글로벌경영연구
第 26 卷 1 號
2014年 2月

China's Trade in Value Added and the Value Added in Trade: Evidence from World Input-Output Database(WIOD)

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Abstract

In this paper, we introduced two measures of value added flows between countries with a focus on the Chinese economy: First, "Trade in Value Added," accounts for the value add of one country directly and indirectly embodied in the final consumption of another country. Second, "Value Added in Trade," measures the value added in gross trade flows. Using the recently compiled World Input-Output Database (WIOD), a selection of results in China's trade with various regions compared Asia, the EU-27, Latin America, North America, and Rest of World, based on the presented concepts. We find that for both exports and imports, trade statistics in gross terms have always been larger than the trade in value added in China. We also find that China's bilateral trade balances with various regions in gross terms have been either overestimated or underestimated. For example, China's gross net export in 2009 is overestimated for the EU by 24.5% and by 21.8% for North America, (Canada and the USA) respectively.

Ⅰ. Introduction

With the acceleration of globalization, growth of Multi-National Enterprises (MNEs) and the emergence of a new international production scheme based on cross-border production (Daudin, 2011), international trade in goods and services has rapidly increased in the last several decades. Hummels et al. (2001) also pointed out that the nature of international trade has changed, because the increasing interconnectedness of production processes in a vertical trading chain has each country specializing in particular

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stages of a good's production. A plethora of previous studies (Krugman, 1995; Feenstra and Hanson, 1996; Deardorff, 1998; Jones and Kierzkowsk, 1997) have named this phenomenon as "vertical specialization," "slicing up the value chain," "fragmentation" and "multi-stage production" According to Yi (2003), "vertical specialization" is sensitive to trade costs, as it implies an increase in the number of borders crossed by each good. Timmer et al. (2013, p.3) stated, "In essence, International fragmentation of production expands the opportunities of countries to specialize according to comparative advantage and hence gain from trade."

However, as global production procedures are fragmented across various countries, the data on gross exports and imports might mislead the realities of international trade. The conventional gross statistics tally the gross value of goods at each border crossing, rather than the net value added between border crossings. In addition, without considering the intermediate inputs that have been imported to produce those exports which may cause 'double-counting' problems, means that the gross data overstates the domestic content of exports (Johnson and Noguera, 2012).

To the best of our knowledge, there is a lack of empirical research for the value added by China in global production networks. Therefore, we need to attempt to quantify international trade in terms of value added rather than gross value especially when calculating overall Chinese exports and imports. Utilizing the World Input-Output Database (WIOD), this paper investigates the value added of each industrial sector, and possible trends in the share of global value added, captured by Chinese activities during the years of 1995 to 2009.

In this paper, we build on two concepts to calculate and analyze the value added content of trade with a focus on the Chinese economy. The first, "trade in value added" accounts for the value added of one country directly and indirectly contained in final consumption of another country (Stehrer, 2012; Johnson and Noguera, 2012). The second concept, "value added in trade" calculates the value added contained in gross trade flows between two countries (Stehrer, 2012).

This paper is organized as follows: In Section 2, we present the research framework of these two concepts and define measures of both *trade in value added*

and the value added in trade. Also, there is analaysis of the differences of approach in bilateral trade relations. Section 3 describes the data sources, which were recently published 'World Input-Output Database (WIOD)' used for our calculations. The data for WIOD has been collected and compiled annually beginning in 1995 through 2009 for 35 separate industries (ISIC Revision 3), including agriculture, manufacturing and service sectors. The data covers 40 countries (27 EU countries, Turkey, Canada, USA, Mexico, Japan, Korea, Taiwan, Australia, Brazil, Russia, India, Indonesia and China), which account for about 85% of world GDP: the rest (15% of world GDP) as a whole is also recorded under the item of Rest of the World (RoW) with the same 35 disaggregated industries. In Section 4, we provide our empirical results and discussion in 3 selections. To preview our results, the first selection shows China's international trade in gross terms has continuously increased over the past 15 years. The second finding shows the trend of the differences and similarities between gross and value added trades in China. Finally, the third selection shows the differences in the share of domestic and foreign value added in China's total exports; especially in manufacturing industries. Section 5 concludes.

Ⅱ. Research Framework

1. Measuring Trade in Value Added

As production procedures are fragmented across various countries, the likelihood that data on gross exports and imports might mislead the reality of international trade has become increasingly prominent. This is because the fragmentation of production on a global scale is liable to result in a double account of trade data. Countries engaging in processing trade take and accomplish certain tasks in a drawn out production procedure, creating their own value added that should be exported to another country (industry) for the next step of production. The imports of those goods, which are considered to be intermediates of the importing country, carry value added created at the previous production location (i.e. the exporting country that performed the previous step of production). At the end, final goods that are exported to satisfy final demand should embody value added created in other countries as

well as that created in the country finishing and shipping the final goods. Therefore, the data on gross exports do not fit well with the reality that the final country adds only part of the final value.

Alternatively, the concept of trade in value added is to measure the true flows of trade in value added. It is developed to measure only value added created by processing those intermediates after deducting value added embodied in the imports. It even corresponds better with the concept of GDP which measures values of final goods and services, or the sum of value added produced at each production process.

1.1 Exports of Value Added

Exports of value added measures the value added by a country contained in the consumption of another country; that is, it evaluates the level of contribution made by the exporting country. In the development of the formula for this, we start with a general framework of input-output analysis as follows:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{f} = \mathbf{L}\mathbf{f}$$

where $\mathbf{x}$ is (nc×1) vector of gross output (with n being the number of countries and c the number of products or industries), $\mathbf{A}$ denotes the (nc×nc) matrix of input coefficients (i.e. the ratio of input to gross output in the specific industry), and $\mathbf{f}$ denotes the (nc×1) vector of final demandconsisting of final demand from n countries. The first equality could be simplified to the second equality by defining the Leontief inverse, $\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}$. To get a concrete understanding without losing generality, we can consider partitioned matrices for an international input-output table with three countries as follows:

$$\begin{bmatrix} \mathbf{x}^{r} \\ \mathbf{x}^{s} \\ \mathbf{x}^{t} \end{bmatrix} = \begin{bmatrix} \mathbf{A}^{rr} & \mathbf{A}^{rs} & \mathbf{A}^{rt} \\ \mathbf{A}^{sr} & \mathbf{A}^{ss} & \mathbf{A}^{st} \\ \mathbf{A}^{tr} & \mathbf{A}^{ts} & \mathbf{A}^{tt} \end{bmatrix} \begin{bmatrix} \mathbf{x}^{r} \\ \mathbf{x}^{s} \\ \mathbf{x}^{t} \end{bmatrix} + \begin{bmatrix} \mathbf{f}^{r} \\ \mathbf{f}^{s} \\ \mathbf{f}^{t} \end{bmatrix} = \begin{bmatrix} \mathbf{L}^{rr} & \mathbf{L}^{rs} & \mathbf{L}^{rt} \\ \mathbf{L}^{sr} & \mathbf{L}^{ss} & \mathbf{L}^{st} \\ \mathbf{L}^{tr} & \mathbf{L}^{ts} & \mathbf{L}^{tt} \end{bmatrix} \begin{bmatrix} \mathbf{f}^{rr} + \mathbf{f}^{rs} + \mathbf{f}^{rt} \\ \mathbf{f}^{sr} + \mathbf{f}^{ss} + \mathbf{f}^{st} \\ \mathbf{f}^{tr} + \mathbf{f}^{ts} + \mathbf{f}^{tt} \end{bmatrix} \quad (1)$$

where $\mathbf{x}^{i}(i = r, s, t)$ denotes the (n×1) vector of country *i*'s gross output, $\mathbf{L}^{ij}$ is the (n×n) Leontief inverse between country *i* and *j*, and $\mathbf{f}^{ij}$ is the (n×1) vector of final demand for country *i*'s products by country *j*.This definition implies in our three country context that the world demand for final goods produced in country **r**, for example, should

be $f^r = f^{rr} + f^{rs} + f^{rt}$, which is a (n×1) vector that includes both domestic demand (f^{rr}) and foreign demand ($f^{rs} + f^{rt}$); on the other hand, country *r*'s demand for final goods be a (nc×1) vector of $f^{\cdot r} = [(f^{rr})', (f^{sr})', (f^{tr})']'$.

