	0.1	0.0	0.4	2.3
NAFTA		3.6	3.4	0.2	**6.7**	0.5	3.5	0.4	2.5	0.5	1.3	15.6
South America		0.6	0.6	0.0	0.6	**0.3**	0.6	0.1	0.4	0.1	0.4	2.5
ASIA		5.4	5.0	0.4	7.5	0.4	**10.7**	1.9	7.5	1.3	2.6	26.6
	ASEAN	0.7	0.7	0.0	0.8	0.0	2.2	**0.5**	1.4	0.3	0.3	4.1
	East Asia	4.1	3.8	0.3	6.2	0.3	7.4	1.2	**5.3**	0.8	1.9	19.8
	Rest of ASIA	0.6	0.6	0.0	0.5	0.0	1.2	0.2	0.8	**0.2**	0.4	2.7
ROW		7.5	6.9	0.6	5.3	0.4	6.0	0.6	4.2	1.2	**2.1**	21.4
World		37.4	34.5	2.9	24.9	1.9	24.7	3.5	17.3	3.9	11.0	100.0
Change rate of bilateral TiVA share between 1995 and 2005 (%)												
1995-2005		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**-10.9**	-14.6	60.8	3.5	-34.8	-25.0	-58.5	-22.8	28.6	-10.8	-11.5
	EU15	-14.3	**-17.6**	55.4	1.0	-35.7	-26.4	-59.2	-24.2	25.6	-14.8	-14.5
	Rest of EUROPE	70.7	65.7	**102.4**	126.9	0.0	45.1	0.0	42.9	0.0	90.5	74.8
NAFTA		-5.0	-6.8	51.3	**-4.4**	-34.0	-38.5	-54.8	-39.4	-3.4	-11.8	-16.6
South America		23.2	20.2	0.0	41.4	**-12.1**	12.9	-29.8	13.4	0.0	14.2	17.7
ASIA		21.3	17.1	146.3	6.0	0.3	**-8.6**	-41.9	-1.2	52.1	30.6	3.8
	ASEAN	4.7	1.6	0.0	1.8	9.5	-10.2	**-25.0**	-14.6	102.7	12.5	-3.7
	East Asia	19.0	14.2	155.2	3.1	-5.1	-10.4	-49.1	**1.6**	39.1	27.3	1.9
	Rest of ASIA	79.5	78.5	0.0	77.6	0.0	9.5	-13.6	8.4	**55.4**	83.2	40.5
ROW		11.6	9.7	40.4	56.7	-4.0	68.3	16.0	59.8	199.7	**95.3**	40.6
World		-2.1	-5.4	62.7	10.5	-21.0	-7.5	-42.0	-4.8	57.6	9.5	**0.0**

Figure 7 TiVA share at the country level for 2005 (%)

