The Value-Added in Trilateral Trade among Mainland China, Taiwan and the United States: A Global Value Chain Approach

Hsing-Chun-Lin[*], Ruey-Wan Liou[**], Ching-Cheng Chang[***]
and Shih-Hsun Hsu[****]

Abstract

The issue of trade imbalance between Taiwan, the U.S. and China, which are concerned by all walks of life today, is based on the results of traditional trade statistics. However, the traditional trade statistics method is "gross" statistics, which is different from the "net amount" of GDP statistics. As a result, the increase in the amount of foreign trade in a country does not necessarily mean that GDP has risen, causing an overestimation of the contribution of exports to GDP, and distorting a country's presentation of external competitiveness. This paper will clarify the true situation of the trade between Taiwan, the United States, and China from the perspective of the value added trade and trade in value-added. Although the results obtained by the two methods of estimation are different, the results of both countries tend to be consistent when one country agglomerates all its trade counterparties and industrial sectors. Just as in the taxation theory, the economic end-result (metaphor for trade in value-added) and the legal end-result (for example, value added in trade) are summed together and equal to the total tax.

The value-added of Taiwan's additional value is far less than the current total amount of statistical exports, among which the value of Taiwan's value added to U.S. exports as a percentage of Taiwan's GDP shows a declining trend and represents a decline in Taiwan's economic dependence on the United States. On the other hand, the value of Taiwan's value added to China as a percentage of Taiwan's GDP is on the rise, reflecting the increasing dependence of Taiwan's economy on China. However, Taiwan's value added to the United States is slightly higher than that of traditional trade statistics. Taiwan has surpassed the United States. Taiwan's value added to China is far lower than traditional Taiwan's surpassing China. There are different trends. It is mainly Taiwan's exports to China, many of which are

[*] Professor, Department of Applied Economics, National Chiayi University, Taiwan.

[**] Director in Department of Statistics Office, Ministry of Transportation and Communications, R.O.C.

[***] Research fellow, Institute of Economics, Academia Sinica, and Professor, Department of Agricultural Economics, National Taiwan University, Taiwan.

[****]Professor, Department of Agricultural Economics, National Taiwan University, Taiwan and Corresponding author. Phone: +886 (2) 33662665; Email: m577@ntu.edu.tw.

assembled and processed and then exported to the United States. Finally, the United States "adsorbs" the value added created by Taiwan. As a result, Taiwan's value added to the United States exceeds that of traditional statistics, which is an value added outperformed the traditional low.

The results indicate that Taiwan's exports are mainly for foreign OEMs, and key original components rely on imports, resulting in a higher share of foreign acquisitions. A closer look at the source of the domestic value-added of Taiwan's exports is mainly due to the export of intermediate goods, and the proportion is increasing. On the contrary, the proportion of the final goods exports has gradually declined. Among them, the export to the United States was mainly from the final goods exports before 2004, and it was transformed to mainly intermediate goods exports after 2005. As for Taiwan's exports to China, the proportion of exports from intermediate goods has been higher in the past 15 years. This shows that Taiwan's industry is participating in global value chain activities and moving to the upper and middle streams. Comparison of Taiwan to the United States and Taiwan to China's VAX and DVA, Taiwan's actual value added earned from the United States is greater than the apparent the United States paid. This is because the United States has absorbed the US's bilateral trade exchanges from Taiwan and the United States. Also, VAX is larger than DVA because the value added created by Taiwan is invisible in other countries' exports to the United States, and the United States also indirectly absorbs the value added created by Taiwan through other countries. Secondly, the value added that Taiwan earns from China is less than China has apparently paid to for Taiwan. The main reason is that part of the value added that China has paid to Taiwan is passed on to other countries, and the United States is the main absorbing country. This shows that China is an important processing and transfer station for Taiwan's exports to the United States.

Keywords: Value Added in Trade, Trade in Value Added, Intra-country Input-Output table.

JEL code: E01，E16，F1，F14，F23，L14

The Value-Added in Trilateral Trade among Mainland China, Taiwan and the United States: A Global Value Chain Approach

1 Introduction

Taiwan's economy guide to foreign trade. China's main counterparty has always been the closest relationship between the United States and Taiwan. The United States is also traditionally Taiwan's most important export market, and Taiwan's dependence on the United States' exports (the ratio of Taiwan's exports to the United States to Taiwan's total exports). From the 1970s, it continued to rise, reaching the highest 48.8％ in 1984, but gradually declined in more than ten years. However, it remained the highest in the world. Until December 2001 and January 2002, when the two sides of the Taiwan Strait joined the WTO, the situation gradually improved. China has surpassed the United States since 2004 to become Taiwan's largest export region.

Taiwan's largest export market replace by the China. The most important reason was that after the mid-1990s, many high-tech industries reduced production costs and laid out market opportunities for China's accession to the WTO. They began large-scale investment in China and gradually established production between the factories across the Taiwan Strait. The supply chain, from Taiwan production of components and semi-finished products, and then exported to China Taiwanese factory assembly or processing into the final product and then exported to the rest of the world, thus forming a vertical division of labor between the two sides of the industry. The production and sales model of "Taiwan Receipts and Overseas Production" continues to this day. This can be seen in the continuous increase in the proportion of overseas production in Taiwan's export order statistics, reaching 54.2％ in 2016.

Although the United States has now retreated to Taiwan's second-largest export market, Taiwan's export dependence on the United States still exceeded 12.0％ in 2016, reaching 12.1 ％. As for China's dependence on the U.S. market, it was 18.0％ in 2015. The U.S. is China's largest export market and export source country. In 2016, it exceeded US$ 347 billion in U.S. dollars. China is also In the United States, the largest importing country and source of foreign investment, in 2016, theChina's exports accounted for 21.1％ of the US import market.

The standards mentioned above concerning the degree of dependence on exports by Taiwan or China to the United States, or the trade-out (excess) and current account surpluses adopted by the United States are in fact based on the results of traditional trade statistics. However, there is a well-known flaw in traditional trade statistics (Feenstra, 1998), which is

the statistical method of "gross" statistics, which is different from the "net amount" of GDP, so that the amount of foreign trade of a country increases, but it does not necessarily mean GDP. Rising, reluctantly combining the two (such as exports as a share of GDP) will lead to an overestimation of the contribution of exports to GDP.

Traditional trade statistics distorting the presentation of a country's external competitiveness has aggravated by the rise of global value chains (GVCs) in recent years (see Backer and Miroudot, 2012; Gereffi and Fernandez-Stark, 2011). The reason for this is mainly the fact that current trade statistics regulate the entry of goods into the country's borders, regardless of the number of exits and exits, and are counted separately in the export and import statistics. However, over the past 30 years, "globalization" has been surging. With the leap in information technology, the cost of transportation and communication has dropped drastically. Driven by comparative advantages, more and more manufacturers have cut the original value chain into several parts, such as design and production. Assembling, marketing, etc., and distributing them in different countries, the fragmentation (fragmentation of production) or outsourcing of derivative products is extremely common. Since countries are all focused on one task rather than all processes, the intermediate materials needed are imported from foreign countries and then exported to countries that specialize in downstream processes. Under the current statistical method, the amount of imported intermediate products is implied in the total export volume, resulting in higher export statistics. One of the most typical cases is the Apple iPod (Dedrick *et al*., 2010). The study pointed out that the ex-factory price of an iPod in China is US$144. The major components are mainly from Japan, followed by the United States and South Korea, and the China as the final assembly base. The value of this product is fully reflecting in exports, mainly in the United States. Under the pattern of the foreign trade market, therefore, it enjoys a very high outreach to the United States. In fact, the proportion of the additional value acquired by China does not reach 10%.

To correct the defects of traditional foreign trade statistical methods, the OECD and the WTO launched the Measuring Trade in Valued Added on March 15, 2012. The European Union (EU), the IMF, the World Bank, and the United Nations Trade Organization (UNCTAD) have also value added-added trade studies. In 2014, the host country of the APEC meeting in China proposed to promote the study of global value chains and was unanimously endorsed by all member states. Due to the consistency of this issue among international agencies, it is foreseeable that the value-added trade data will become the mainstream of international statistics in the future.

The subject of this article is set to discuss the value-added trade between Taiwan and the United States. However, considering the influence of China on the economic and trade

development in Taiwan and the United States, plus the fact that Taiwanese manufacturers use China as a processing base to export the final product to the United States. It is very common that if China excluded, it will inevitably detract from the integrity of the content of the analysis. Therefore, the study will expand to Taiwan, the United States, and the Middle East.

Second, if this article only focuses on trade in value added, it is sufficient to quote the value-added trade statistics database published on the website by the joint OECD-WTO joint plan, as it includes Taiwan, the United States, and China. The data on the value-added trade of the 62 countries and 34 industries in the country base on data for 1995, 2000, 2005, 2008, and 2011, which is quite complete. However, the value added of the global value chain is not only a measure of trade in value-added alone, but also value-added in trade. It also has a very rich application reference value. Therefore, this paper will explain in detail the meaning and relevance of trade in valued added and value−added in trade, and compare the results of the two estimates. Also, this article will also summarize the indicators used in the literature to measure countries' participation in the global value chain. Examples include vertical specialization and domestic or foreign contents of exports.

2. The Structure of the Inter-country Input-output Table and Global Leontief Inverse Matrix

When we estimate the value added of exports at all stages of the global value chain, regardless of the approach used, requires the use of inter-country input-output table (ICIO). Previous studies such like IDE-JETRO (2006) in Japan External Trade Organization, GTAP table in Purdue University, OECD (2012) and Timmer *et al.*, (2015) all applied the ICIO and calculated the Leontief inverse matrix. In this section, we introduce the structure of the inter-country input-output table and global Leontief inverse matrix. We simplify three countries and two products in the inter-country input-output table (see Table 1).

Table 1 is the extension of the single country Input-output table, the same character of these two tables is the total outputs (horizontal summation) is equal to the total inputs (vertical summation). The differences between them include two parts: the first one is that the total outputs can categorize into intermediate and final demand in ICIO and the total outputs of traditional IO table are all listed as exports. The second one is the intermediate input in ICIO also categorized according to different countries, and traditional IO not classify. Accordingly, we define z_{21}^{ss} is the first commodity x_1^s which produced by country s and applied the second product in s country; z_{21}^{rs} is the first commodity x_1^s which produced by country s and applied the second product in r country; va_1^{ss} is the value added that country s produce the first

product; y_1^{ss} is the final demand of the country for the first product produced by country s; y_1^{rs} is the final demand of the country for the first product produced by country r.