By pre-multiplying a row vector of value added coefficients $v^i (i = r, s, t)$, or value added per unit of gross output (i.e. the ratio of value added to gross output in a specific industry, where the value added is defined as the gross output minus the sum of intermediate inputs), we can calculate a vector of value added $VA = [v^r \; v^s \; v^t]'$ as follows:

$$VA = \begin{bmatrix} \hat{A}^r & 0 & 0 \\ 0 & \hat{A}^s & 0 \\ 0 & 0 & \hat{A}^t \end{bmatrix} \quad (2)$$
$$= \begin{bmatrix} L^{rr} L^{rs} L^{rt} \\ L^{sr} L^{ss} L^{st} \\ L^{tr} L^{ts} L^{tt} \end{bmatrix} \begin{bmatrix} f^{rr} + f^{rs} + f^{rt} \\ f^{sr} + f^{ss} + f^{st} \\ f^{tr} + f^{ts} + f^{tt} \end{bmatrix}$$

Where $\hat{A}^i (i = r, s, t)$ is the (n×n)diagonal matrix of a vector of country *i*'s value added coefficients v^i.

Equation (2) sets a framework in which the trade in value added is analyzed. We can calculate country *r*'s exports of value added ($t^r_{TinVA,X}$) to all the other countries by setting $v^i = 0, (i = s, t)$ and the entries for country *r*'s domestic final demand, i.e. $f^{\cdot r} = 0$. Formally,

$$t^r_{TinVA,X} = [v^r \; 0 \; 0] \begin{bmatrix} L^{rr} L^{rs} L^{rt} \\ L^{sr} L^{ss} L^{st} \\ L^{tr} L^{ts} L^{tt} \end{bmatrix} \begin{bmatrix} 0 + f^{rs} + f^{rt} \\ 0 + f^{ss} + f^{st} \\ 0 + f^{ts} + f^{tt} \end{bmatrix}$$
$$= v^r L f^{rr} (f^{rs} + f^{rt}) + v^r L^{rs} (f^{ss} + f^{st})$$
$$+ v^r L^{rt} (f^{ts} + f^{tt}) = v^r L f^{-r} \quad (3)^{1)}$$

Since the focus is on country *r*'s exports of value added, Equation (3) excludes value added created by the other two countries by setting their value added coefficients to zero. Also, Equation (3) excludes value added created to meet country *r*'s final domestic demand. Note that this approach does not include the value added that has been exported to another country and then returns back home: for example, if one would include f^{sr} in the second element of the vector of final demand, there would appear a term of $v^r L^{rs} f^{sr}$, which should capture the value added that has been created in country *r* in the form of intermediate goods, exported to country *s,* and then,

1) In practice, the numerical result should have a (1×1) dimension, which is a scalar for the trade in value added aggregated at the national level. However, we can get a disaggregated values at industrial level, by using (c×c) diagonal matrix $\hat{A}$ instead of (1×c) vector v.

ultimately, returns back to country *r* in the form of final goods to satisfy country *r*'s final demand. This fact clarified by equation (3) means that the concept of trade in value added is concerned with where the value added is absorbed. It measures only the amount of value added created in and exported from country *r* to satisfy the other countries' final demands.[2)]

To be precise, the first term in the second line captures value added created by country *r* to export final goods to the other countries, *s* and *t*. The second terms captures value added created by country *r* to satisfy country *s*' domestic final consumption and exports to country *t*: note here that as country *s'* production and supply of domestic ($\mathbf{f}^{ss}$) and foreign ($\mathbf{f}^{st}$) final demands use intermediate inputs imported from country *r*, they embody the value added created by country *r*, which is captured by multiplying these final demand with $\mathbf{v}^{r}\mathbf{L}^{rs}$. Finally, in a similar way, the third term captures value added created by country *r* to meet country *t*'s domestic and foreign final demand. Succinctly, it can be reduced to the stacked matrix formulae after the last equality sign in equation (3), where $\mathbf{f}^{-r}$ indicates the (nc×1) vector of final demand of all countries except for country *r*.

1.2 Imports of Value Added

Imports of value added measures the value added that country *r* imports from the other all countries to meet its own final demands: $\mathbf{f}^{\cdot r} = \mathbf{f}^{rr} + \mathbf{f}^{sr} + \mathbf{r}^{tr}$. In another words, it measures the amount of value added imported to satisfy domestic consumption of final goods in country *r*. In the same framework for input-output analysis suggested in Equation (2), imports of value added can be measured by setting country *r*'s vector of value added coefficients to zero, i.e. $\mathbf{v}^{r} = 0$, and excluding final demand of all other countries, i.e. $\mathbf{f}^{\cdot s} = \mathbf{f}^{\cdot t} = 0$.

$$\begin{aligned} \mathbf{t}^{r}_{\mathrm{TinVA,IX}} &= [0\ \mathbf{v}^{s}\ \mathbf{v}^{t}] \begin{bmatrix} \mathbf{L}^{rr} & \mathbf{L}^{rs} & \mathbf{L}^{rt} \\ \mathbf{L}^{sr} & \mathbf{L}^{ss} & \mathbf{L}^{st} \\ \mathbf{L}^{tr} & \mathbf{L}^{ts} & \mathbf{L}^{tt} \end{bmatrix} \begin{bmatrix} \mathbf{f}^{rr} + 0 + 0 \\ \mathbf{f}^{sr} + 0 + 0 \\ \mathbf{f}^{tr} + 0 + 0 \end{bmatrix} \\ &= (\mathbf{v}^{s}\mathbf{L}^{sr} + \mathbf{v}^{t}\mathbf{L}^{tr})\mathbf{f}^{rr} + (\mathbf{v}^{s}\mathbf{L}^{ss} + \mathbf{v}^{t}\mathbf{L}^{ts}))\mathbf{f}^{sr} \\ &\quad + (\mathbf{v}^{s}\mathbf{L}^{st} + \mathbf{v}^{t}\mathbf{L}^{tt})\mathbf{f}^{tr} = \mathbf{v}^{-r}\mathbf{L}\mathbf{f}^{r} \end{aligned} \quad (4)$$

It is useful to understand the implication of the second line of the above equation, which is derived by expanding

2) In contrast to the concept of trade in value added, the notion of value added in trade discussed in the next section is concerned with where the value added is created.

the first equation and reorganizing terms. The first term in the second line accounts for the value added created in countries *s* and *t* and imported to country *r* to satisfy its final demand. The second term, on the other hand, accounts for value added that is created by these two other countries, and embodied in country *r*'s imports of final demand from country *s*. Note again that country *s*'s exports of final goods to country *r* embody value added created in country *t* as well as value added created domestically in country *s*. Because country *s's* imports intermediate inputs from country *t* to produce its exports to country *r*, those effects are captured by the term $(v^s L^{ss} + v^t L^{ts})$. The third term is interpreted in a similar fashion as it accounts for value added created in countries *s* and *t*, and then imported into country *r* via imports of final demand from country *t*.