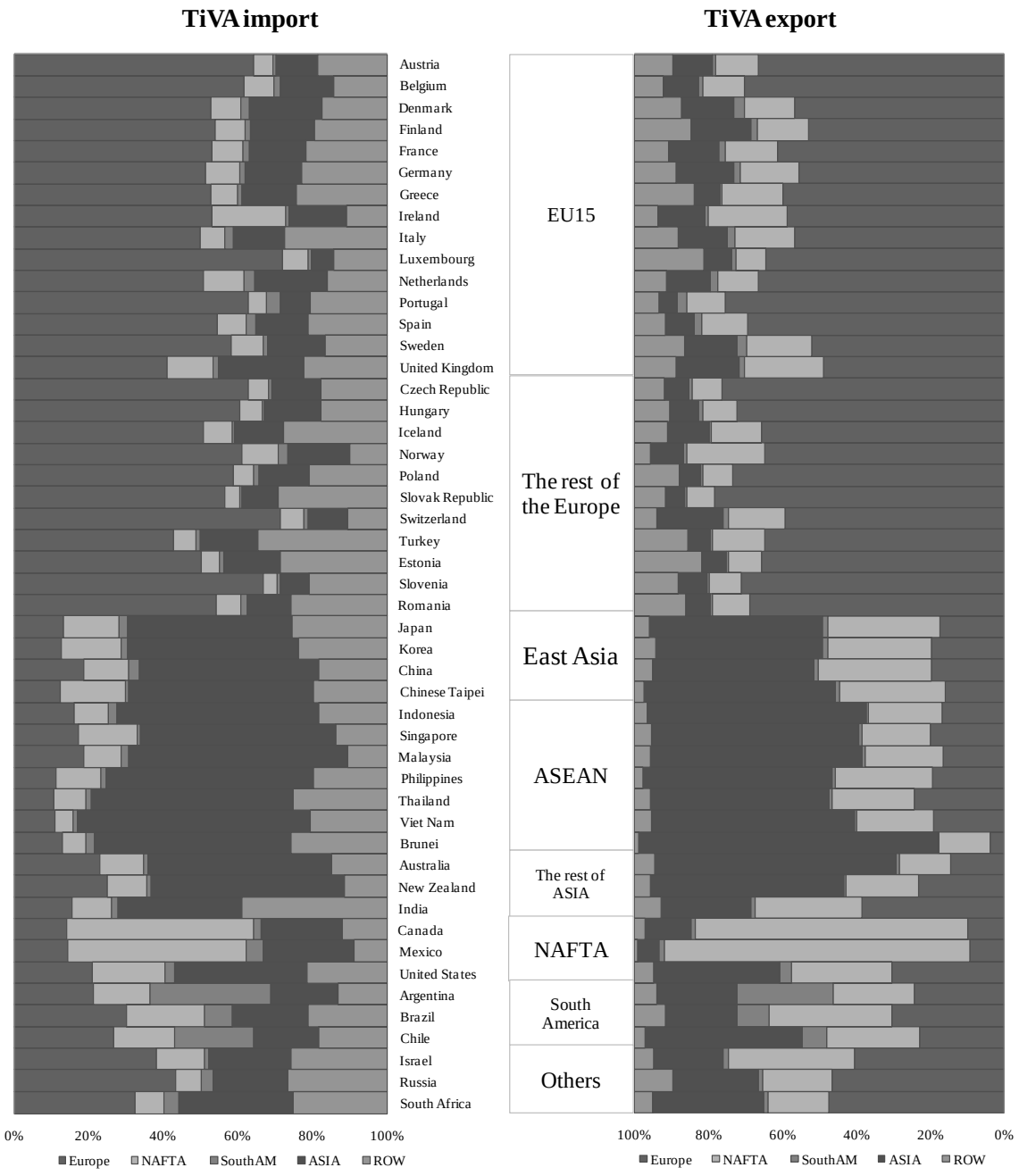

Table 4 TiVA in terms of trade in intermediate goods across regions (%)