If we extend above example to G countries with N commodities then we can estimate the Eq. (1):

Table 1：The Structure of Inter-Country Input-Output Table

country		Intermediate input						Final demand			Total output
		s		r		t		S	r	t	
		1	2	1	2	1	2				
s	1	z_{11}^{ss}	z_{12}^{ss}	z_{11}^{sr}	z_{12}^{sr}	z_{11}^{st}	z_{12}^{st}	y_1^{ss}	y_1^{sr}	y_1^{st}	x_1^s
	2	z_{21}^{ss}	z_{22}^{ss}	z_{21}^{sr}	z_{22}^{sr}	z_{21}^{st}	z_{22}^{st}	y_2^{ss}	y_2^{sr}	y_2^{st}	x_2^s
r	1	z_{11}^{rs}	z_{12}^{rs}	z_{11}^{rr}	z_{12}^{rr}	z_{11}^{rt}	z_{12}^{rt}	y_1^{rs}	y_1^{rr}	y_1^{rt}	x_1^r
	2	z_{21}^{rs}	z_{22}^{rs}	z_{21}^{rr}	z_{22}^{rr}	z_{21}^{rt}	z_{22}^{rt}	y_2^{rs}	y_2^{rr}	y_2^{rt}	x_2^r
t	1	z_{11}^{ts}	z_{12}^{ts}	z_{11}^{tr}	z_{12}^{tr}	z_{11}^{tt}	z_{12}^{tt}	y_1^{ts}	y_1^{tr}	y_1^{tt}	x_1^t
	2	z_{21}^{ts}	z_{22}^{ts}	z_{21}^{tr}	z_{22}^{tr}	z_{21}^{tt}	z_{22}^{tt}	y_2^{ts}	y_2^{tr}	y_2^{tt}	x_2^t
Value added		va_1^s	va_2^s	va_1^r	va_2^r	va_1^t	va_2^t				
Total inputs		x_1^s	x_2^s	x_1^r	x_2^r	x_1^t	x_2^t				

Note: Under each country, "1" represents the first product and "2" represents the second product.

$$\begin{bmatrix} X_1 \\ \vdots \\ X_r \\ \vdots \\ X_G \end{bmatrix} = \begin{bmatrix} A_{11} & \cdots & A_{1r} & \cdots & A_{1G} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ A_{r1} & \cdots & A_{rr} & \cdots & A_{rG} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ A_{G1} & \cdots & A_{Gr} & \cdots & A_{GG} \end{bmatrix} \begin{bmatrix} X_1 \\ \vdots \\ X_r \\ \vdots \\ X_G \end{bmatrix} + \begin{bmatrix} Y_{11} & \cdots & Y_{1r} & \cdots & Y_{1G} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ Y_{r1} & \cdots & Y_{rr} & \cdots & Y_{rG} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ Y_{G1} & \cdots & Y_{Gr} & \cdots & Y_{GG} \end{bmatrix} \begin{bmatrix} 1 \\ \vdots \\ 1 \\ \vdots \\ 1 \end{bmatrix} \quad (1)$$

where X_r is a N×1 gross output vector of country r, where r = 1,2, . . . , G. A_{sr} is a N×N intermediate input coefficient matrix of country r for inputs from country s. Y_{sr} is a N×1 final demand vector, for goods absorbed by country r originating from country s. Therefore, the final demand vector of country r is the summation of both, domestic and foreign, demands of final goods $\sum_{s=1}^{G} Y_{sr}$. The final goods produced by country r are comprised of sales to the domestic and foreign market given by $\sum_{u=1}^{G} Y_{ru}$.

Next, let V represent the primary input coefficient vector of the global input-output table, i.e. V = [V_1,V_2, · · · ,V_G], where V_r is a 1×N primary input coefficient vector of country r, for r = 1,2, . . . , G. Assume that A denotes the GN×GN global intermediate input coefficient matrix shown in the first term on the RHS of Eq. (1), then V can also be written as V = i'(I − A) where i is a GN × 1 unit vector and I the identity matrix.

One distinguishing difference between the world and classical IO tables lies in how the exports of goods and services are accounted for. Specifically, the world IO table tracks exports

of intermediate products in the intermediate sector while the final demand sector includes only the export of final products, i.e. for Y_{sr}, $s \neq r$. On the other hand, in the classical IO table the final demand sector contains exports of both, final and intermediate, products.

By using Eq. (1), gross exports between bilateral countries can be rewritten as:

$$E_{sr} = Y_{sr} + A_{sr}X_r, \qquad s, r = 1,2,\cdots,G, s \neq r \tag{2}$$

where E_{sr} is a N×1 vector, the elements of which are products exported from country s to country r. Y_{sr} and $A_{sr}X_r$ are the vectors of final and intermediate goods absorbed by country r imported from country s, respectively. Eq. (1) goes through Leontief's inverse operation,

$$\begin{bmatrix} X_1 \\ \vdots \\ X_r \\ \vdots \\ X_G \end{bmatrix} = \begin{bmatrix} I-A_{11} & \cdots & -A_{1r} & \cdots & -A_{1G} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ -A_{r1} & \cdots & I-A_{rr} & \cdots & -A_{rG} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ -A_{G1} & \cdots & -A_{Gr} & \cdots & I-A_{GG} \end{bmatrix} \begin{bmatrix} \sum_{u=1}^{G} Y_{1u} \\ \vdots \\ \sum_{u=1}^{G} Y_{ru} \\ \vdots \\ \sum_{u=1}^{G} Y_{Gu} \end{bmatrix}$$

$$= \begin{bmatrix} B_{11} & \cdots & B_{1r} & \cdots & B_{1G} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ B_{r1} & \cdots & B_{rr} & \cdots & B_{rG} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ B_{G1} & \cdots & B_{Gr} & \cdots & B_{GG} \end{bmatrix} \begin{bmatrix} \sum_{u=1}^{G} Y_{1u} \\ \vdots \\ \sum_{u=1}^{G} Y_{ru} \\ \vdots \\ \sum_{u=1}^{G} Y_{Gu} \end{bmatrix} \tag{3}$$

where B denotes the GN×GN Leontief's inverse matrix in Eq. (3). Then, the element B_{sr} represents the overall production effects on country s induced by a unit final good demand increase in country r. When the primary input coefficient vector V is multiplied by the Leontief's inverse matrix B, it becomes

$$VB = i'(I-A)(I-A)^{-1} = i' \tag{4}$$

3. Estimating the Value Added in Global Value Chains

The value added generated at each stage of the global value chain can be measured from two perspectives: one is "trade in value added" and the other is "value-added in trade." Tradein value added estimates that a country's exports are treated as final needs (consumption or investment) by the importing country and that the export goods arrive in the importing country, whether directly or indirectly (via a third country), and the original exporting country obtains from the importing country. This approach is also the definition adopted by the OECD Joint Program with the WTO. The value added of the trade is to estimate the value-added contents

contained in the total bilateral exports of countries and countries. The source of the shares includes the direct counterparties and other countries where the rival countries are exporting. Although the results obtained by the two methods of estimation are different, the results of both countries tend to be consistent when any one country agglomerates all its trade counterparties and industrial sectors. This article will explain in Sections 3.3, and 3.4 show the additional value of trade and trade with value added is estimated, and in Section 3.5, the value added export (VAX) derived from the trade definition of value-added and the definition of value added based on trade The relationship between the domestic share of value added (DVA) and the actual estimated results are shown in Section 5 below.

When using various indicator definitions, it is necessary to clarify the problem of overestimation and double counting caused by "export return" and "re-export." If a country estimates the share of value added by the country from its total export value, in fact, some of its exports eventually return to the country with imports as the ultimate needs of the nationals. For example, a country exports the production of its components to foreign countries. Processing, and then shipped back to the domestic assembly into the final product, because the share of the value added of the export is absorbed by the natives, if not removed may result in overestimating the results. If the final product is re-exported, there may be a problem of duplicate calculation of the value added.

3.1 Vertical Specialization Degree

The definition of value-added trade is tracked the value-added countries and industries in the production chain. Balassa (1967) defined vertical specialization as the continuous production process of a commodity is divided into a vertical trade chain. Each country adds value to each stage of the production process according to its comparative advantages. Hummels *et al*. (2001) extended the concept of Balassa (1967) and define the measurement with symbol VS, in the example with three countries and two commodities in section 3; we can define country 1's vertical specialization degree as:

$$VS = m_1(I - A_{11})^{-1}E_1 \tag{5}$$

$m_1$is the horizontal coefficient of input coefficient of imported products produced by the 1st country in both countries. VS is the total amount of inputs between the first and second countries for the production of two kinds of export products, direct and indirect use of imported products in Eq. (5) due to$(I - A_{11})^{-1} = I + A_{11} + A_{11}^2 + \cdots$.

3.2 Domestic and Foreign Shares of Total Exports

In section 2 we described the matrix $\hat{V}B$ is generated by the diagonalized value-added matrix $\hat{V}$ Multiplied by Leontief inverse matrix B. The elements in columns are the final goods of the industry of the country, using the products of domestic and foreign upstream industries as intermediate inputs, and then inducing the value added created by these industries directly and indirectly. The sum of all elements in a vertical row is 1. Therefore we can conclude that the elements in columns are the decomposed weight in final goods and can further estimate the total export value drives the value added created by domestic and foreign industries to increase production, i.e., national and foreign shares of total exports.

$$\hat{V}B\hat{E}=\begin{bmatrix} \hat{V}_1B_{11} & \hat{V}_1B_{12} & \hat{V}_1B_{13} \\ \hat{V}_2B_{21} & \hat{V}_2B_{22} & \hat{V}_2B_{23} \\ \hat{V}_3B_{31} & \hat{V}_3B_{32} & \hat{V}_3B_{33} \end{bmatrix}\begin{bmatrix} \hat{E}_1 & 0 & 0 \\ 0 & \hat{E}_2 & 0 \\ 0 & 0 & \hat{E}_3 \end{bmatrix}$$
$$=\begin{bmatrix} \hat{V}_1B_{11}\hat{E}_1 & \hat{V}_1B_{12}\hat{E}_2 & \hat{V}_1B_{13}\hat{E}_3 \\ \hat{V}_2B_{21}\hat{E}_1 & \hat{V}_2B_{22}\hat{E}_2 & \hat{V}_2B_{23}\hat{E}_3 \\ \hat{V}_3B_{31}\hat{E}_1 & \hat{V}_3B_{32}\hat{E}_2 & \hat{V}_3B_{33}\hat{E}_3 \end{bmatrix} \quad (6)$$

It is worth emphasizing that the method of this section is to directly dismantle the total export amount, but because the total export volume contains the semi-finished products shipped to foreign countries for processing and entering and leaving the country for many times, the domestic and foreign shares obtained through dismantling can hardly avoid double counting. Problem. At the same time, this dismantling method focuses on the starting point (supply end) of export goods, and does not care about which country the export goods will use to reach; on the contrary, if the country's or industry's contribution is traced back from the endpoint (used end) of the export goods, the results will not the same as we descript in the subsection. This is the content of the next section of value-added trade.

3.3 Trade in Value-added

The so-called trade in value-added deals with export goods considered as final demand (consumption or investment) by the importing country, and whether the export goods arrive at the importing country directly or indirectly via a third country, and the exporting country obtains the additional income it receives from the importing country. Previous studies usually applied the methodology of Johnson and Noguera (2012) such as Lin *et al*. (2017). In this paper, we presented in another way, not only at a glance but also with the content of the next section (value added of trade). Specifically, it is to obtain the forward linkage effect of the final product export value of each country (forward linkage effect).

For convenience, we extend the example in section 3 and integrate the final demand of the inter-country input-output table into a matrix Y and multiplying the matrix $\hat{V}B$：

$$\hat{V}BY=\begin{bmatrix} \hat{V}_1B_{11} & \hat{V}_1B_{12} & \hat{V}_1B_{13} \\ \hat{V}_2B_{21} & \hat{V}_2B_{22} & \hat{V}_2B_{23} \\ \hat{V}_3B_{31} & \hat{V}_3B_{32} & \hat{V}_3B_{33} \end{bmatrix}\begin{bmatrix} Y_{11} & Y_{12} & Y_{13} \\ Y_{21} & Y_{22} & Y_{23} \\ Y_{31} & Y_{23} & Y_{33} \end{bmatrix}$$

$$=\begin{bmatrix} \hat{V}_1(B_{11}Y_{11}+B_{12}Y_{21}+B_{13}Y_{31}) & \hat{V}_1(B_{11}Y_{12}+B_{12}Y_{22}+B_{13}Y_{32}) & \hat{V}_1(B_{11}Y_{13}+B_{12}Y_{23}+B_{13}Y_{33}) \\ \hat{V}_2(B_{21}Y_{11}+B_{22}Y_{21}+B_{23}Y_{31}) & \hat{V}_2(B_{21}Y_{12}+B_{22}Y_{22}+B_{23}Y_{32}) & \hat{V}_2(B_{21}Y_{13}+B_{22}Y_{23}+B_{23}Y_{33}) \\ \hat{V}_3(B_{31}Y_{11}+B_{32}Y_{21}+B_{33}Y_{31}) & \hat{V}_3(B_{31}Y_{12}+B_{32}Y_{22}+B_{33}Y_{32}) & \hat{V}_3(B_{31}Y_{13}+B_{32}Y_{23}+B_{33}Y_{33}) \end{bmatrix} \quad (7)$$

In Eq. (7), we can find that the main diagonal element of the right matrix of the second equal sign contains three items in each element. Taking the first element as an example, the first item$\hat{V}_1B_{11}Y_{11}$ is the final value of the first country's self-produced final goods Y_{11}, which induces the increase in domestic production, and the second one$\hat{V}_1B_{12}Y_{21}$ is the final good resulting from the import of the second country into the second country. However, the second country imports the intermediate good from the first country, which induces the first country to increase production, and the value added generated by the first country. The third item $\hat{V}_1B_{13}Y_{31}$ is similar to the second item, resulting from the final import of the third country's production by the first countryY_{31}. But the third country imports the middle income from the first country, which induces the first country to increase production, and the value added generated by the first country.