Given the formula for export and import of value added, we can define country *r*'s net trade in value added as the difference between the value added exports to and imports from countries *s* and *t*. That is:

$$t^r_{TinVA,net} = t^r_{TinVA,X} - t^r_{TinVA,IM} \quad (5)$$

2. Measuring the Value Added in Trade

The concept of value added in trade is different from that of the trade in value added, even though they are related to each other. Whereas trade in value added simply measures the flows of value added and is not concerned with the location in which it is absorbed, the notion of trade in value added is to decompose value added contained or, in another term, the source of value added, which is often referred to in the related literature as the factor content of trade (e.g. Trefler and Zhu, 2009).

In measuring value added by sources, it is important to incorporate flows of intermediate goods in two senses. First, intermediate inputs themselves embody value added, representing part of value added, the sources of which are observable directly. Second, value added created in a country could flow back and forth to home (the source country) via a third country. It seems that the structure of the modern flow of value added among trade partners has become more complicated when the fact that the imported intermediate inputs could contain value added created in that importing country

is taken into account. By way of example, Country 1 could export intermediate goods to Country 2. Country 2 could use them to produce final goods or for further processing, and then export them back to Country 1; alternatively, Country 2 could use them to produce other intermediate goods and export the processed intermediate goods to Country 3, and then Country 3 could use them to produce final goods that would be exported back to Country 1. All these simple cases show that the measurement of value added created in Country 1 should take into account the flows of value added via third (or fourth, fifth, and so forth) countries.

Building on Koopman et al. (2010), we can formally separate domestic and foreign contents of trade at the industrial level for each country. We can again utilize the three country case without loss of generality. Let's first define gross exports as follows:

$$\mathbf{E}=\begin{bmatrix}\mathbf{E}^{r} & 0 & 0\\ 0 & \mathbf{E}^{s} & 0\\ 0 & 0 & \mathbf{E}^{t}\end{bmatrix} \tag{6}$$

Where $\mathbf{E}^{i}$ denotes the $(n\times n)$ diagonal matrix, with the diagonal element being country *i*'s gross exports by industry to the other countries. Note that the gross exports are the sum of both final and intermediate goods by industry. Also, we define the matrix of value added coefficients, which is required to calculate value added shares out of the gross exports, as follows:

$$\mathbf{V}=\begin{bmatrix}\mathbf{V}^{r} & 0 & 0\\ 0 & \mathbf{V}^{s} & 0\\ 0 & 0 & \mathbf{V}^{t}\end{bmatrix} \tag{7}$$

$$\mathbf{VAS}=\begin{bmatrix}\mathbf{V}^{r} & 0 & 0\\ 0 & \mathbf{V}^{s} & 0\\ 0 & 0 & \mathbf{V}^{t}\end{bmatrix}\begin{bmatrix}\mathbf{L}^{rr} & \mathbf{L}^{rs} & \mathbf{L}^{rt}\\ \mathbf{L}^{sr} & \mathbf{L}^{ss} & \mathbf{L}^{st}\\ \mathbf{L}^{tr} & \mathbf{L}^{ts} & \mathbf{L}^{tt}\end{bmatrix}$$

$$=\begin{bmatrix}\mathbf{V}^{r}\mathbf{L}^{rr} & \mathbf{V}^{r}\mathbf{L}^{rs} & \mathbf{V}^{r}\mathbf{L}^{rt}\\ \mathbf{V}^{s}\mathbf{L}^{sr} & \mathbf{V}^{s}\mathbf{L}^{ss} & \mathbf{V}^{s}\mathbf{L}^{st}\\ \mathbf{V}^{t}\mathbf{L}^{tr} & \mathbf{V}^{t}\mathbf{L}^{ts} & \mathbf{V}^{t}\mathbf{L}^{tt}\end{bmatrix} \tag{8}$$

Where $\mathbf{v}^{i}$ is country *i*'s $(1\times n)$ vector of value added coefficients by industry, and, as in above, $\mathbf{L}$ the Leontief inverse matrix. Equation (8) which is the multiplication of value added coefficients and the Leontief inverse matrix represents the shares of value added by country and industry. In particular, the diagonal $(n\times n)$ sub-matrices represent the share of domestic value added for the corresponding country. On the other hand, the off-diagonal sub-matrices measure the share of foreign value added contributed by coun-

try and industry; to be precise, each column of $(1\times n)$ $\mathbf{V^iL^{ij}}$ measures the share of value added created in country *i,* but embodied in country *j*'s product. This is so because, by definition, the value added coefficient of an industry in a country is equal to one minus sum of the intermediate input shares from all countries including domestically produced inputs. Technically, as for Equation (8), the sum along each column is equal to unity.

Having defined the matrix of share of value added, we can calculate value added by source in gross exports for each industry by multiplying it with the matrix of gross exports, as in Equation (6).

$$\mathbf{t_{VAinT} = VAS \cdot E} \qquad (9)$$

$$= \begin{bmatrix} \mathbf{V^rL^{rr}} & \mathbf{V^rL^{rs}} & \mathbf{V^rL^{rt}} \\ \mathbf{V^sL^{sr}} & \mathbf{V^sL^{ss}} & \mathbf{V^sL^{st}} \\ \mathbf{V^tL^{tr}} & \mathbf{V^tL^{ts}} & \mathbf{V^tL^{tt}} \end{bmatrix} \begin{bmatrix} \mathbf{E^r} & 0 & 0 \\ 0 & \mathbf{E^s} & 0 \\ 0 & 0 & \mathbf{E^t} \end{bmatrix}$$

$$= \begin{bmatrix} \mathbf{V^rL^{rr}E^r} & \mathbf{V^rL^{rs}E^s} & \mathbf{V^rL^{rt}E^t} \\ \mathbf{V^sL^{sr}E^r} & \mathbf{V^sL^{ss}E^s} & \mathbf{V^sL^{st}E^t} \\ \mathbf{V^tL^{tr}E^r} & \mathbf{V^tL^{ts}E^s} & \mathbf{V^tL^{tt}E^t} \end{bmatrix}$$

Equation (9) provides the disaggregated value added by source of a country's gross exports for each industry. Following the implication of the share of value added in Equation (8), the diagonal sub-matrices measure domestic content of value added in the gross exports for each country, which is further divided into industries; the off-diagonal sub-matrices capture foreign value added embodied in the gross exports. For example, $\mathbf{V^rL^{rr}E^r}$ is the $(1\times n)$ row vector of value addeddomestically created in country *r*, the *k*-th element of which represents domestic value added attributable to its *k*-th industry. In contrast, $\mathbf{V^sL^{sr}E^r}$ is the $(1\times n)$ row vector of value added created in country *s*, but embodied in country *r*'s gross exports, with its *k*-th element being foreign value added contributing to country *r*'s *k*-th industry.