Bilateral TiVA share in total TiVA in terms of intermediate products for 1995 (%)												
1995		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**14.0**	13.4	0.7	3.1	0.4	2.9	0.7	1.9	0.4	3.0	23.5
	EU15	13.5	**12.9**	0.6	3.0	0.4	2.9	0.6	1.9	0.4	2.9	22.6
	Rest of EUROPE	0.6	0.5	**0.1**	0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.9
NAFTA		2.8	2.7	0.1	**4.3**	0.4	3.7	0.6	2.7	0.4	1.0	12.2
South America		0.4	0.4	0.0	0.3	**0.2**	0.4	0.1	0.3	0.0	0.2	1.6
ASIA		2.5	2.4	0.1	3.5	0.2	**6.9**	1.8	4.6	0.5	1.0	14.1
	ASEAN	0.5	0.4	0.0	0.4	0.0	1.6	**0.4**	1.2	0.1	0.2	2.7
	East Asia	1.8	1.8	0.1	2.8	0.2	4.5	1.3	**2.8**	0.3	0.7	10.0
	Rest of ASIA	0.2	0.2	0.0	0.2	0.0	0.8	0.1	0.6	**0.1**	0.1	1.4
ROW		4.8	4.5	0.3	2.1	0.3	2.8	0.4	2.1	0.3	**0.7**	10.8
World		24.6	23.4	1.2	13.3	1.5	16.7	3.5	11.6	1.6	5.9	62.1
Bilateral TiVA share in total TiVA in terms of intermediate products for 2005 (%)												
2005		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**12.6**	11.6	1.1	3.2	0.3	2.6	0.3	1.8	0.5	2.8	21.6
	EU15	11.6	**10.7**	0.9	3.1	0.3	2.5	0.3	1.7	0.5	2.6	20.1
	Rest of EUROPE	1.0	0.9	**0.2**	0.2	0.0	0.1	0.0	0.1	0.0	0.2	1.5
NAFTA		2.6	2.5	0.1	**4.3**	0.3	2.4	0.3	1.8	0.4	0.9	10.5
South America		0.5	0.5	0.0	0.4	**0.2**	0.5	0.1	0.4	0.1	0.2	1.9
ASIA		3.1	2.9	0.2	4.0	0.3	**7.1**	1.1	5.1	0.9	1.4	15.8
	ASEAN	0.5	0.5	0.0	0.5	0.0	1.6	**0.3**	1.0	0.2	0.2	2.8
	East Asia	2.2	2.1	0.2	3.2	0.2	4.6	0.7	**3.4**	0.5	1.0	11.2
	Rest of ASIA	0.4	0.3	0.0	0.3	0.0	0.9	0.1	0.7	**0.1**	0.2	1.8
ROW		5.6	5.1	0.4	3.9	0.3	5.2	0.5	3.7	0.9	**1.5**	16.4
World		24.5	22.6	1.9	15.8	1.4	17.8	2.3	12.8	2.7	6.8	66.2
Change rate of bilateral TiVA share between 1995 and 2005 (%)												
1995-2005		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**-10.0**	-13.4	56.5	5.2	-25.0	-10.5	-52.3	-5.3	36.8	-7.6	-8.0
	EU15	-13.5	**-16.6**	53.3	1.7	-25.6	-12.2	-52.4	-7.0	28.9	-12.1	-11.3
	Rest of EUROPE	69.5	70.0	**66.7**	142.9	0.0	71.4	0.0	60.0	0.0	84.6	77.0
NAFTA		-5.4	-7.0	62.5	**0.5**	-25.0	-34.2	-50.0	-34.7	-5.4	-13.1	-13.3
South America		24.4	20.0	0.0	38.7	**-14.3**	16.3	-28.6	14.7	0.0	4.5	17.1
ASIA		23.0	18.9	133.3	15.0	13.0	**2.8**	-37.9	11.9	70.0	45.4	12.5
	ASEAN	11.1	9.3	0.0	15.9	33.3	-2.5	**-14.3**	-10.3	109.1	40.0	5.6
	East Asia	22.4	16.9	166.7	13.4	5.6	3.4	-46.6	**21.4**	53.1	44.9	12.6
	Rest of ASIA	50.0	47.8	0.0	35.0	0.0	11.3	-7.7	10.2	**62.5**	66.7	26.8
ROW		15.6	13.5	51.7	79.9	6.9	83.7	32.5	76.3	200.0	**106.8**	52.1
World		-0.5	-3.5	61.5	19.0	-11.8	6.3	-34.3	9.9	71.5	14.7	**6.7**

Table 5 TiVA in terms of trade in final goods across regions (%)