The second term of the right-hand side of the Eq. (7) is the value-added export or import value of each country. For example, the item $\hat{V}_1(B_{11}Y_{12}+B_{12}Y_{22}+B_{13}Y_{32})$ is the value-added the export value of the first country from the second country. The first item $\hat{V}_1B_{11}Y_{12}$ originates from the final good (Y_{12}) of the second country's import of the first country, and thus induces the first country to increase production and brings value added; the second one $\hat{V}_1B_{12}Y_{22}$comes from the second country's use of the final good (Y_{22}) of self-production, but the second country from the first The import of a middle-income by a country induces the first country to increase production and brings additional value. The third one $\hat{V}_1B_{13}Y_{32}$ comes from the final good (Y_{32}) of a second country's import of a third country, but the third country imports a middle income from the first country, thereby inducing one country increases production and brings value added. The three items in common are that the value added created by the production of the first country was finally absorbed by the second country. The main contributor to the ultimate fiscal consumer country is the second country. These three items

add up to the first country's attachment to the second country. Value export value or the trade in value added by the second country to the first country.

According to Johnson and Noguera (2012), we use VAX^{sr} to represent the value added export value of one country s to another country r[1]:

$$\mathrm{VAX}^{sr} = \hat{\mathrm{V}}_s \mathrm{B}_{ss} \mathrm{Y}_{sr} + \hat{\mathrm{V}}_s \mathrm{B}_{sr} \mathrm{Y}_{rr} + \hat{\mathrm{V}}_s \sum_{t \neq s,r}^{G} \mathrm{B}_{st} \mathrm{Y}_{tr}, \ s, r = 1, 2, ..., G, \ s \neq r. \tag{8}$$

The third item on the right side of the equal sign of the above formula is the value of the export value of the s country that first exports the intermediate wealth to the third country, and is finally absorbed by country r, and the value of the additional value obtained by country s from country r; this is the indirect country of the exporting country (via a third country) Value added export value obtained.

Johnson and Noguera (2012) use VAX as a percentage of total exports (VAX ratio) as a measure of the ability of a country/department to create value added. Since VAX includes the value added of stealth in the downstream industry's export value, the VAX ratio creates several problems in its application. For example, transport services are intermediate inputs for automobiles and mobile phones, and VAX in the transport service industry is invisible in the export value of automobiles and mobile phones. When the export goods are consumed (absorbed) by foreign countries, the transport service industry obtains its due value-added exports. Value. However, because the transportation service industry does not directly export, the VAX ratio of the transportation service industry is ∞. Also, the direct export value of certain industries is extremely small, but there is a high forward linkage effect. Its products are indirectly caused by the export of downstream industries. The value-added exports may also result in a very large VAX ratio, which means that the VAX ratio is not guaranteed to be between 0 and 1 when it is used for export, i.e., the value of the additional value is not guaranteed to be less than the export value of traditional foreign trade statistics. The VAX ratio will only fall within 1 when the total value added by each department adds up to the total value added.

The next subsection describes the value added of dismantling trade. Since the share of value added is part of the total export volume, this share must be smaller than the export value of traditional foreign trade statistics, which is the largest difference between the value added and the export value of value added. As for the sources of the value-added shares of exports,

[1] If the number of products is assumed to be only one, we change the bold black letters (representing vectors or matrices) into lowercase letters. At this time, the value-added exports of the first country to the second country are written as:

$$\mathrm{VAX}^{12} = v_1 b_{11} y_{12} + v_1 b_{12} y_{22} + v_1 b_{13} y_{32}.$$

there are direct counterparties to bilateral exchanges and third countries that have exported their imports after processing.

3.4 Value added in Trade

The value added in trade is the analysis of the value added contents inherent in the total bilateral export of a country or industry to industry; the source includes the direct contact with the opponent countries or industries, as well as opponents of the country or industry exported to other countries or industries. According to Wang *et al*. (2013), this paper decomposes the export sectors into 16 items. Compare with Koopman *et al*. (2014); the characteristics can be fine to study the trade relations between countries and products, as well as the relationship between the upper and lower reaches of each product.

3.4.1 Decomposition of Final Goods Export

In this subsection, we explain the decomposition of the final goods exports vector $\mathrm{Y_{sr}}$ shown in the first term on the right hand side of Eq. (2). According to Eq. (4), we know that multiplication of the primary input coefficient vector V and Leontief's inverse matrix B corresponds to a $1 \times$ GN vector with unity elements. Utilizing the property, we select the sth column of matrix B and multiply it by vector V. This results in a $1 \times$ G vector with unity elements:

$$\sum_{t=1}^{G} \mathrm{V}_t \mathrm{B}_{ts} = \begin{bmatrix} 1 & 1 & \cdots & 1 \end{bmatrix}_{(1\times G)} = \mathrm{V}_s \mathrm{B}_{ss} + \mathrm{V}_r \mathrm{B}_{rs} + \sum_{t\neq s,r}^{G} \mathrm{V}_t \mathrm{B}_{ts}. \tag{9}$$

When transposing Eq. (9), the three terms on its right hand side $(\mathrm{V_s B_{ss}})'$, $(\mathrm{V_r B_{rs}})'$ and $\sum_{t\neq r,s}^{G} \mathrm{V_t B_{ts}}$, can be seen as weight vectors with the summation of elements on the same position of each vector equal to unity. Defining # as an element-wise vector multiplication operator and using the three weight vectors, country s' final goods exports to country r at sector levels can be decomposed into the sum of three terms:

$$\begin{aligned} \mathrm{Y}_{sr} &= \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} \# \mathrm{Y}_{sr} = \left((\mathrm{V}_s \mathrm{B}_{ss})' + (\mathrm{V}_r \mathrm{B}_{rs})' + (\sum_{t\neq s,r}^{G} \mathrm{V}_t \mathrm{B}_{ts})' \right) \# \mathrm{Y}_{sr} \\ &= \underbrace{(\mathrm{V}_s \mathrm{B}_{ss})' \# \mathrm{Y}_{sr}}_{1^{\mathrm{st}}} + \underbrace{(\mathrm{V}_r \mathrm{B}_{rs})' \# \mathrm{Y}_{sr}}_{2^{\mathrm{nd}}} + \underbrace{(\sum_{t\neq s,r}^{G} \mathrm{V}_t \mathrm{B}_{ts})' \# \mathrm{Y}_{sr}}_{3^{\mathrm{rd}}}. \end{aligned} \tag{10}$$

To better understand each term on the right-hand side of Eq. (10), we provide the following economic interpretations. The 1st term, $(\mathbf{V^s B^{ss}})' \# \mathbf{Y_{sr}}$, is country *s*' domestic value-

added embodied in its final goods exports to country *r*.

The 2nd term, $(\mathbf{V^r B^{rs}})'$ # $\mathbf{Y_{sr}}$, is country r' (importer) value-added embodied in country s' final goods exports to country r. The reason why the importer grabs this portion of value added is country *s* for the sake of producing exported final goods turns to country r for intermediate inputs which induces country *r*' production and earns its value added.

The 3rd term, $(\sum_{t=1}^{G} \boldsymbol{V^t B^{ts}})' \# \boldsymbol{Y^{sr}}$, is country *t'* (the third country) value added embodied in country *s'* final goods exports to country *r*. The reason why this portion of value added is earned by foreign countries instead of exporter (country *s*) is similar to that of previous term. The only difference is country *s* the now turns to third country try for intermediate inputs. Summing the 2nd and 3rd term yields the foreign value added embodied in country *s*' final goods exports to country *r*.

As the final goods exports are treated as an exogenous variable in classical Leontief's input-output analysis, the procedure regarding its decomposition is relatively simple and straightforward. In contrast, the decomposition of intermediate goods exports is comparatively more difficult as they are endogenous in the classical input-output model. We will discuss how Wang *et al*. (2013) decomposed the intermediate goods exports into various components in the next subsection.

3.4.2 Decomposition of Intermediate Goods Export

In decomposing the intermediate goods exports vector $A_{sr}X_r$ shown in the second term on the right-hand side of Eq. (8), the strategy is to rewrite the exports vector as linear combination of each country's final demands. First of all, similar to the splitting procedure of Eq. (9), the intermediate goods exports vector, $A_{sr}X_r$ can undergo the following decomposition steps:

$$
\begin{aligned}
\mathrm{A}_{sr}\mathrm{X}_r &= \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} \#(\mathrm{A}_{sr}\mathrm{X}_r) = \left((\mathrm{V}_s\mathrm{B}_{ss})' + (\mathrm{V}_r\mathrm{B}_{rs})' + (\sum_{t\neq s,r}^{G} \mathrm{V}_t\mathrm{B}_{ts})' \right) \#(\mathrm{A}_{sr}\mathrm{X}_r) \\
&= \left((\mathrm{V}_s\mathrm{L}_{ss})' + (\mathrm{V}_s\mathrm{B}_{ss})' - (\mathrm{V}_s\mathrm{L}_{ss})' + (\mathrm{V}_r\mathrm{B}_{rs})' + (\sum_{t\neq s,r}^{G} \mathrm{V}_t\mathrm{B}_{ts})' \right) \#(\mathrm{A}_{sr}\mathrm{X}_r) \\
&= (\mathrm{V}_s\mathrm{B}_{ss})' \#(\mathrm{A}_{sr}\mathrm{X}_r) + (\mathrm{V}_s\mathrm{B}_{ss} - \mathrm{V}_s\mathrm{L}_{ss})' \#(\mathrm{A}_{sr}\mathrm{X}_r) + (\mathrm{V}_r\mathrm{B}_{rs})' \#(\mathrm{A}_{sr}\mathrm{X}_r) \\
&\quad + (\sum_{t\neq s,r}^{G} \mathrm{V}_t\mathrm{B}_{ts})' \#(\mathrm{A}_{sr}\mathrm{X}_r),
\end{aligned}
\tag{11}
$$

The right-hand side of the third equalization has been inserted the$(\mathbf{V^s L^{ss}})'$ terms where $\mathbf{L^{ss}} = (\mathbf{I} - \mathbf{A^{ss}})^{-1}$ is the Leontief's inverse matrix of country *s*' domestic products.