In general, therefore, the sum of off-diagonal elements along a column should capture the foreign value added (foreign contents or foreign source) embodied in the gross exports of the corresponding country and industry. It is important to note that formula (9) could effectively and properly attribute foreign and domestic contents of value added when intermediate products go back and forth in a complicated pattern via other countries, which could not be captured when we consider the direct flows of intermediate products between the involved countries (Koopman et al., 2010; Johnson and Noguera, 2010).

Ⅲ. Data: the World Input-Output Database (WIOD)

The analysis of the flows of value added and their contents by source in the world economic context requires vast information on trade flows in addition to the structure of world production represented by international input-output tables. In particular, the latter information should be crucial, since it could provide the foundation on which multi-national production chains are considered. In the modern world economy, a vast number of products are processed in various production locations across a variety of countries; in many cases, intermediates are exported to other countries to be processed there and then returned back to the country of origin in the form of final goods or more processed intermediates. Furthermore, a production stage occurring in a country for a good is likely to create effects in other countries, since economic interactions between the two countries may be needed to complete the given productive task.

All these interactive productive processes and back and forth of intermediate and/or final goods among countries implies that a two-country analysis may not be appropriate even for an analysis of bilateral trade. This is so because such an approach does not account for the flows of value added through third countries. Take the hypothetical example in which Country 1 exports intermediate goods to Country 2, which tosses it to another country, Country 3, for further processing, and, ultimately, Country 3 sends it back to Country 1. An analysis of bilateral trade between Countries 1 and 2 could not capture the true flows of value added between them because it should miss the value added by Country 2 and transferred to Country 1 through Country 3. It is only when the Country 3 is incorporated in the analysis explicitly that an accurate picture can emerge. This simple case exemplifies the necessity to include, as much as possible, all the countries that are inter-related.

The present thesis carries out an empirical analysis of the so-called global value chains with a focus on the Chinese economy. Considering the concerns laid out above, it would not be complete without a consideration of the extent and manner of connectedness among all countries and industries, which requires data on outputs and flows among coun-

try-industry as well as inputs by country-industry and their domestic and foreign uses. Although the related concerns and the analytical models are relatively simple in theory, it would be prove quite problematic to actually construct a dataset sufficiently vast to completely account for world trade flows disaggregated at industrial level for each country, in addition to global input-output tables that track global sources of input for each country-industry.

Although there has been some effort to construct international input-output databases, the outcomes have proven unsatisfactory in terms of coverage and detail. For an example, based on the well-known GTAP database, the global Inter-Country Input-Output (ICIO) tables were introduced (Koopman et al., 2010). While these tables provide information on bilateral trade flows in a consistent manner on a global scale, they are limited in that the GTAP database does not distinguish imported final goods from intermediate goods. Without the separation of imports in terms of end-use, it is impossible to establish the network of value chains and hence the flows of value added across borders. This implies that additional procedures should be required to establish a dataset for the international source and use of intermediate goods. However, this procedure cannot help but to rely on an assumption on how total imports are composed between final and intermediate goods, thereby reducing the ability to precisely assess the reality.

The Asian International Input Output Tables (AIOT) are another example of the efforts to meet the demand for establishing such a database (for details, see Hiroshi et al., 2013). It covers 76 industrial sectors in each of 9 Asian countries and the US. However, given that the coverage of AIOT is limited to 9 Asian countries and the US, it excludes other regions whose role in the larger world economy remains unknown. When we consider the fact that these Asian economies have participated actively in the global economy through trades with western nations and other regions, and are taking a leading role in the global production network, this limitation could be considered critical. This is so even if the focus would be on trade flows and value chains 'within' Asian regions, because, as mentioned above, it would not capture the feedback effects via third party countries. Furthermore, the AIOT are compiled and published only once every

5 years, rendering them lightly outdated. For example, the 2005 table, the most recent AIOT, was published in 2012, a full 7 years after the targeted period.

The present study utilizes the World Input-Output Database (WIOD, 2012), which was compiled by 11 research institutions under the direction of the Groningen Growth and Development Centre at the University of Groningen, Netherland, with financial support from European Commission, and which recently became publicly available (See Timmer et al., 2012 for details). This database mainly consists of international input out tables for countries: first, in addition to national supply and use of domestic products, it provides separate data on imported inputs from all included partner countries and industries; second, it records details of final demand by foreign countries as well as domestic demand. Combining the international supply and use of intermediate goods with international demand for final goods, one could consider the feedbacks via third country trade partners and work out a comprehensive map of global value chains as well as flows of value added from a truly global perspective. (A schematic outline of the WIOT is presented in [Figure 2] in Timmer (2012))

The data for WIOD have been collected and compiled annually starting in 1995 up to 2009 for 35 industries (ISIC Revision 3), including agriculture, manufacturing and service sectors. They cover 40 countries (27 EU countries, Turkey, Canada, USA, Mexico, Japan, Korea, Taiwan, Australia, Brazil, Russia, India, Indonesia and China), which account for about 85% of world GDP: the rest (15% of world GDP) as a whole is also recorded under the item of Rest of World with the same 35 disaggregated industries. The database can be used even more effectively by combining it with Socio-Economic Accounts (SEAs) data, which are the addenda providing detailed information on the number of employment per 1 million US dollars, labor compensation for different levels of skill, and even capital stock by country and industry.

Ⅳ. Results and Discussion

1. China's International Trade

Using WIOD, this section empirically investigates China's trade in value added,

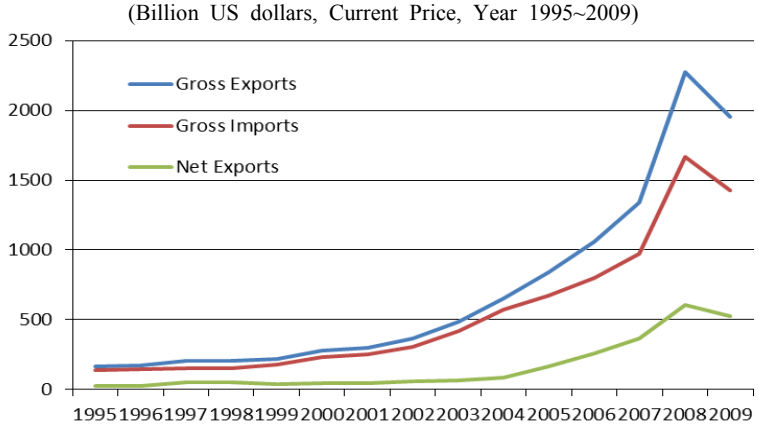
which is not captured by gross exports and imports. [Figure 1] shows the volume of China's international trade in gross term. As shown, China's international trade in gross terms has constantly increased over the last 15 years. In particular, it is after 2002 that China's trade begins a rapid increase. This may most probably be explained by the fact that China became a member of WTO in the late 2001. Net exports have also increased in the same pattern, implying that exports have increased even faster than imports.

2. Gross Trade and Trade in Value Added

As alluded to in the previous section, trade statistics measured in gross terms might present a misleading the reality. They include the values created in the exporting country as well as those that have been imported through intermediate goods: the latter may represent very little what the economy under consideration really does. Therefore, to measure only the values created domestically and those imported should provide the useful information required to understand the reality of foreign trade of a country.