Bilateral TiVA share in total TiVA in terms of final products for 1995 (%)												
1995		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**8.7**	8.3	0.4	1.6	0.3	2.3	0.6	1.5	0.2	2.1	14.9
	EU15	8.4	**8.0**	0.4	1.5	0.3	2.2	0.6	1.5	0.2	2.0	14.4
	Rest of EUROPE	0.3	0.3	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4
NAFTA		1.0	1.0	0.0	**2.7**	0.3	2.0	0.4	1.4	0.2	0.5	6.6
South America		0.1	0.1	0.0	0.1	**0.1**	0.1	0.0	0.1	0.0	0.1	0.5
ASIA		1.9	1.9	0.1	3.7	0.2	**4.8**	1.5	3.0	0.4	1.0	11.6
	ASEAN	0.2	0.2	0.0	0.4	0.0	0.8	**0.3**	0.4	0.0	0.2	1.6
	East Asia	1.6	1.6	0.1	3.2	0.1	3.8	1.1	**2.4**	0.3	0.8	9.5
	Rest of ASIA	0.1	0.1	0.0	0.1	0.0	0.3	0.1	0.1	**0.0**	0.1	0.5
ROW		1.9	1.8	0.1	1.2	0.1	0.8	0.1	0.5	0.1	**0.4**	4.4
World		13.7	13.0	0.6	9.3	0.9	10.0	2.6	6.5	0.9	4.1	37.9
Bilateral TiVA share in total TiVA in terms of final products for 2005 (%)												
2005		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**7.6**	6.9	0.7	1.6	0.1	1.3	0.2	0.8	0.3	1.8	12.4
	EU15	7.1	**6.5**	0.6	1.5	0.1	1.2	0.2	0.8	0.3	1.7	11.6
	Rest of EUROPE	0.5	0.4	**0.1**	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.7
NAFTA		1.0	0.9	0.1	**2.4**	0.2	1.1	0.2	0.7	0.2	0.5	5.1
South America		0.1	0.1	0.0	0.2	**0.1**	0.1	0.0	0.1	0.0	0.1	0.6
ASIA		2.3	2.2	0.2	3.6	0.1	**3.7**	0.8	2.4	0.5	1.2	10.8
	ASEAN	0.2	0.2	0.0	0.3	0.0	0.6	**0.2**	0.3	0.1	0.1	1.3
	East Asia	1.9	1.7	0.1	3.0	0.1	2.8	0.5	**1.9**	0.4	0.9	8.6
	Rest of ASIA	0.2	0.2	0.0	0.3	0.0	0.3	0.1	0.1	**0.1**	0.2	0.9
ROW		2.0	1.8	0.2	1.4	0.1	0.8	0.1	0.5	0.2	**0.6**	5.0
World		13.0	11.9	1.1	9.1	0.6	6.9	1.2	4.5	1.2	4.2	33.8
Change rate of bilateral TiVA share between 1995 and 2005 (%)												
1995-2005		**EUROPE**			**NAFTA**	**South America**	**ASIA**				**ROW**	**World**
			EU15	Rest of EUROPE				ASEAN	East Asia	Rest of ASIA		
EUROPE		**-12.4**	-16.5	70.7	0.6	-50.0	-43.8	-66.1	-45.3	17.4	-15.2	-16.9
	EU15	-15.7	**-19.0**	57.9	-0.6	-50.0	-44.4	-65.5	-45.9	18.2	-18.6	-19.5
	Rest of EUROPE	68.8	57.1	**150.0**	33.3	0.0	0.0	0.0	0.0	0.0	100.0	65.9
NAFTA		-4.0	-7.1	25.0	**-12.1**	-46.4	-46.3	-61.0	-48.6	0.0	-9.6	-22.7
South America		33.3	22.2	0.0	38.5	**0.0**	0.0	0.0	0.0	0.0	44.4	24.5
ASIA		19.1	14.9	150.0	-2.5	-18.8	**-24.6**	-46.9	-20.6	28.9	16.0	-6.7
	ASEAN	-8.3	-8.7	0.0	-13.2	0.0	-24.4	**-35.5**	-25.6	75.0	-13.3	-17.9
	East Asia	14.9	11.0	160.0	-6.0	-21.4	-26.8	-51.4	**-21.3**	20.7	11.5	-9.6
	Rest of ASIA	140.0	166.7	0.0	177.8	0.0	8.0	-14.3	0.0	**50.0**	128.6	78.8
ROW		2.1	0.6	23.1	17.2	-27.3	10.5	-28.6	-3.7	175.0	**70.3**	12.7
World		-5.0	-8.6	67.2	-1.6	-34.8	-30.5	-52.1	-30.8	32.6	2.2	**-10.8**

Figure 8 Induced trade in intermediate goods by France's imports from Germany (1995, 2005)