In the next step, we describe the treatments about $\mathbf{X}_r$the gross outputs produced by country *r*. First, by using the elements within the Leontief's inverse matrix **B** shown in Eq. (3), $\mathbf{X}_r$ is the overall output induced by domestic and foreign final demands and, hence, can run through the following transformation:

$$\begin{aligned} X_r &= \sum_{t=1}^{G} B_{rt} \sum_{u=1}^{G} Y_{tu} = B_{rr} \sum_{u=1}^{G} Y_{ru} + B_{rs} \sum_{u=1}^{G} Y_{su} + \sum_{t\neq r,s}^{G} B_{rt} \sum_{u=1}^{G} Y_{tu} \\ &= B_{rr} Y_{rr} + B_{rr} Y_{rs} + B_{rr} \sum_{t\neq r,s}^{G} Y_{rt} + B_{rs} Y_{ss} + B_{rs} \sum_{t\neq s}^{G} Y_{st} + \sum_{t\neq r,s}^{G} B_{rt} Y_{ts} \\ &+ \sum_{t\neq r,s}^{G} B_{rt} Y_{tt} + \sum_{t\neq r,s}^{G} \sum_{u\neq s,t}^{G} B_{rt} Y_{tu}. \end{aligned} \tag{12}$$

Secondly, from Eq. (2), $\mathbf{X}_r$ must be used as either an intermediate or final goods at home or abroad, ie.

$$X_r = A_{rr} X_r + Y_{rr} + \sum_{t\neq r}^{G} (A_{rt} X_t + Y_{rt}). \tag{13}$$

Where the third term is country *r*' aggregated gross exports to all other countries. Denoting this term as $\mathbf{E}_{r*}$, then, Eq. (13) can undergo a further transformation as following

$$X_r = (I - A_{rr})^{-1} (Y_{rr} + E_{r*}) = L_{rr} Y_{rr} + L_{rr} E_{r*} \tag{14}$$

Substituting $\mathbf{X}^{\mathbf{r}}$ in the 1st term with Eq. (12), and both 3th and 4st term with Eq. (11). Finally, Eq. (18) turns out to be:

$$
\begin{aligned}
A_{sr}X_r = & \underbrace{(V_sL_{ss})'\#(A_{sr}B_{rr}Y_{rr})}_{1^{st}} + \underbrace{(V_sL_{ss})'\#(A_{sr}B_{rr}Y_{rs})}_{2^{nd}} \\
& + \underbrace{(V_sL_{ss})'\#(A_{sr}B_{rr}\sum_{t\neq r,s}^{G}Y_{rt})}_{3^{rd}} + \underbrace{(V_sL_{ss})'\#(A_{sr}B_{rs}Y_{ss})}_{4^{th}} \\
& + \underbrace{(V_sL_{ss})'\#(A_{sr}B_{rs}\sum_{t\neq s}^{G}Y_{st})}_{5^{th}} + \underbrace{(V_sL_{ss})'\#(A_{sr}\sum_{t\neq r,s}^{G}B_{rt}Y_{ts})}_{6^{th}} \\
& + \underbrace{(V_sL_{ss})'\#(A_{sr}\sum_{t\neq r,s}^{G}B_{rt}Y_{tt})}_{7^{th}} + \underbrace{(V_sL_{ss})'\#(A_{sr}\sum_{t\neq r,s}^{G}\sum_{u\neq s,t}^{G}B_{rt}Y_{tu})}_{8^{th}} \\
& + \underbrace{(V_sB_{ss}-V_sL_{ss})'\#(A_{sr}X_r)}_{9^{th}} + \underbrace{(V_rB_{rs})'\#(A_{sr}L_{rr}Y_{rr})}_{10^{th}} \\
& + \underbrace{(V_rB_{rs})'\#(A_{sr}L_{rr}E_{r*})}_{11^{th}} + \underbrace{(\sum_{t\neq s,r}^{G}V_tB_{ts})'\#(A_{sr}L_{rr}Y_{rr})}_{12^{th}} \\
& + \underbrace{(\sum_{t\neq s,r}^{G}V_tB_{ts})'\#(A_{sr}L_{rr}E_{r*}).}_{13^{th}}
\end{aligned}
\tag{15}
$$

Eq. (15) indicates that the intermediate goods exports from country *s* to country *r* at sector levels can be completely decomposed into to the sum of 13 terms. In the following, we briefly give their explanation respectively.

3.4.3 Summary

Decompose the Eq. (10) into three terms, decompose the Eq.(15) into 13 terms, according to Wang *et al*. (2013), we can categorize above 16 terms into four types as Figure 1:

Country s' gross exports to country r {

1. Value-added content country s earned from abroad including r:
   (7)–1^{st} , (12)–1^{st} , –3^{rd} , –7^{th} , –8^{th} .
2. Value-added content returned home country s:
   (12)–2^{nd} , –4^{th} ,–6^{th} .
3. Value-added content grabbed by foreign countries including r:
   (7)–2^{nd} , –3^{rd} , (12)–10^{th} , –12^{th} .
4. Pure double-counted parts:
   (12)–5^{th} , –9^{th} , –11^{th} , –13^{th} .

Figure 1: Classification of 16 Components within Gross Exports into 4 Major Categories

It's worth emphasizing that the sources of the value-added content in the first category not only result from the direct trading partner but also other countries as these countries finally absorb the exported goods, via the exporting country's direct trading partner. This contrasts with the valued-added exports which are equivalent to the amount exporting country obtains from its direct trading partner (see Section 3.1).

Also, knowing the composition of the value-added content is key to analyzing the position of a country in global value chains. Specifically, Figure 1 indicates the value-added content consists of five items, the first of which, (8)– 1st, results from exporting final goods, whereas the remaining four, intermediate goods. A country with a high proportion of value-added content from final goods exports largely plays the role of downstream activities in global value chains. In contrast, a higher proportion of value added from intermediate goods exports represents more emphasis on upstream activities.

The second category is the value-added content returned to home country. Although this category constructs the GDP, the value-added obtained from domestic, not foreign. Moreover, the third category the value-added content grabbed by foreign countries and includes four items. The first two items are the value-added which came from foreign; the later two ones are value-added from the intermediate goods by foreign. The higher proportion of value added from the first two items indicates the country imported raw materials or components engaged in low-level assembly activities more, otherwise, the country engaged in high-level assembly activities.

The contents of both the third and fourth categories in Figure 1 are attributed to abroad in the end and is referred to as vertical specialization (Hummels, Ishii, and Yi, 2001 and Antas, 2013). It is mainly used to measure the production sharing of a country in the world.

Generally speaking, the net value-added content on the bilateral country or bilateral sectors (i.e. value added in exports minus value added in imports) does not equal the net exports of conventional gross trades. However, once aggregating overall trading partners and traded goods, the two differently-defined net values come to equivalence, which is also equal to net value-added exports (Liou *et al*., 2016).

3.5 The Relationship between VAX and DVA

This section introduces the relationship between VAX and DVA. First, if there are more than three trading nations, the VAX value is not equal to the DVA. We extended the example in section 3.3 and simplified to only one product, the VAX of the country 1 to country two defines as follows:

$$\mathrm{VAX}^{12} = v_1 b_{11} y_{12} + v_1 b_{12} y_{22} + v_1 b_{13} y_{32}, \tag{16}$$

The third term of Eq. (16) in the right-hand side is the country 1's value-added export value from country 3 Eq. (17) descript the DVA of the country 1 to country 2:

$$\begin{aligned}\mathrm{DVA}^{12} = {} & v_1 b_{11} y_{12} + v_1 l_{11} a_{12} b_{22} y_{22} + v_1 l_{11} a_{12} b_{22} y_{23} \\ & + v_1 l_{11} a_{12} b_{22} y_{33} + v_1 l_{11} a_{12} b_{23} y_{32}\end{aligned} \tag{17}$$

$l_{11} = (1 - a_{11})^{-1}$ is the multiplier of domestic goods in country 1.

According to $(\mathrm{I} - \mathrm{A})\mathrm{B} = \mathrm{I}$, we can get:

$$a_{12} b_{22} = (1 - a_{11}) b_{12} - a_{13} b_{32} = l_{11}^{-1} b_{12} - a_{13} b_{32},$$

$$a_{12} b_{23} = (1 - a_{11}) b_{13} - a_{13} b_{33} = l_{11}^{-1} b_{13} - a_{13} b_{33}.$$

Substitute above two formulas into the second term and the fifth term in Eq. (17):

$$\begin{aligned}\mathrm{DVA}^{12} = {} & v_1 b_{11} y_{12} + v_1 b_{12} y_{22} - v_1 l_{11} a_{13} b_{32} y_{22} + v_1 l_{11} a_{12} b_{22} y_{23} \\ & + v_1 l_{11} a_{12} b_{23} y_{33} + v_1 b_{13} y_{32} - v_1 l_{11} a_{13} b_{33} y_{32}\end{aligned} \tag{18}$$

Compare with Eq. (16) and Eg. (18), we can find DVA^{12} is not equal to VAX^{12},

$$\begin{aligned}\mathrm{DVA}^{12} - \mathrm{VAX}^{12} = {} & (v_1 l_{11} a_{12} b_{22} y_{23} + v_1 l_{11} a_{12} b_{23} y_{33}) \\ & - (v_1 l_{11} a_{13} b_{32} y_{22} + v_1 l_{11} a_{13} b_{33} y_{32})\end{aligned} \tag{19}$$

The first parenthesis to the right of the (19) equal sign is the value-added export value of the first country from the third country. The actual situation is that the first country exports the intermediate product to the second country, but the final product is the third National absorption. The second parenthesis to the right of the (19) equal sign is the value-added export value obtained by the first country from the second country. Now the situation becomes that the first country exports the intermediate product to the third country, but the final production becomes the final product. The second country absorbs it. The opposite direction of these two kinds of indirect trade is just the opposite. Under normal circumstances, the two kinds of value-added export value will not be equal. This means that the bilateral value-added export value (VAX) is not equal to the domestic value added (DVA). In other words, if a country's indirect value-added export value from its counterparty country is greater than its value indirectly obtained from other countries, the export's domestic value-added (DVA) will be greater than the value-added export (VAX).

In short, the value added export (VAX) and the domestic value added (DVA) of total exports are measured from different perspectives on the contribution of a country's participation in the global value chain, the former being the ultimate (direct and indirect) absorption of exports (The consumer side traces back the value-added source country or industry, while the latter directly dismantles the value-added share from the beginning of the export, regardless of which country or industry the ultimate share of the value added share is

absorbed. When a country adds up the value added export (VAX) and the domestic value added (DVA) of the total exports, the two have the same results. However, if we only observe bilateral trade between countries and countries, or products, these two results are not the same. In other words, the two concepts are related, and each has its meaning. They are similar but not the same. We can use the economic incidence in taxation theory as a metaphor for VAX (the ultimate absorbing state or industry of value added) and statutory incidence as a metaphor for DVA (the initial source country or industry of value added). The former is a tax. The true burden of taxation, the latter is the taxpayer (the payer can pass on the part of the tax burden to the bearer), both summed together, are equal to the total tax.

4. Data sources

The inter-country input-output (ICIO) table used in this paper comes from the World Input-Output Database (WIOD). Timmer *et al*. (2015) and Dietzenbacher *et al*. (2013) give a detailed description of its compiling methodology the World Input-Output Table (WIOT). Panel data is one of WIOD's major characteristics. The latest data series range annually from 2000 to 2014 with forty-four countries and the other area including twenty-seven European members and other thirteen countries: the U.S., Canada, Brazil, Mexico, China, India, Japan, Korea, Australia, Taiwan, Turkey, Indonesia, and Russia, etc. WIOD's Industries are classified into 56 sectors (see Appendix 1).

The major reason why WIOD can offer time serial data lies in its compiling methodology, i.e., it adopts the supply and uses tables (SUTs) as the source at the beginning rather than the purified input-output table. As the supply and use tables directly link to the national income data, the former data thus can be easily adapted to the frequent modification of the latter.

Besides, in connecting the bilateral trades among these countries, WIOD adopts the UN Comtrade database, except Taiwan retrieving from OECD as it has no UN membership. The Comtrade database offers HS 6-digit product classification codes, which are helpful in distinguishing between semi-finished product, finished products or investment, etc.

As the final step in constructing the symmetric IO table, WIOD uses the so-called "fixed product-sales structure" assumption, which states that each product has its own specific sales structure regardless of the industry in where it produces.

5. Result analysis

5.1 Export and Bilateral Trade Analysis between Taiwan, the United States, and China

Facilitate comparison with the other two sections' contents; this section reviews the total export volume and bilateral trade between Taiwan, the United States, and China from the existing statistical basis for foreign trade; see Figure 3 and Appendix 2. It is worth emphasizing that the source for this subsection is the World Input-Output Database (WIOD), which is not the same as the number released on the official website of each country.

Also, IO data contain goods and services, complete foreign exchange accounts should be "exports and import of goods and services" and "trade surplus, the trade deficit." For the sake of writing, the following will simplify the so-called "export, import" and " deficit, surplus," which is different from "commodity" of export, import and surplus and deficit in the first section of this article quoted the custom of each country.