As argued by other studies (Stehrer, 2012; Hummels et al., 2001; Daudin et al., 2011; Johnson and Noguera, 2012), there are substantial differences between the two measures. [Figure 2] shows the trend of the difference between gross and value added trades in China. It observes

(Billion US dollars, Current Price, Year 1995~2009)



[Figure 1] China's Gross Exports and Imports

that, for both exports and imports, trade statistics in gross terms have always been larger than the trade in value added. Furthermore, the differences have been even extensive as China's international trade expands, and as both exports and imports move in a similar pattern in both trend and magnitude.

The gap between gross trade and trade in value added could be considered to be a good indicator that shows the characteristics of China's international trade. Second, when measuring the proportion that trade in value contributes to gross trade, we can identify different patterns between exports and imports. First of all, [Figure 3] shows that the ratio of value added exports to gross exports has been far greater than that for imports. The share of values created in China and exported was more than 80% in the late 1990s, and about 70% since the mid-2000s. On the other hand, the share of value added created in the other countries and imported accounts for slightly more than 20% during the late 1990s, and reached its highest level of 45% in 2008. This implies more remarkably that there is a tendency for the two figures to converge. The ratio for exports has been constantly decreasing, while the ratio for imports has been steadily increasing over the same period. Put another way, the former was higher than the latter by about 60% point in the mid-1990s, with the gap decreasing to 32% point in 2009. These significantly different patterns could indicate that the Chinese economy has engaged in processing trade. As well known, China imports parts as intermediate inputs, assembles them to produce final goods or process for more sophisticated intermediates and then exports them. Logically, as the share of processed final goods increases, the share of value added exports declines; as the intermediates to produce final goods to be exported increase, the share of value added imports should increase. The expanding gap between gross and value added trade in [Figure 2] could also reflect these characteristics.

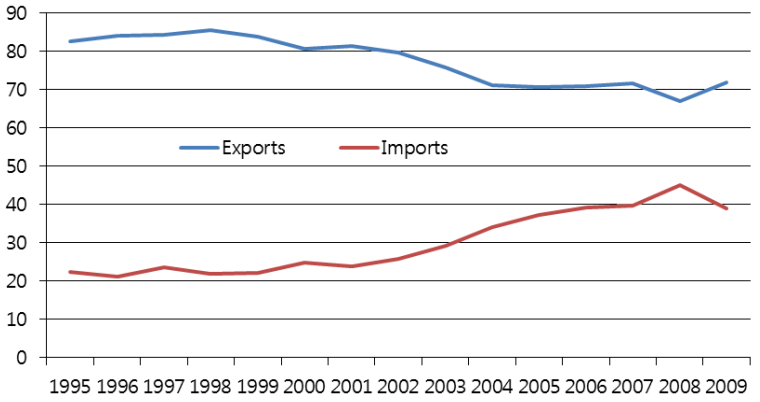
Finally, but not least importantly, as implied by the two almost overlapping curves in [Figure 2], the gap of the two net exports is not that substantial. This is contrary to the considerable difference between gross trade and value added trade statistics for exports and imports, and a sharp contrast to the conventional wisdom supported by studies using international input output tables that argues that Chi-

nese net exports in gross terms has been overestimated.

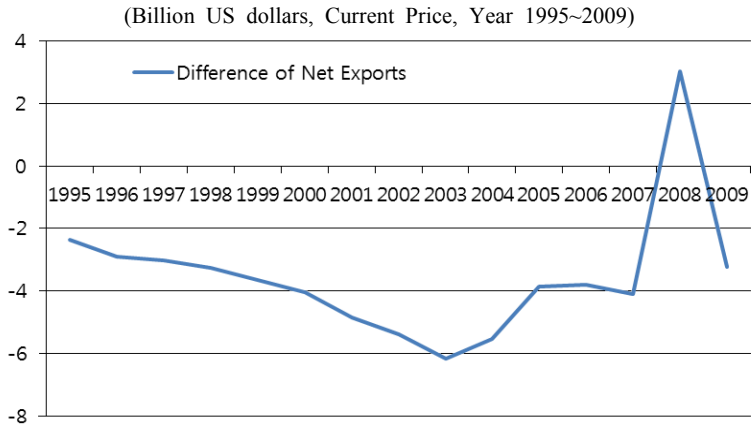
Finally, but not least importantly, as implied by the two almost overlapping curves in [Figure 2], the gap of the two net exports is not that substantial. This is contrary to the considerable difference between gross trade and value added trade statistics for exports and imports, and a sharp contrast to the conventional wisdom supported by studies using international input output tables that argues that Chinese net exports in gross terms has been overestimated.

[Figure 4] demonstrates that, though marginal relative to the size of net ex-

[Figure 2] Differences of Trade Statistics: Gross vs. Value Added



[Figure 3] Share of Trade in Value Added out of Gross Trade (%), Year 1995~2009



[Figure 4] Difference of Net Exports: Gross vs. Value Added

ports,[3] net export in value added terms has been even greater than gross net exports, with the difference ranging from about 6.1 billion US dollars to 2.3 billion US dollars with the exception of the year 2008 when world financial and economic turbulence occurred. The surprising results in terms of net exports would reflect the coincidence of the two gap curves. Consider the relationship behind [Figure 4],

$$NE_G - NE_V = (E_G - IM_G) - (E_V - IM_V)$$
$$= (E_G - E_V) - (IM_G - IM_V) < 0,$$

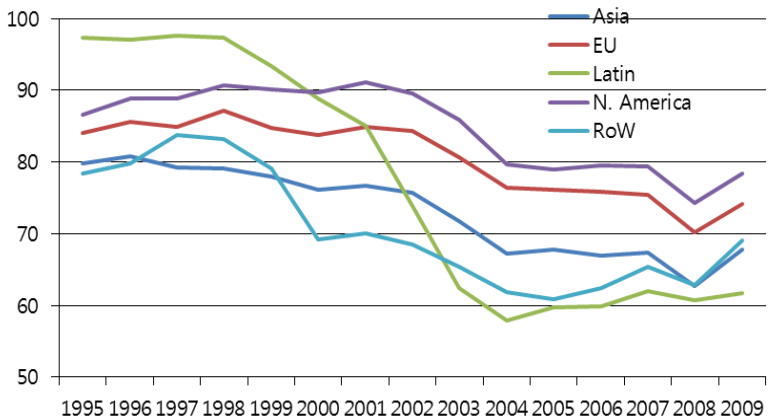
where NE denotes net exports, E, IM are exports and imports, respectively, and the subscripts G and V indicate gross and value added, respectively. The last two terms are represented in [Figure 2], respectively. Recalling the patterns represented in [Figure 3], we could suggest that the increase in import of value added (IM_V) has been more rapid than the increase in export of value added (E_V).