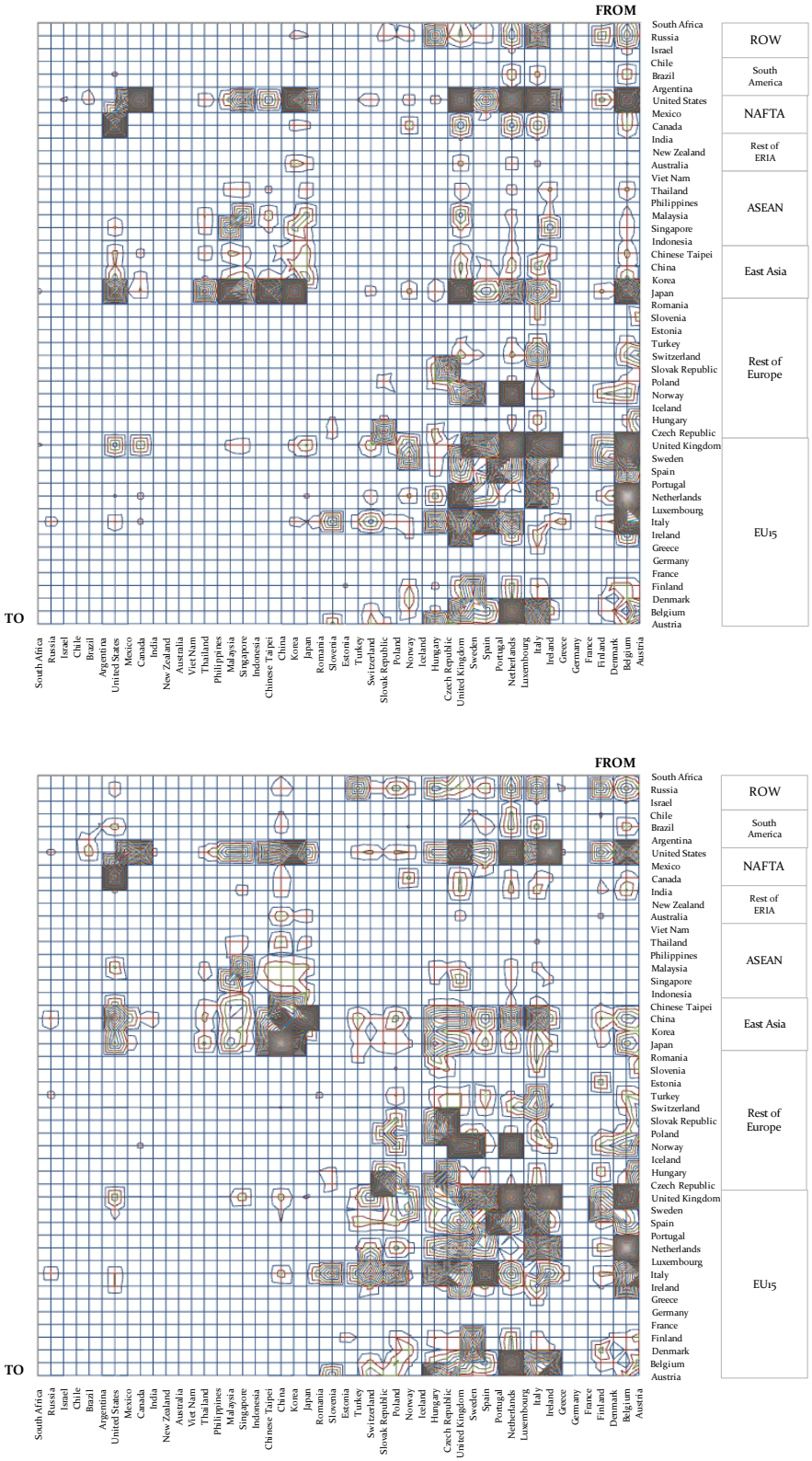

Figure 9 Induced trade in intermediate goods by Japan's imports from China (1995, 2005)