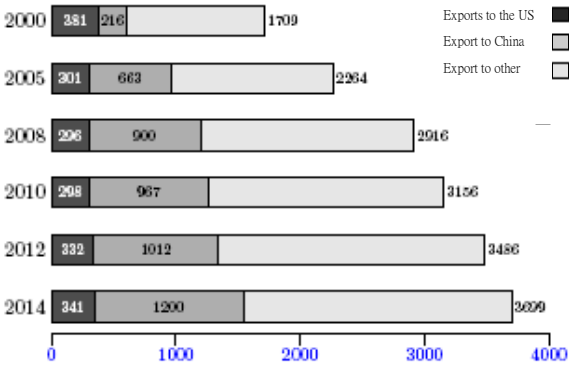
First, we can see from Figure 3 (a) that Taiwan's total exports increased from 170.9 billion U.S. dollars in 2000 to 369.9 billion U.S. dollars in 2014. In the same period, Taiwan's total exports to the United States dropped from 38.1 billion U.S. dollars to 34.1 billion U.S. dollars, accounting for the total share of Taiwan's exports from 22.3% to 9.2%. In contrast, Taiwan's total exports to China expanded rapidly from 21.6 billion U.S. dollars to 120 billion U.S. dollars, accounting for 32.4% of Taiwan's total exports from 12.6%. As for the trade balance, Figure 3 (b) shows that Taiwan has maintained a surplus, increasing from 17.5 billion U.S. dollars in 2000 to 76.7 billion U.S. dollars in 2014. As China replaced the United States as the largest export market in Taiwan, China jumped to Taiwan's largest source of surplus. In previous years, a surplus of Taiwan to China even surpassed the total amount of Taiwan surplus. In 2014, Taiwan surpassed China by the US $ 76.4 billion, only slightly lower than the total amount of 76.7 billion U.S. dollars. Taiwan's surplus of trade from the United States has been on a downward trend, with a slow climb since 2010, 17.6 billion U.S. dollars in 2014, lower than 18.9 billion U.S. dollars in 2000.

Secondly is the U.S. foreign trade situation. Figure 3 (c) shows that the total U.S. exports increased from 926.5 billion U.S. dollars in 2000 to 1,977.2 billion U.S. dollars in 2014. The United States used to be the largest exporter in the world but surpassed by China since 2010 and be the second largest exporter in the world. Traditionally, the U.S. foreign trade market has focused on neighboring countries. In 2014, U.S. exports to Canada and Mexico (the US $ 279.1 billion and 178.6 billion U.S. dollars) respectively accounted for 15.1% and 9.3% of the total U.S. exports, ranking the top two places. With the rise of China market in recent years, the U.S. exports to China have risen rapidly, reaching 112.1 billion U.S. dollars in 2014, accounting for 5.8% of the total U.S. exports from 1.3% in 2000, ranking the third largest exporter in the United States. At the same time, China is also the largest source country of the United States, the United States surged from 39.1 billion U.S. dollars in China to 2,353.3

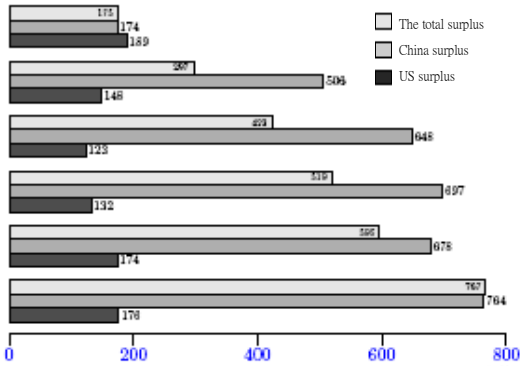
billion U.S. dollars in 2014, accounting for the proportion of the United States deficit amount increased from 10.9% to 49.3%. In contrast, the share of the U.S. exports to Taiwan in the total U.S. exports dropped from 2.1% in 2000 to 0.9% in 2014, ranking the 16th among U.S. exporters. The share of the United States to Taiwan's deficit amount compared to the total deficit trade amount of United States by the 2000 year to 5.3% in 2014 to 3.7%; see Figure 3 (d)

As for China's foreign trade, Figure 3 (e) shows that the total China exports increased from USD 261.9 billion in 2000 to USD 2 trillion 425.5 billion in 2014. At an average annual rate of increase of 17.2%, exceeding the annual growth of 5.4% in the United States and Taiwan's annual growth of 5.7%. Since 2010, China is to be the world's largest exporter. Among them, the United States was the largest export market in China. China exports to the United States rose to the US $ 347.3 billion in 2014 from the US $ 51.6 billion in 2000, while its share of total exports dropped from 19.7% to 14.3%. As China exports to Taiwan increased from 4.2 billion U.S. dollars in 2000 to 43.6 billion U.S. dollars in 2014; accounting for less than 2% of China's total exports, ranking the tenth among China exporters. Overall, the trade volume of China exceeded 500 billion U.S. dollars and reached 587.2 billion U.S. dollars in 2014. China enjoyed huge surplus with the United States but surpassed Taiwan. Refer to Figure 3 (d).

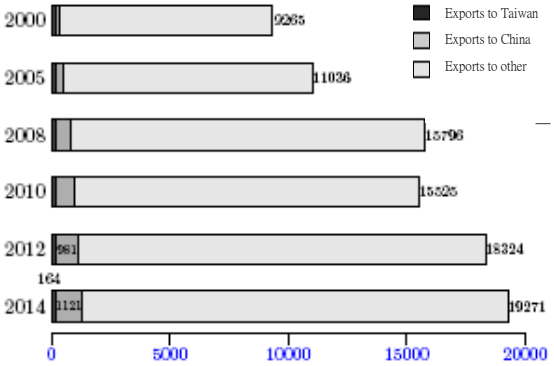
(a) Taiwan's total exports and exports to the USA and China



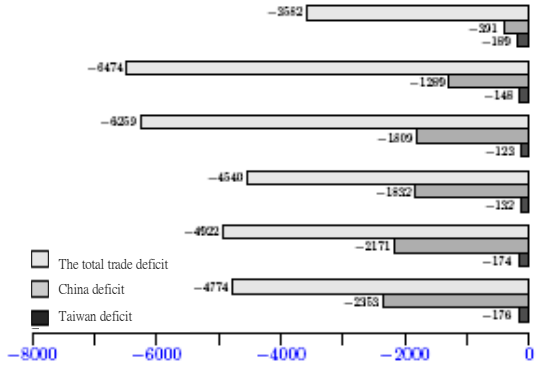
(b)Taiwan's total trade surplus and trade surplus to the USA and China



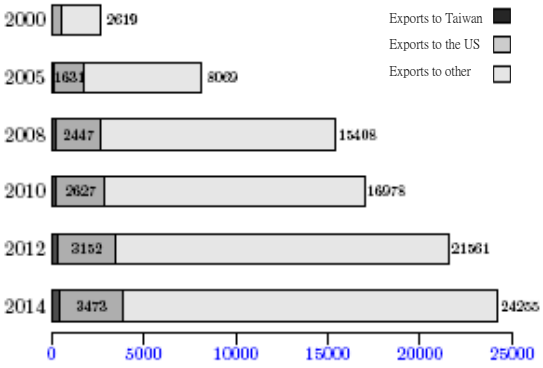
(c) Total exports of the USA and exports to Taiwan and China



(d) Total trade deficit of the USA and trade deficit to Taiwan and China



(e) China's total exports and Exports to Taiwan and the USA



(f) China's total trade surplus and trade (surplus) deficit to Taiwan and the USA

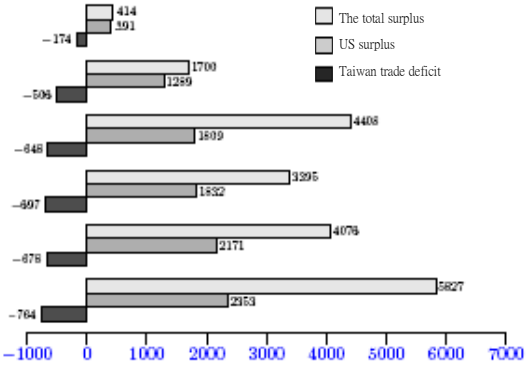


Figure 3 Current Exports and (Surplus) Deficit in Foreign Trade Statistic

5.2 Analysis of VAX between Across Strait and the United States

This subsection mainly focuses on value-added export and bilateral value-added trade in Taiwan, the United States, and China. One of the focuses of the analysis is the comparison with the current foreign trade statistics in the preceding section; see Figure 4 and Appendix 4.

First, we can see from Figure 4 (a) that Taiwan's value-added export value increased from 105.6 billion U.S. dollars in 2000 to 214.4 trillion U.S. dollars in 2014, doubled in the past 15 years. If compared with the total amount of current foreign trade statistics, the value of value-added exports in Taiwan is much smaller than the total value of exports, with the former accounting for less than 60％ of the total, and only 58.0％ in 2014.

Observing the export value of Taiwan's value-added services to China, although the amount was in the rising trend, it increased from 11.4 billion U.S. dollars in 2000 to 53.3 billion U.S. dollars in 2014 but was significantly lower than total Taiwan's exports to China. For example, Taiwan's value-added export to China accounts for only 44.4％ of total Taiwan's exports to China ($ 120 billion US dollars) in 2014. It shows that Taiwan imports have a very high proportion of imported parts to China, If its contribution excludes, the value added that Taiwan obtains from China will be 55.6％ less than that of the current foreign trade statistics on the total China exports. As for Taiwan's value added exports to the United States, the value of Taiwan's exports has dropped first and then raised in the past 15 years, reaching 29.8 billion U.S. dollars in 2014, accounting for 87.4％ of Taiwan's total U.S. exports (35.1 billion U.S. dollars) in that year.

Second, observe the value-added trade balance in Taiwan; see Figure 4 (b). In section 4.3 of this paper, it shows that the trade balance between value-added trade in a country and traditional foreign trade statistics are equal when all trade partner countries and products are added up. As can be seen from a comparison of Figure 4 (b) with Figure 2 (b) Taiwan's actual data shows that indeed. However, as far as the bilateral value-added trade deficit between the two countries is concerned, it will not be equal with the trade balance of traditional foreign trade statistics.

Observing the situation in Taiwan, Taiwan has surpassed the value added by the United States over the past 15 years (that is, the value added of the United States to Taiwan surpassed its value; see Figure 4 (d)), but slightly higher than traditional trade statistics, take 2014 as an example. The former is 18.8 billion U.S. dollars, and the latter is 17.6 billion U.S. dollars. However, Taiwan's surpassing value added to China (that is, its China surged its value added to Taiwan; see Figure 4 (f)) is far below traditional Taiwan's surpassing of China was the

same as in 2014. The former being 32.5 billion U.S. dollars and the latter being 76.4 billion U.S. dollars, the former being 57.5% less than the latter.

The reasons why the surpass and performance difference of Taiwan's exports to the United States and China compared to traditional trade statistics are mainly because the exports Taiwan to China are mostly shipping to the United States through assembly processing, and finally the United States "absorbed" Taiwan's value added. Therefore, the condition of surpassing value added of Taiwan to the United States is higher than the traditional statistics, and surpass value added of Taiwan to China is lower than the traditional statistics.