Moving on to trade patterns by region, we observe both similarities and asymmetries among regions. [Figures 5] through 9 show China's trade with various regions, identifying the asymmetries. First, it is shown that the share accounted for by trade in value added (measured by the ratio of trade in value added to gross trade) has been steadily decreasing for

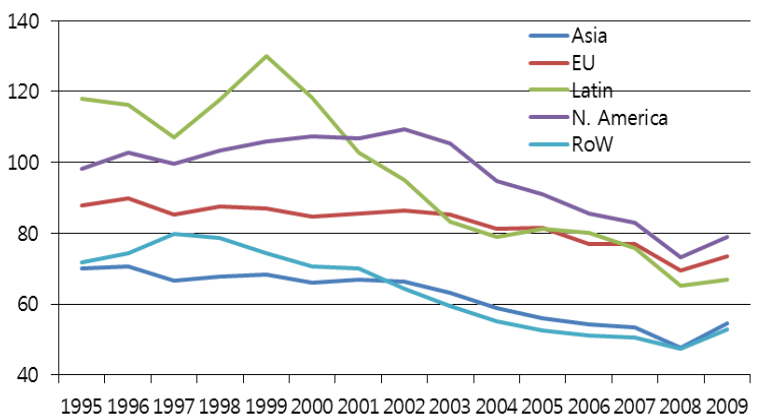
3) In 2003 when the net export in terms of value added exceeded gross net export by the highest level of 6.1 billion dollars, it was 69.1 and 63.0 billion dollars, respectively: and in 1995 when the difference recorded the lowest level of 2.3 billion dollars, it was 28.2 and 25.8 billion dollars, respectively.

both exports and imports. This pattern seems to strengthen after 2001, as shown in [Figure 5] and [Figure 6].

However, in absolute numbers, the share of imports are on average higher than those for exports to all regions, implying that the value added that China creates and exports is smaller in proportional terms against gross trade than value added created in other countries and imported. For example, in trade with North America (Canada and USA), China's export of value added had accounted for about 90% out of gross exports up to



[Figure 5] China's Trade in Value Added by Region: Exports (% out of Gross Exports)



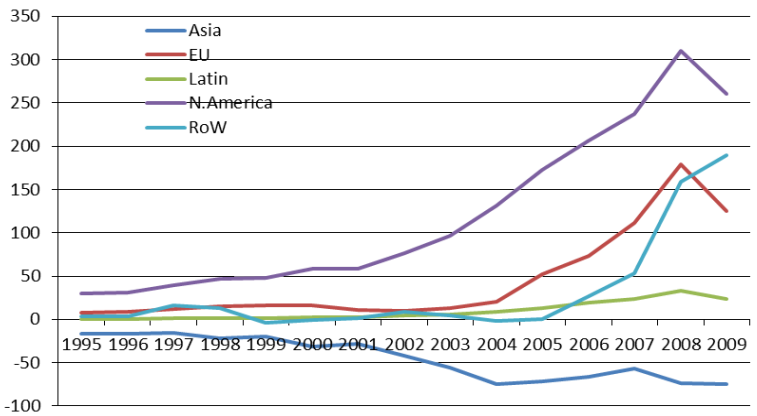
[Figure 6] China's Trade in Value Added by Region: Imports (% out of Gross Imports)

2002 and then started declining to about 79% in 2009, while the share of China's imports of value added had even exceeded 100% until 2003 and constantly fell to reach about 80% of gross imports in 2009.

Second, empirical results reveal that China's bilateral trade balances with various regions in gross terms have been either overestimated or underestimated (Asia and the rest of world).

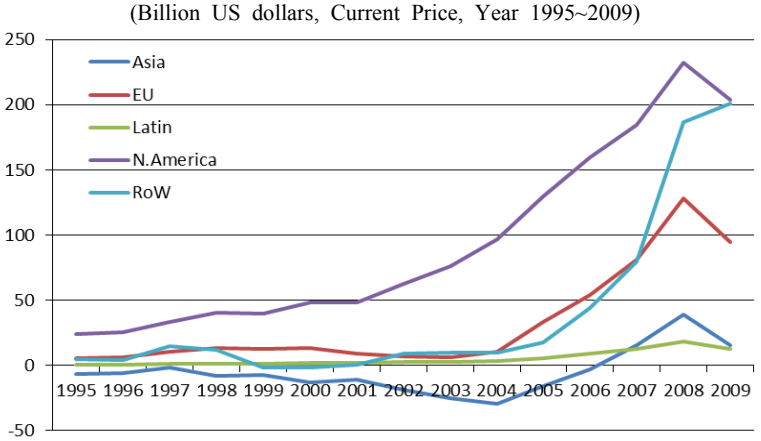
[Figure 7] through [Figure 9] and <Ta-

(Billion US dollars, Current Price, Year 1995~2009)

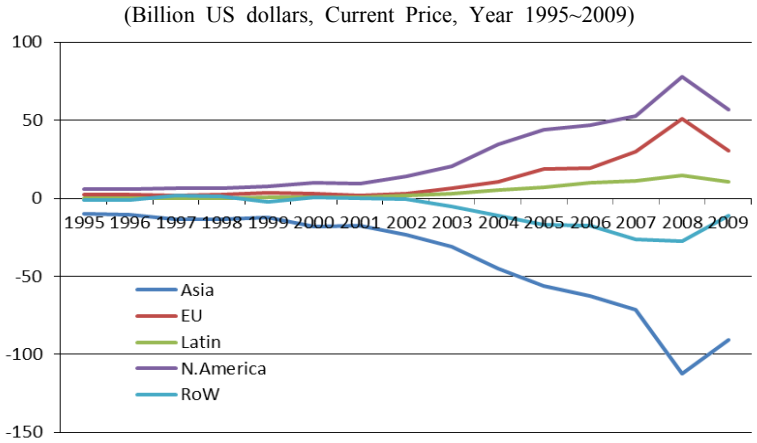


[Figure 7] China's Gross Net Export by Region

(Billion US dollars, Current Price, Year 1995~2009)



[Figure 8] China's Net Export of Value Added by Region

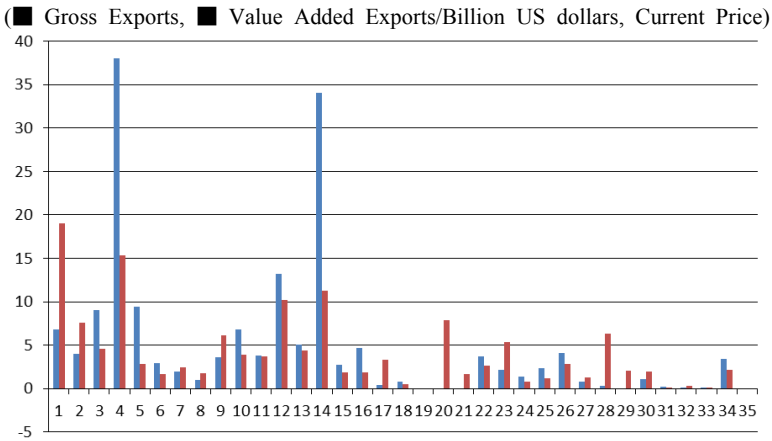


[Figure 9] China's Net Export: Difference between Gross and Value Added by Region

ble 1> clearly show China's trade balances and the differences between gross trade balances and net trade in value added for various regions. According to the Figures, China has experienced trade surplus with all regions except for Asia. As for North America, the EU, and Latin America, China's bilateral trade balances in gross terms has been inflated relative to those in trade in value added, and the magnitude of the overestimation has even continuously increased. As calculated in <Table 1>, China's gross net export in 2009, for example, is overestimated for the EU by 24.5% and by 21.8% for North America, when compared with trade in value added. In contrast, China's gross trade balance with Asia and the rest of world has been underestimated compared with the net trade in value added. In particular, China's bilateral trade with Asia has recorded deficit since 1995.