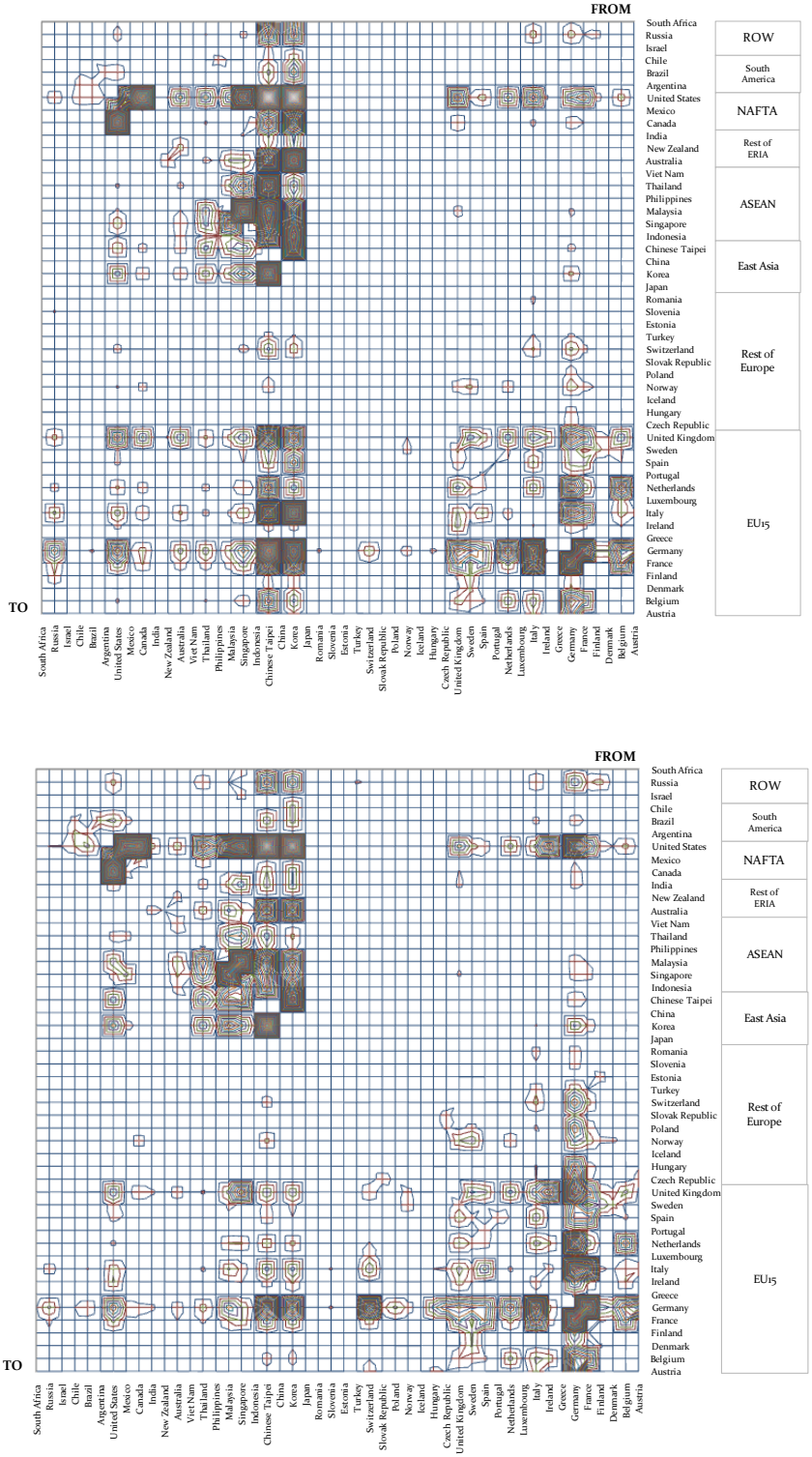

Table 6 Comparative advantage indicator based on TiVA for selected industries (1995)