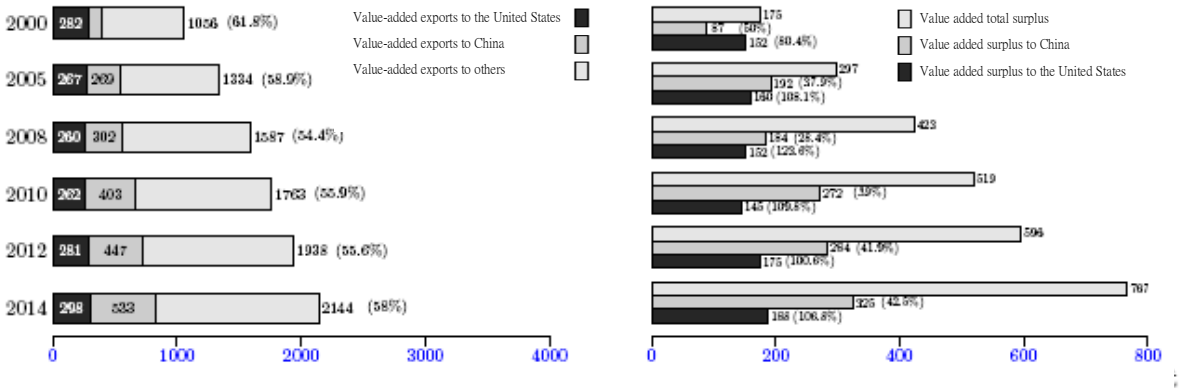
In an aspect of value added of the United States exports, as shown in Figure 4 (c), from the Figure of 732 billion U.S. dollars in 2000 to 1,157.5 billion U.S. dollars in 2014, it accounts for about 80% of the total export statistics of the current trade, higher than Taiwan. Also, Figure 4 (d) shows that the value added of the United States to China import surplus (that is the value added of China to the United States is surpluses, see figure 4 (f)). $ 32.1 billion U.S. dollars in 2000 and increasing to $ 201.5 billion U.S. dollars in 2014, although the trend of expansion, the amount of surpluses is low then the traditional foreign trade statistics, the reduction of more than 10%. Figure 4 (e) shows the increase of China value-added exports from $ 215.9 billion U.S. dollars in 2000 to $ 1,957.7 billion U.S. dollars in 2014, accounting for about 80% of the total foreign trade statistical exports, the same as in the United States, higher than Taiwan.

Since the value-added export value derives from the foreign demand for the final product, the value of the export-oriented value-added on the share of the domestic GDP can be used to reflect the dependence of a country's GDP on the final needs of the country. Figure 5 (a) shows that the share of Taiwan's value-added exports to the United States in Taiwan's GDP has been declining from 8.5% in 2000 to 5.6% in 2014, accounting for a decrease in the share of Taiwan's total value-added exports. This Figure shows that on behalf of Taiwan's economic dependence on the United States decreased.

In contrast, Figure 5 (b) shows the share of Taiwan's value-added exports to China in Taiwan's GDP. It had been on an upward trend from 3.4% in 2000 to 10.0% in 2014. The share of total value-added exports in Taiwan also increased from 10.8% to 24.9%, up by more than twice, which represents that the dependence of Taiwan's economy on China has gradually increased. Finally, Figure 5 (c) shows that the share of China exports of U.S. value-added exports to China, and that of the total value-added exports to China has decreased, meaning China economy's dependence on the United States is declining.

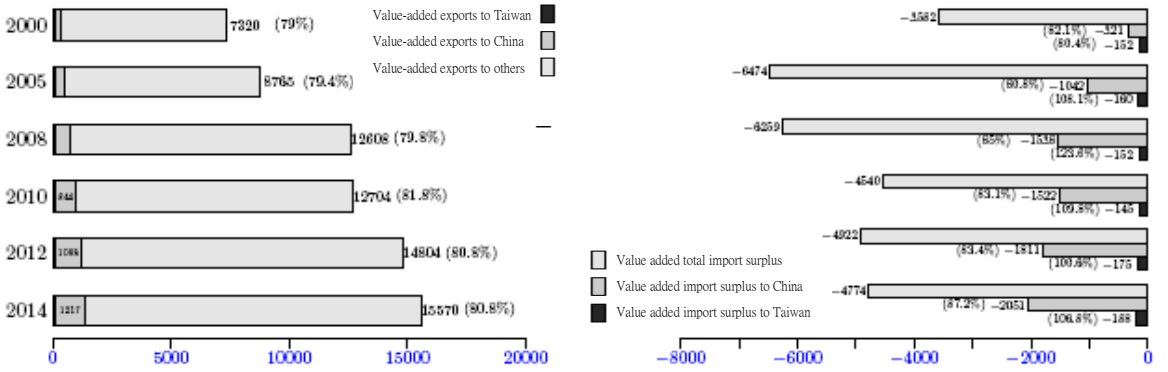
(a) Taiwan's value added export

(b) Value added export surplus in Taiwan



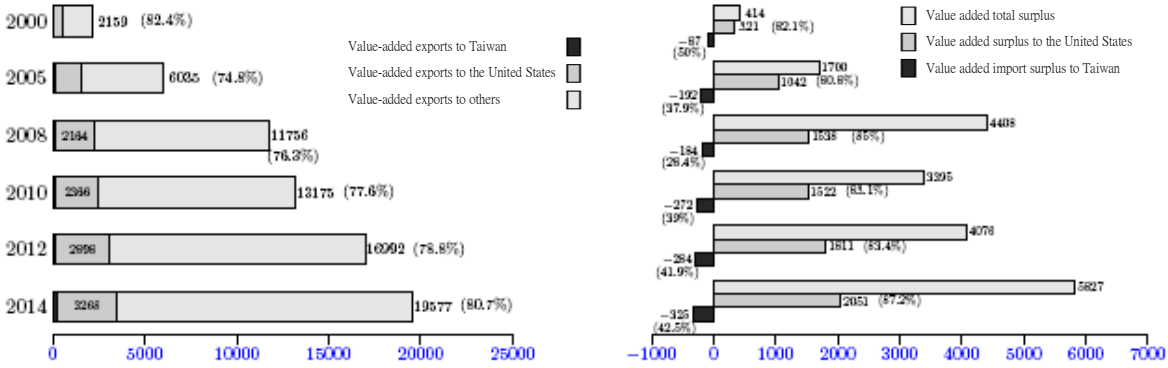
(c) USA value added export

(d) USA value added import surplus



(e) China's value added export

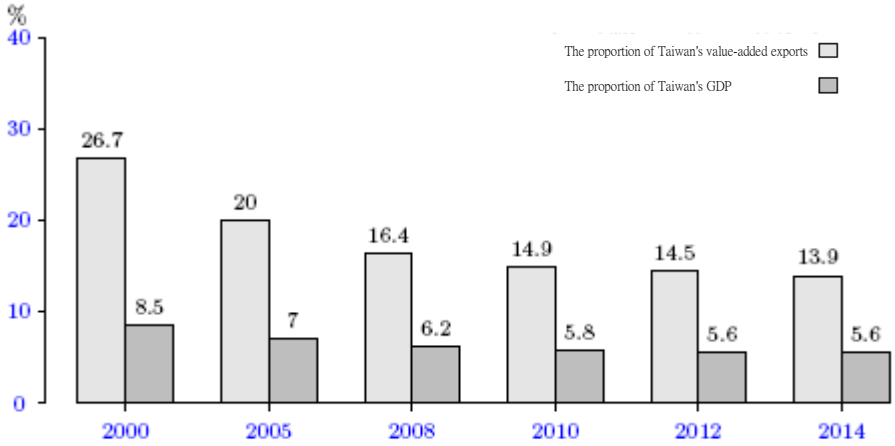
(f) Value added export surplus in China



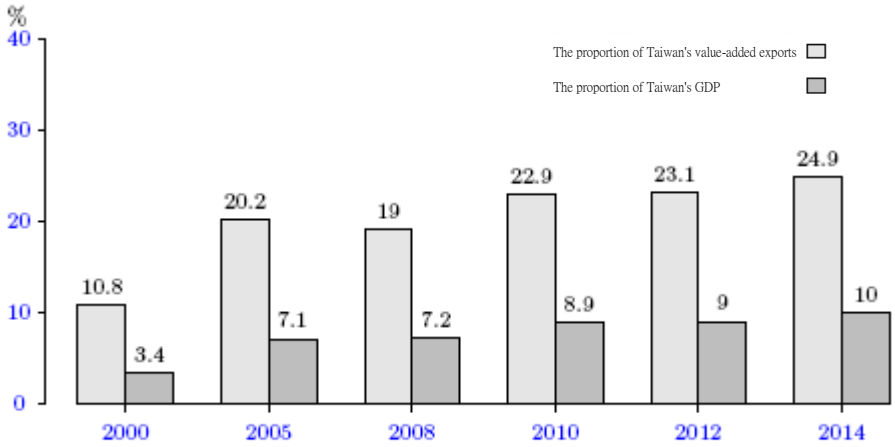
Note: The figures in brackets refer to the proportion of the current foreign trade statistics in Figure 3

Figure 4: Exports Value added and Value added Surplus(Deficit)

(a) The share of Taiwan's value-added exports to the United States



(b) The share of Taiwan's value-added exports to China



(c) The share of China's value-added exports to the United States

Figure 5: Proportion of Exports Value added

5.3 Decomposition of Bilateral Exports between Across Strait and the United States

This subsection presents the result of decomposition of total bilateral exports between Taiwan, the United States, and China. See Figure 6 and Appendix 4 ~ 12.

First of all, Figure 6 (a) shows that the proportion of value-added content earned from abroad (DVA) within Taiwan's total exports is the highest, diminishing before 2010 but slowly increasing again after 2010, reaching to 57.9% in 2014. The second largest share of value-added content grabbed by foreign countries (FVA) distributed by Taiwan from its total exports, the trend was just the opposite of DVA. However, it dropped slowly after 2011 but still reached 28.1% in 2014, mainly because the bulk of Taiwanese exports concentrated on few industries, and major in OEM, the key raw materials and components rely on imports, resulting in a higher share of foreign. Taiwan's third largest share of pure double-counted parts (PDC) also dropped after 2011, about 13.7% in 2014, while the share of total exports returning to Taiwan was small. On the whole, the content of Taiwan's exports has been developing in a benign and surplus direction. Decomposition results of Taiwan's total exports to the United States and China; we can see that the overall result is about the same, with the highest proportion of DVAs. See Figure 6 (b) and (c). The big difference is that FVA has a higher proportion of exports to the United States than its exports to China while PDC takes the opposite direction. Its share of exports to China is higher than that of the United States, indicating that the vertical division of labor across the Taiwan Strait is very close, frequent foreign transactions round trips to repeat the calculation of the relatively large number of cases.

Second, we observe the decomposition results of the total US exports. Figure 6 (d) shows that the share of value-added content earned from abroad (DVA) is the highest, at about 80%, much higher than the proportion of DVAs in Taiwan. The other three shares are relatively small. In the United States' exports to Taiwan and China, the share of DVAs remained at about 80%, indicating that the United States has greater control over the value added of exports. As for the decomposition results of China total exports, Figure 6 (g) shows that the share of value-added content earned from abroad (DVA) in China exports is the highest. In the past 15 years, the share had dropped to a lower level in mid-2000, and then slowly rebounded to 80.7% in 2014, far higher than the proportion of DVAs in Taiwan. The main reason is that in recent years, China has been actively attracting foreign manufacturers to invest and set up factories. As a result, the development of industries has increased in diversity, resulting in an increased share of value added from abroad.

In contrast, the share of value-added content grabbed by foreign countries (FVA) from China and the share of pure double-counted parts (PDC) among total China exports are lower

than those from Taiwan. Figure 6 (h) shows that DVA accounts for a relatively low proportion of DVAs in total China exports, whereas PDC and RDV account for a relatively high proportion of the total. It's the same situation with Taiwan's PDC exports to China the high share of each other, both illustrating the close division of industries across the Strait and increasing the frequency of foreign trade transactions. A closer observed the components of share of value-added content earned from aboard (DVA) shows the structural changes in exports (i.e., the DVA share of Figure 6 subdivided into two). Figure 7 (a) shows that the DVA in Taiwan's total exports mainly comes from the exports of intermediary goods, and its proportion has been on the rise. In contrast, the proportion of exports from the final exports has been gradually decreasing.

Observed Taiwan's exports to the United States, Figure 7 (b) shows that the DVA acquired by Taiwan mainly came from the exported final goods before 2004, and then it was mainly converted into the intermediate goods after 2005. Inspect of DVA Taiwan exports to China, the share of exports from intermediate goods has been high in the past 15 years. From the above trends in the DVA composition of Taiwan's exports, we can see that the Taiwanese industry's involvement in the global value chain is moving towards the middle and upper stream.

However, the analysis before this content shows that Taiwan relies on the import of upstream intermediate components and raw materials. Therefore, if the traditional import control measures are further removed or reduced, the external competitiveness of the industry will increase, and then Taiwan on the role of the upstream in the global value chain is expected to improve even more.