<Table 1> Difference between Gross and Value Added by Region (% out of gross net export)

Year	Asia	EU	Latin	N.America	RoW
1995	60.7	29.8	33.6	20.0	-23.2
1996	64.0	27.9	29.3	18.3	-28.7
1997	89.1	16.0	13.1	16.1	11.3
1998	62.3	13.6	15.6	14.2	8.5
1999	62.6	20.4	27.7	16.2	59.7
2000	58.5	18.3	29.9	17.5	-42.8
2001	61.4	17.7	28.9	16.3	25.7
2002	55.1	29.0	41.3	18.0	-4.9
2003	55.7	49.9	58.0	21.5	-115.8
2004	60.3	50.7	61.7	26.1	868.6
2005	78.1	35.6	55.5	25.3	-1986.7
2006	95.3	26.7	52.2	22.7	-65.2
2007	126.7	27.0	47.7	22.1	-49.3
2008	153.5	28.5	43.8	25.0	-17.4
2009	121.0	24.5	45.9	21.8	-5.9



[Figure 10] China's Gross vs. Value Added Exports by Industry (1~35), Year 1995

However, when measured by net trade in value added, it has switched from deficit to surplus since 2007 (see [Figure 8]). Finally, major part of China's trade surplus is accounted for by its trade surplus with North America, the EU, and the rest of world. In particular, it is notable that the rest of world has emerged since the mid-2000 as the one of the important sources of trade surplus for China.

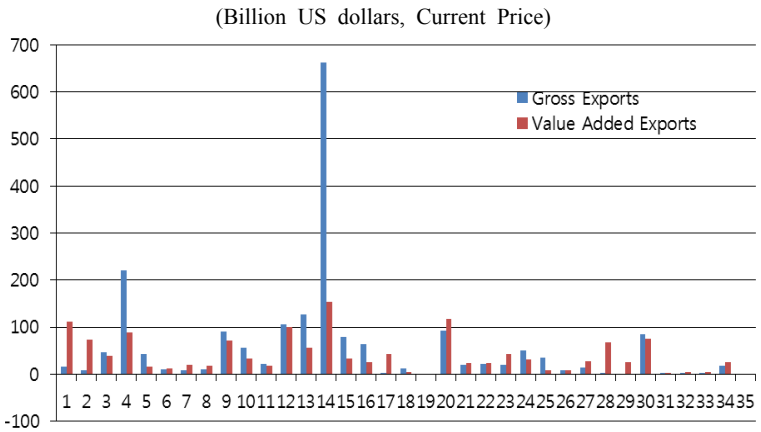
We can also look at the patterns of gross trade and trade in value added by industry (for the industrial code, see <Appendix 2>). [Figure 10] and [Figure 11] compares gross exports with value added exports by industry for 1995 and 2009 respectively (see <Appendix 2> for industry classification).[4)]

First, as shown above, China's exports have grown explosively in terms of both gross and value added, which can be identified by comparing the absolute level of exports between the two figures.

Second, the gap between gross and value added exports are mainly positive for manufacturing industries (industry code of 3 through 16), but the opposite cases are also found for some other industries which are usually affiliated with first and tertiary industries.

As for 1995, value added exports ex-

4) Here we provide data for only exports. WIOTs used in this study do provide information on the detailed intermediate imports by industry, but do not provide information on imports of final demand, which means that it is impossible to calculate total imports by industry including both intermediates and final demands. For the comparison purpose between gross and value added exports, we present exports only without imports.



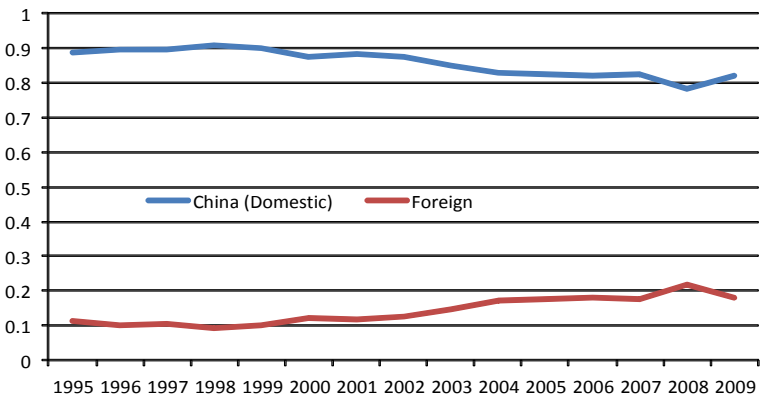
[Figure 11] China's Gross vs. Value Added Exports by Industry (1~35), Year 2009

ceeded gross exports in industry 7 through 9 among manufacturing industries; it is also the case for the first industry including agriculture, fishing, and forestry and mining and quarry, and for some tertiary industries including industry 17, 20, 21, 23, 27, 28, 29, and 30.

In 2009, a similar pattern is found, for some industries, in a stronger fashion. Industry 6 in the manufacturing industry is added as an industry in which value added exports exceed gross exports, while it is strengthened in the first industries in the sense that the ratio of value added exports to gross exports increased. In particular, two industries have experienced a dramatic change. First, whereas the textile industry (code 4) was the most important export industry in 1995 in gross exports, exporting 380 billion dollars, its relative importance declines sharply in 2009, maintaining similar proportion of value added export against gross export of about 40% as it was in 1995. Second, industry of Electrical and Optical Equipment (code 14) takes the biggest part of gross exports in 2009, showing the dramatic growth of exports during the sample period. However, the share of value added exports out of gross exports has fallen from 33% in 1995 to 23% in 2009, implying the increase in processing trade.

3. Value Added in Trade

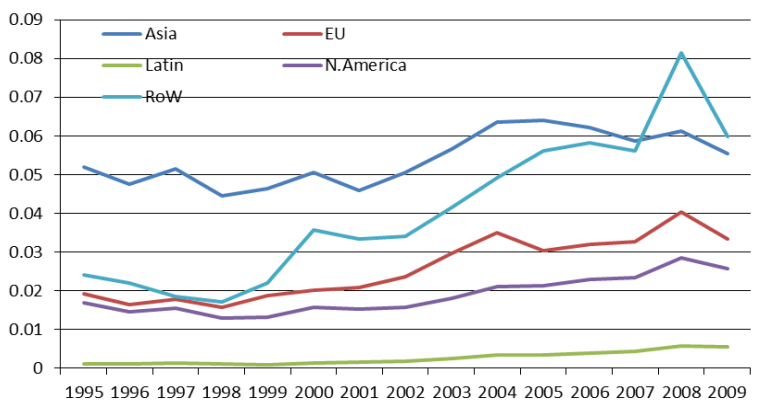
[Figure 12] shows the share of domestic and foreign value added in China's



[Figure 12] Domestic and Foreign Share(%) of Value Added in Total Exports

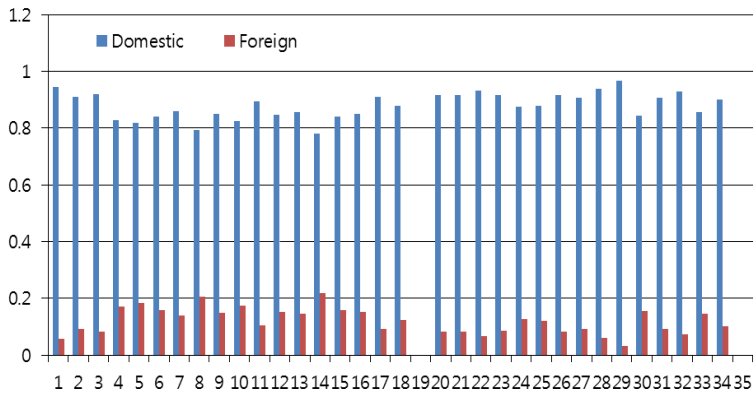
total exports. We can see from this figure that during the sample period, the share of value added created in China and exported has gradually decreased, while foreign share of value added has increased. In fact, China's domestic share of value added accounted for 88.6%, which dropped to 82% in 2009. Recalling the rapid growth of Chinese exports, this means that the value added created in foreign country and embodied in Chinese exports has grown at higher rate than the gross exports.