1995	Office, accounting & computing machinery				Motor vehicles, trailers & semi-trailers			
Rank	Country	RCA	Country	RCA by TiVA	Country	RCA	Country	RCA by TiVA
1	Singapore	6.80	Ireland	9.55	Mexico	3.01	Mexico	4.50
2	Ireland	5.27	Singapore	6.50	Spain	2.69	Japan	2.47
3	Chinese Taipei	3.60	Chinese Taipei	3.21	Canada	2.45	Germany	2.42
4	Mexico	3.16	Mexico	2.86	Japan	2.19	Spain	2.30
5	Japan	2.13	Poland	1.95	Germany	2.00	Canada	2.05
6	United States	1.59	Japan	1.81	Belgium	1.76	Sweden	1.80
7	Hong Kong	1.49	United Kingdom	1.52	Sweden	1.61	Belgium	1.47
8	United Kingdom	1.47	United States	1.52	Slovenia	1.32	Korea	1.27
9	China	1.06	Hong Kong	1.47	France	1.20	Poland	1.14
10	Poland	0.92	RoW	1.03	Austria	1.17	Austria	1.10
11	Korea	0.83	France	0.97	Portugal	1.06	France	0.99
12	France	0.80	Korea	0.53	Poland	0.98	Hungary	0.97
13	Canada	0.57	Australia	0.47	Hungary	0.94	Brazil	0.90
14	Australia	0.46	Spain	0.47	United States	0.94	United Kingdom	0.83
15	Spain	0.39	China	0.47	Italy	0.84	Argentina	0.77
16	Finland	0.33	Germany	0.42	Korea	0.84	Italy	0.72
17	Netherlands	0.32	Netherlands	0.34	Brazil	0.84	Slovenia	0.64
18	Italy	0.31	Romania	0.33	United Kingdom	0.81	Portugal	0.63
19	Germany	0.28	Italy	0.31	Argentina	0.78	South Africa	0.57
20	Romania	0.28	Sweden	0.27	South Africa	0.72	United States	0.50
21	Sweden	0.15	Finland	0.24	Czech Republic	0.56	Czech Republic	0.44
22	Norway	0.13	Argentina	0.19	Slovak Republic	0.49	Turkey	0.43
23	Argentina	0.13	Canada	0.17	Netherlands	0.35	China	0.42
24	RoW	0.13	Slovak Republic	0.14	Turkey	0.32	Chinese Taipei	0.41
25	Hungary	0.10	Norway	0.12	India	0.28	Slovak Republic	0.37
26	Czech Republic	0.08	Slovenia	0.11	Chinese Taipei	0.26	India	0.31
27	Switzerland	0.08	Denmark	0.10	China	0.21	Netherlands	0.30
28	Estonia	0.08	Estonia	0.10	Australia	0.19	Thailand	0.28
29	Denmark	0.06	Czech Republic	0.09	Romania	0.18	Finland	0.27
30	Brazil	0.06	Hungary	0.09	Finland	0.17	Malaysia	0.27

Table 7 Comparative advantage indicator based on TiVA for selected industries (2005)

2005	Office, accounting & computing machinery				Motor vehicles, trailers & semi-trailers			
Rank	Country	RCA	Country	RCA by TiVA	Country	RCA	Country	RCA by TiVA
1	Mexico	5.48	Singapore	7.93	Mexico	2.75	Mexico	3.83
2	Singapore	4.49	Thailand	5.81	Japan	2.46	Japan	3.02
3	Ireland	4.03	Mexico	4.84	Germany	2.44	Germany	2.85
4	China	4.01	Hong Kong	4.65	Spain	2.33	Hungary	2.49
5	Thailand	3.88	Ireland	3.81	Slovak Republic	2.18	Czech Republic	2.30
6	Hong Kong	3.71	China	2.66	Canada	2.13	Korea	2.14
7	Czech Republic	1.91	Hungary	2.24	Hungary	2.06	Spain	2.11
8	Hungary	1.72	Philippines	1.92	Czech Republic	1.93	Turkey	1.72
9	Japan	1.26	Japan	1.24	Poland	1.79	Sweden	1.67
10	Philippines	1.04	United States	0.86	France	1.76	Slovak Republic	1.60
11	Chinese Taipei	0.83	United Kingdom	0.67	Sweden	1.66	Austria	1.58
12	United States	0.69	Korea	0.55	Austria	1.65	Canada	1.57
13	Korea	0.47	Germany	0.48	Turkey	1.52	Poland	1.48
14	United Kingdom	0.41	Chinese Taipei	0.48	Korea	1.51	France	1.23
15	Germany	0.30	RoW	0.46	Portugal	1.43	Belgium	1.18
16	India	0.30	India	0.39	Belgium	1.41	Portugal	1.13
17	Netherlands	0.26	Czech Republic	0.35	Slovenia	1.38	Romania	1.09
18	France	0.25	Sweden	0.31	Brazil	1.30	Slovenia	0.96
19	Canada	0.23	France	0.30	United States	1.01	Argentina	0.91
20	Spain	0.20	Spain	0.27	Argentina	0.93	Brazil	0.89
21	Sweden	0.17	Netherlands	0.25	South Africa	0.91	Thailand	0.89
22	Italy	0.13	Canada	0.20	Thailand	0.83	South Africa	0.80
23	Brazil	0.13	Denmark	0.19	Italy	0.80	United States	0.69
24	Portugal	0.12	Italy	0.16	Romania	0.58	Italy	0.67
25	Denmark	0.09	Portugal	0.16	Netherlands	0.49	Philippines	0.57
26	Poland	0.08	Poland	0.15	United Kingdom	0.49	Netherlands	0.48
27	RoW	0.08	Slovenia	0.15	Philippines	0.47	United Kingdom	0.47
28	Austria	0.07	Slovak Republic	0.14	India	0.33	Estonia	0.43
29	Slovenia	0.06	Austria	0.10	Australia	0.28	New Zealand	0.35
30	Slovak Republic	0.05	Switzerland	0.10	Estonia	0.27	Finland	0.29