Second, Figures 7 (d) - (f) show the total exports of the United States and the origin of the DVAs exported to Taiwan and China respectively. The three Figures show the same trend, both of which have a higher share of exports from intermediate goods. This shows that the United States in the global value chain is upstream. Figure 7 (g) is the source of the DVA for China's total exports. This Figure shows that the proportion of exports from the final exports is higher than the share of exports from intermediate goods, but the gap between the two gradually narrows. This shows that China has played a role in a "world factory" and is relatively downstream in the global value chain but continues to move toward middle and upstream. If we observe the source of the DVA for China exports to Taiwan and because of the close vertical division of labor between the two sides of the Taiwan Strait, Figure 7(h) shows that the DVAs of China exports to Taiwan mainly come from the exports of intermediate goods.

By contrast the source of DVA for China exports to the United States, we can see from Figure 7(i) that the share of final good exports from China is a high proportion. This shows that the United States is the world's largest consumer market and matches China's comparative advantage in expanding exports.

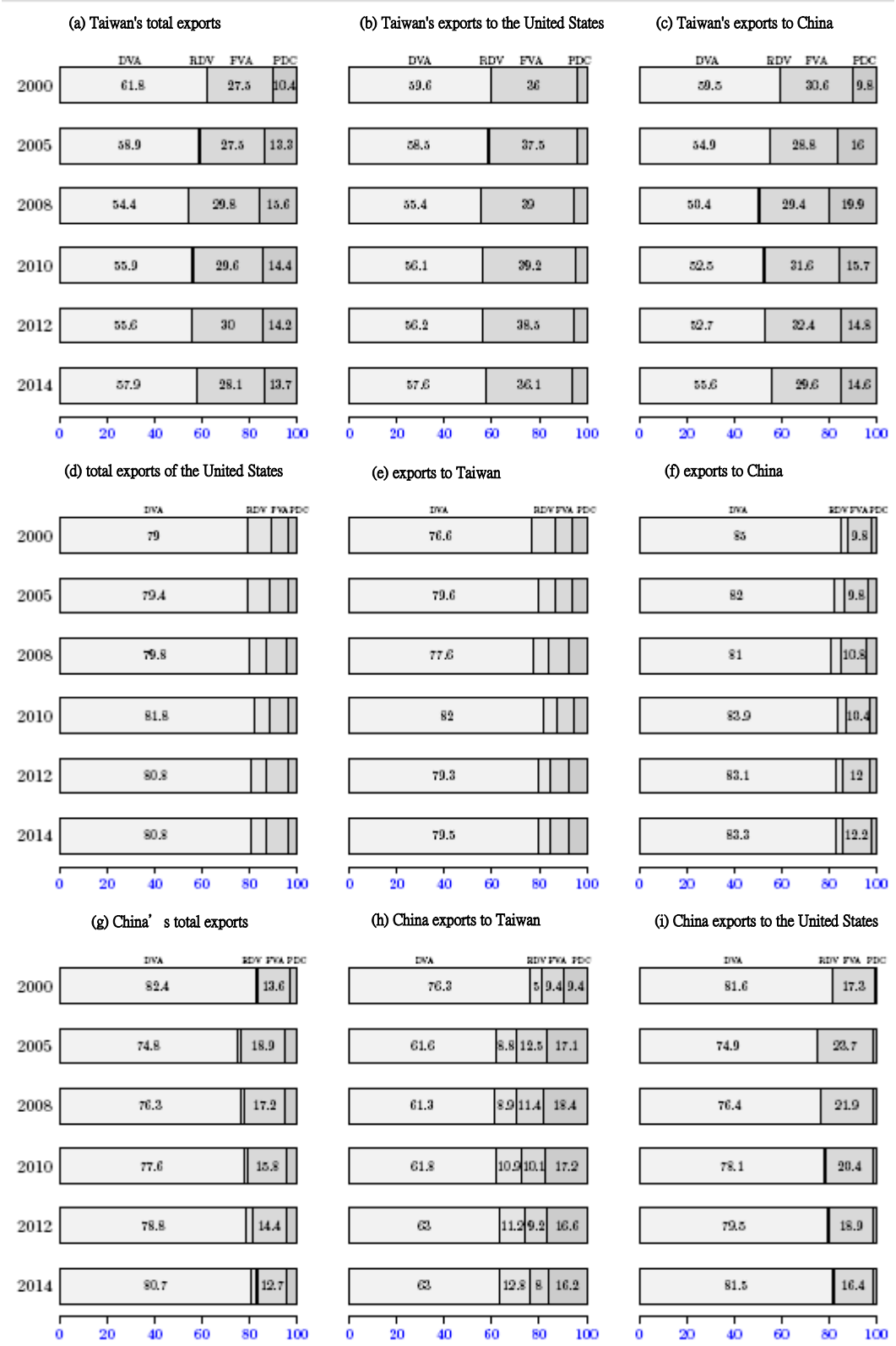


Figure6: Decomposition Total Exports of Taiwan, China and the United States

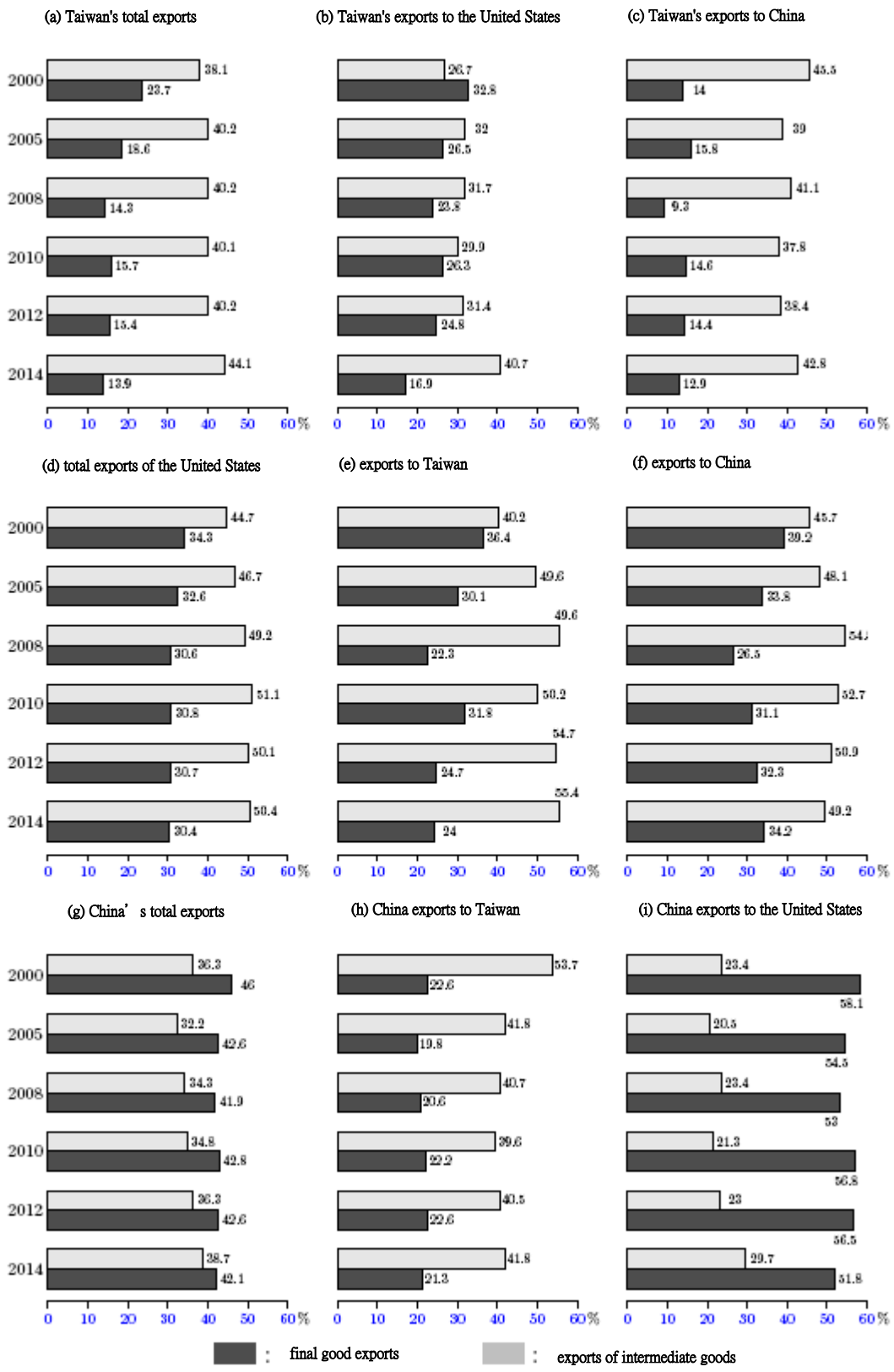


Figure 7: The Source of Exports DVA of Taiwan, China, and the United States

5.4 Comparison of Taiwan's VAX and DVA to the United States and China

Section 4.5 of this article details the relationship between value-added exports (VAX) and domestic value-added exports share (DVA). This section compares Taiwan's VAX against DVA to the United States and China.

First, Figure 8 (a) shows the VAX and DVA from Taiwan to the United States. The Figure shows that the VAX is larger than the DVA. Apart from the year 2000, the gap between the two is about 10 billion U.S. dollars. The actual value-added by the Taiwan earners from the United States is more than the superficial value added of the United States to Taiwan. The reason for this is that the United States, in addition to absorbing the value added created by trade with Taiwan, among the exports of other countries to the United States, the United States indirectly absorbed the value added created by Taiwan through other countries and caused VAX to be larger than the DVA.

Second, observe VAX and DVA from Taiwan to China. Figure 8 (b) shows that the DVA is larger than the VAX, except for 2008 and 2014, and the rest years its difference between the two is about $ 10 billion US dollars. The gap is quite same as VAX and DVA from Taiwan to the United States. However, the explanation reverses. The value added earned from China to Taiwan is less than nominal which it paid to Taiwan. The main reason is that the part of the value added paid by China to Taiwan forwarded to other countries, of which the United States is the main country. As a result, this shows that China is an important processing and transfer station for Taiwan's exports to the United States.

Finally, observe China of the United States VAX and DVA. Figure 8 (c) shows that VAX is larger than that of DVA. It is the same situation with Taiwan in the United States as shown in Figure 8 (a), which represents that the value added earned by China from the United States is more than the nominal value added that the United States has paid to China. The gap widened from 7.8 billion U.S. dollars in 2000 to 43.8 billion U.S. dollars in 2014, indicating that the products exported by China are stealthily growing in exports from other countries to the United States.