Moving on to regional value added contained in China's gross exports, there is a dramatic increase in the share of value added created in the rest of world, which has gradually crowd out that of

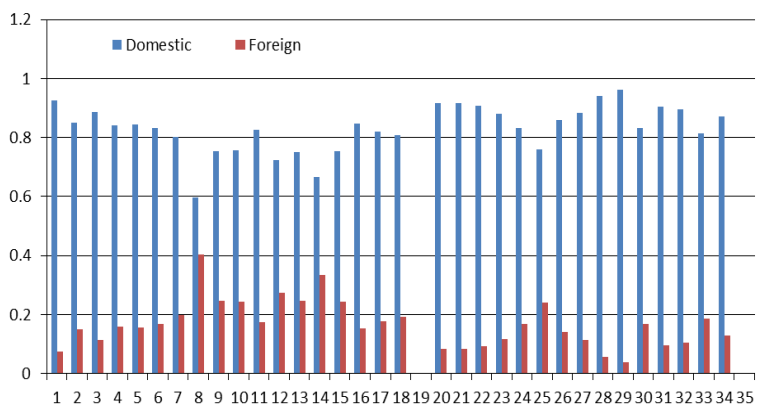


[Figure 13] Domestic and Foreign Share(%) of Value Added in Total Exports by Region

Asian countries. As shown in [Figure 13], Asian share has increased gradually until 2004 and started falling. In contrast, the share taken by the rest of world has increased relatively sharply after 1999, and eventually passed ahead of the Asian share in 2008, taking the biggest share among the five regions. This finding implies that the importance of this region dramatically increased in Chinese exports in the sense that China is now importing the biggest value added for export from this region. As for the other regions of Latin America, North America and EU, they have increased steadily their share of value added in China's exports: that is, China are more relying on imports from these regions for its exports.



[Figure 14] Domestic and Foreign Share(%) of Value Added in Total Exports by Industry (1~35)



[Figure 15] Domestic and Foreign Share(%) of Value Added in Total Exports by Industry (1~35)

Finally, [Figure 14] and [Figure 15] shows the domestic and foreign share of value added in China's total exports. First of all, reflecting the general trend on the division between domestic and foreign share of value added in China's gross exports at national level, foreign share of value added has on average increased, which is represented by taller bars for foreign share in 2009 that those in 1995. Second, the foreign share of value added in China's total exports distribute unevenly across industries. Furthermore, the disproportion of the distribution has strengthened during the sample period. Third, the relative importance of foreign value added in China's gross exports has increased mainly in manufacturing industries. For example, it is the industries of code 8 through 15 that have increased most dramatically its foreign value added in gross exports in China.

Ⅴ. Conclusion

The value of production output, or exports, in a country does not necessarily reflect the amount of value that is added by local production factors. Two concepts of measuring China's value added flows have been presented clarifying the empirical contributions in the recent literature on trade in value added and the factor content of trade.

The paper presents selected empirical findings and the main takeaways from the analysis stand out as follows:

The first major finding argues that China's international trade in gross terms has constantly increased over the last 15 years, may be explained by the fact that China became a member of WIO in late 2001. Net exports have increased by the same pattern during that timeframe, implying that exports have increased even faster than imports.

Secondly, trends display the difference between gross and value added trades in China. Both, China's exports and imports, trade statistics in gross terms have always been larger than the trade in value added. Also, the ratio of value added exports to gross exports has been far greater than that for imports. On the other hand, as the share of processed final goods increases, the share of value added exports declines; as intermediates producing final goods to be exported increases, the share of value added imports should also increase.

Third, the trade patterns by region, observe both similarities and asymmetries. Also, the empirical results reveal that China's bilateral trade balances with various regions in gross terms have been either overestimated or underestimated (Asia and the rest of world).

Fourth, the patterns by industry, the gap between gross and value added exports are mainly positive for manufacturing industries, but the opposite cases are also found for some other industries which are usually affiliated with first and tertiary industries.

Lastly, for the share of domestic and foreign value added in China's total exports, we found that during the same period, the share of value added created in China and exported from China, has gradually decreased; while foreign share of value added has increased. In other words, the value added created in a foreign country and embodied in Chinese exports has grown at a higher rate than the gross exports.

Increased possibilities for global production networks are also intimately linked to the firms, however this paper conveys little information on specific industries, hence, there is a limit to finding managerial implications. For future studies, this may raise new questions for firms in regards to 'how to produce,' 'where to locate activities' and 'whether to keep all activities within the firm or outsource parts of it.'

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<Appendix 1> Countries and Regions in WIOD

EU	Asia
Austria	Australia
Belgium	China
Bulgaria	Indonesia
Cyprus	India
Czech	Japan
Germany	Korea
Denmark	Russia
Spain	Turkey
Estonia	Taiwan
Filand	
France	Latin America
United Kingdom	Brazil
Greece	Mexico
Hungary	
Ireland	North America
Italy	Canada
Latvia	United States
Luxembourg	
Lithuania	Rest of World
Malta	
Netherlands	
Poland	
Portugal	
Romania	
Slovak	
Slovenia	
Sweden	

<Appendix 2> Industry Code

Code	NACE	Industry Name
1	AtB	Agriculture, Hunting, Forestry and Fishing
2	C	Mining and Quarrying
3	15t16	Food, Beverages and Tobacco
4	17t18	Textiles and Textile Products
5	19	Leather, Leather and Footwear
6	20	Wood and Products of Wood and Cork
7	21t22	Pulp, Paper, Paper, Printing and Publishing
8	23	Coke, Refined Petroleum and Nuclear Fuel
9	24	Chemicals and Chemical Products
10	25	Rubber and Plastics
11	26	Other Non-Metallic Mineral
12	27t28	Basic Metals and Fabricated Metal
13	29	Machinery, Nec
14	30t33	Electrical and Optical Equipment
15	34t35	Transport Equipment
16	36t37	Manufacturing, Nec; Recycling
17	E	Electricity, Gas and Water Supply
18	F	Construction
19	50	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel
20	51	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
21	52	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods
22	H	Hotels and Restaurants
23	60	Inland Transport
24	61	Water Transport
25	62	Air Transport
26	63	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
27	64	Post and Telecommunications
28	J	Financial Intermediation
29	70	Real Estate Activities
30	71t74	Renting of M&Eq and Other Business Activities
31	L	Public Admin and Defence; Compulsory Social Security
32	M	Education
33	N	Health and Social Work
34	O	Other Community, Social and Personal Services
35	P	Private Households with Employed Persons