Appendix 1

For simplicity, the growth rate of total trade in goods is given as follows:

$$rq^t = \frac{q^t - q^{t-1}}{q^{t-1}} \ , \tag{a1}$$

where rq^t represents the growth rate of total trade q from the year $t-1$ to t. q^t represents the trade value for year t. The previous equation is easily rewritten as follows:

$$rq^t = \frac{\sum_i q_i^t - \sum_i q_i^{t-1}}{\sum_i q_i^{t-1}}, \tag{a2}$$

where q_i^t represents the trade value in terms of category i for year t. Further rearrangement of the right-hand side of the previous equation provides the growth rate of total trade as follows:

$$rq^t = \sum_i \left[\frac{q_i^{t-1}}{\sum_i q_i^{t-1}} \cdot \frac{q_i^t - q_i^{t-1}}{q_i^{t-1}}\right] = \sum_i [sq_i^{t-1} \cdot rq_i^t] \tag{a3}$$

$$sq_i^{t-1} = \frac{q_i^{t-1}}{\sum_i q_i^{t-1}} \tag{a4}$$

$$rq_i^t = \frac{q_i^t - q_i^{t-1}}{q_i^{t-1}} \ , \tag{a5}$$

where sq_i^t represents the share of category i in the total trade for year t, and rq_i^t represents the exact growth rate of trade for category i from year $t-1$ to year t. Then, the contribution rate of trade in category i to growth of total trade is defined as

$$c_i^t = \frac{sq_i^{t-1} \cdot rq_i^t}{rq^t} \ . \tag{a6}$$

Obviously, $\sum_i c_i^t = 1$ and the relative contribution rate of category (c_i^t) depend not only on its share in total trade (sq_i^{t-1}) but also its growth rate (rq_i^t).

Appendix 2 Country groups

	EUROPE (EU member)	EU15	the rest of EUROPE	NAFTA	South America	ASIA	ASEAN	East Asia	the rest of ASIA	ROW
1 Australia						1			1	
2 Austria	1	1								
3 Belgium	1	1								
4 Canada				1						
5 Czech Republic	1		1							
6 Denmark	1	1								
7 Finland	1	1								
8 France	1	1								
9 Germany	1	1								
10 Greece	1	1								
11 Hungary	1		1							
12 Iceland										1
13 Ireland	1	1								
14 Italy	1	1								
15 Japan						1		1		
16 Korea						1		1		
17 Luxembourg	1	1								
18 Mexico				1						
19 Netherlands	1	1								
20 New Zealand						1			1	
21 Norway										1
22 Poland	1		1							
23 Portugal	1	1								
24 Slovak Republic	1		1							
25 Spain	1	1								
26 Sweden	1	1								
27 Switzerland										1
28 Turkey										1
29 United Kingdom	1	1								
30 United States				1						
31 Argentina					1					
32 Brazil					1					
33 China						1		1		
34 Chinese Taipei						1		1		
35 India						1			1	
36 Indonesia						1	1			
37 Israel										1
38 Russian Federation										1
39 Singapore						1	1			
40 South Africa										1
41 Hong Kong						1		1		
42 Chile					1					
43 Estonia	1		1							
44 Slovenia	1		1							
45 Malaysia						1	1			
46 Philippines						1	1			
47 Thailand						1	1			
48 Romania	1		1							
49 Viet Nam						1	1			
50 Saudi Arabia										1
51 Bulgaria										1
52 Cyprus	1		1							
53 RoW										1
Sum	23	15	8	3	3	14	6	5	3	10