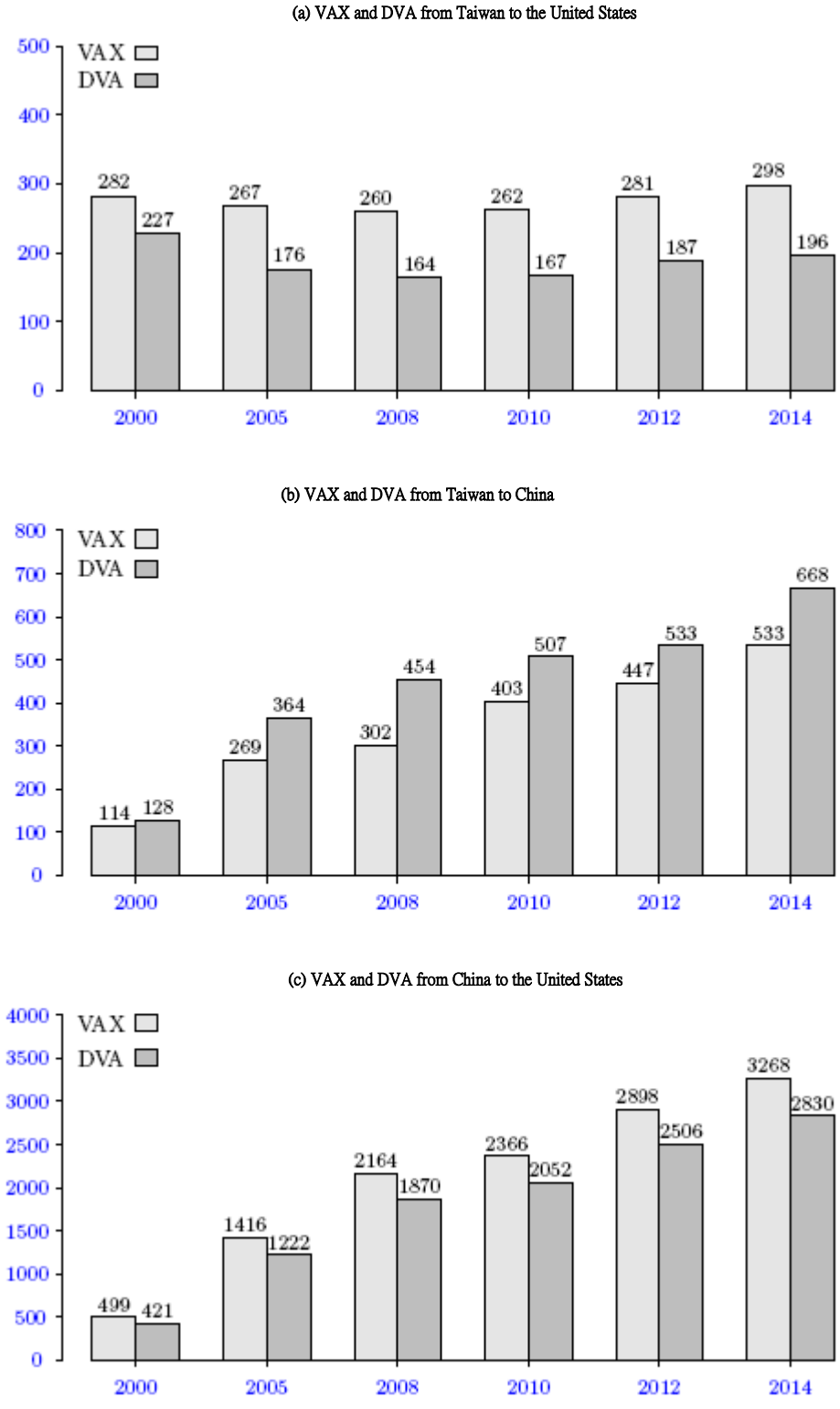


Figure 8: Value added Exports (VAX) and Share of Value-added Content Earned from Abroad (DVA)

6. Conclusion

The topic of this research is expanded to explore trade in value added and value added in trade in Taiwan, the United States, and China. The issue of trade imbalance between Taiwan, the U.S., and China, which are concerned by all walks of life today, is based on the results of traditional trade statistics. However, the traditional trade statistics method is "gross" statistics, which is different from the "net amount" of GDP statistics. As a result, the increase in the amount of foreign trade in a country does not necessarily mean that GDP has risen, causing an overestimation of the contribution of exports to GDP, and distorting a country's presentation of external competitiveness.

This article will clarify the true situation of the trade between Taiwan, the United States, and China from the perspective of the value added trade and trade in value-added. The so-called value added in trade explores the value added embedded in the source country's exports to the absorbing country as final demand, regardless of whether those goods are directly or indirectly arriving at the absorbing country. This approach is also the definition adopted by the OECD Joint Program with the WTO. As for value added in trade is originate regardless of where it is ultimately absorbed. Although the results obtained by the two methods of estimation are different, the results of both countries tend to be consistent when one country agglomerates all its trade counterparties and industrial sectors. Just as in the taxation theory, the economic end-result (a metaphor for value-added trade) and the legal end-result (for example, trade in value added) sum together and equal to the total tax.

Taiwan's value-added exports increased from US$105.6 billion in 2000 to US$214.4 billion in 2014, an increase of one-fold. If compared with the current total foreign trade statistics, Taiwan's value-added exports are much smaller than the total value of exports. The proportion of the former in the latter is less than 60%. In 2014, it was only 58.0%. Among them, Taiwan's value-added exports to the United States have declined and risen in the past 15 years, reaching US$29.8 billion in 2014, accounting for 87.4% of Taiwan's total US exports (US$35.1 billion). As for the value added of Taiwan to China, it has increased from US$11.4 billion in 2000 to US$53.3 billion in 2014, but this amount is obviously lower than the total amount of Taiwan's exports to China, accounting for only 44.4% of the total in 2014. This shows that Taiwan's exports to China contain a very high proportion of imported components, which is a contribution from abroad. If it removes, the value of exports that Taiwan obtains from China will be shrinking 55.6% than the current foreign trade statistics.

As for the bilateral trade in value added between the two countries, in the past 15 years, Taiwan's value added to the United States was slightly higher than that of traditional trade

statistics. Taiwan has surplus toward the United States. Take 2014 as an example. The former is 18.8 billion U.S. dollars. The latter was US$17.6 billion, but Taiwan's value added to China was far lower than the traditional surplus. In 2014, the former was US$32.5 billion, and the latter was US$76.4 billion. Taiwan's difference in value-added toward the United States and the China with the traditional trade statistics show different trends, mainly due to Taiwan's exports to China, many of which are assembled and processed and then exported to the United States. Finally, the United States "adsorbs" value added created by Taiwan. As a result, Taiwan's value added to the United States surplus exceeds that of traditional statistics, while the value added of Taiwan to China surplus is exceedingly low compared to the traditional situation.

Since the value-added export value derives from the foreign demand for final domestic products, the use of value-added exports as a percentage of the national GDP can be used to reflect the dependence of a country's GDP on final foreign demand. In this regard, Taiwan's share of U.S. value-added exports as a percentage of Taiwan's GDP shows a downward trend, which represents a decline in Taiwan's economic dependence on the United States. On the other hand, the value added of Taiwan exports to China as a percentage of Taiwan's GDP is on the rise and, reflecting the increasing economic dependence of Taiwan on China. The value added of China exports to the U.S. as the share of China's GDP has shown a decreasing trend, implying that the economic dependence of China on the United States has decreased.

As for the dismantling observation of total export volume, the share of domestic value-added in Taiwan's total export volume showed a downward trend until 2010, but it slowly picked up after 2010 and reached 57.9％ by 2014; the second largest share was foreign acquisitions. The share reached in 2014 was still as high as 28.1％, indicating that Taiwan's exports are mainly for foreign OEMs, and key original components rely on imports, resulting in a higher share of foreign acquisitions. If we look closely at the result of the dismantling of Taiwan's total exports to the United States and China, it is roughly the same as the dismantling result of Taiwan's overall exports. The major difference is that the proportion of foreign share in exports to the United States accounts higher than the proportion of exports to China. The proportion of purely duplicated shares in the export of China than the United States is higher, indicating that there is a close vertical division of labor between the two sides of the strait, and frequent repetitive calculations of the total amount of exports caused by the frequent return of foreign trade.

A closer look at the source of the domestic value-added of Taiwan's exports is mainly due to the export of intermediate goods, and the proportion is increasing. On the contrary, the proportion of the final goods exports has gradually declined. Among them, the export to the

United States was mainly from the final goods exports before 2004, and it transformed to mainly intermediate goods exports after 2005.

As for Taiwan's exports to China, the proportion of exports from intermediate goods has been higher in the past 15 years. This shows that Taiwan's industry is participating in global value chain activities and moving to the upper and middle streams. However, due to Taiwan's reliance on imports of upstream intermediate components and raw materials, the role of Taiwan in the global value chain will increase if traditional import control measures are further removed or reduced to increase the competitiveness of the industry. Comparison of Taiwan to the United States and Taiwan to China's VAX and DVA, Taiwan's actual value added earned from the United States is greater than the apparent the United States paid. Itis because the United States has absorbed the US's bilateral trade exchanges from Taiwan and the United States. Also, VAX is larger than DVA because the value added created by Taiwan is invisible in other countries' exports to the United States, and the United States also indirectly absorbs the value added created by Taiwan through other countries.

Secondly, the value added that Taiwan earns from China is less than China has apparently paid to for Taiwan. The main reason is that part of the value added that China has paid to Taiwan is passed on to other countries, and the United States is the main absorbing country. It shows that China is an important processing and transfer station for Taiwan's exports to the United States. As for the value added that China earned from the United States is greater than the United States has apparently paid to China. The gap between the two shows an expanding trend, indicating that the products exported by China are stealthy among other countries' exports to the United States, and scale is becoming increasingly large.

Comparing the estimation results, we can see that the economic development status of Taiwan, the United States, and China are different over the years. First of all, although the statistics on foreign trade in the three countries are increasing year by year, compared to the United States and China, the ratio of Taiwan's value-added gained, and growth rate in the trade process is relatively slow. Secondly, in respect of individual industries, in the past, the main trade object of Taiwan's computer, electronic and optical products industry was the United States. From 2000 to 2014, Taiwan's export and linkage effects with the United States gradually decreased. On the contrary, the effect of the linkage on China gradually increased.

The results of the study show that in the process of international trade production and processing Taiwan has increasingly relied on cross-strait economic and trade cooperation. Regarding overall economic development and trade import and export, Taiwan's trade structure tend to be on China. The government should appropriately conduct tariffs, offshore transactions, trade negotiations and cooperation centers and other relevant influences in cross-

strait economic for policy adjustments. Compared with the trade between Taiwan and China in recent years, and the exports on Taiwan forward to the United States, the empirical analysis of this study shows that the share of value added Taiwan gained has been decreasing year by year, and the share of Taiwan's returns to Taiwan has been almost zero. It suggests that Taiwan's industries can adjust through product upgrades and technological innovations during the Taiwan-US trade interaction; increase products of high value added and volume of foreign trade to improve the share of value added in trade Taiwan to the US.

Another aspect that is worth paying attention is that, from the empirical results, it can be found that the coming and going of international trade involves the locally available share, the returned share, the share of the export place, and the possible duplicate calculation share; these data reflect international trade region, trade surpluses and deficits between different regions cannot be analyzed simply by relevant statistics on policies. The trade negotiations between Taiwan and other countries must be able to further study the various shares in the trade process to formulate relevant policies, for providing a more accurate reference.

Because the statistics of bilateral or multilateral trade data collected by various governments are not the same, the WIOD database used in this study base on the integration and estimation of input and output data and trade data of various products or industrial sectors in various countries, and with various governments. The published bilateral or multilateral trade statistics are inevitably somewhat inconsistent. Before quoting the research results of this report, the public should first understand the sources and methods of calculation, content for use and reference

Reference

Lin J. S., Y. R. Lin, S. M. Lin (2017), "Multi-lateral Value –Added Trade Cross-Strait Trading Relationship," *Taiwan Economic Forecasting and Policy*, 47：2, 37-77.

Liou, R. W., H. C. Lin, C. C. Chang, H S. Hsu (2016), "The Global Value Chain Analysis of Cross-Strait Trade," *Agriculture and Economics*, 57. 1-39.

Antras, P (2013), Firms, contracts and global production, CREI Lectures in *Macroeconomics*, Chapter 1.

Backer, K.D. and S. Miroudot (2012), *Mapping gobal value chains,* OECD Trade Policy Papers, No. 159, OECD publishing.

Balassa, B. (1967), *Trade liberalization among industrial countries：objectives and alternatives*, New York：McGraw Hill for the Council on Foreign Relations,

Dedrick, J., Kraemer, K.L. and Linden, G. (2010), "Who profits from innovation in global value chains? a study of the iPod and notebook PCs," *Industrial and Corporate Change*, 19：1, 81-116.

Dietzenbacher, E., B. Los, R. Stehrer, M.P. Timmer and G.J. de Vries (2013), "The construction of world input-output tables in the WIOD Project," *Economic Systems Research,* 25, 71-98.

Feenstra, R. (1998), "Integration of trade and disintegration of production in the global economy," *Journal of Economic Perspectives,* Fall, 31-50.

Foster-McGregor, N. and R. Stehrer (2013), "Value added content of trade：a comprehensive approach," *Economics Letters,* 120：2, 354-357.

Gereffi，G. and K. Fernandez-Stark (2011), *Global value chain analysis：a primer*, Center on Globalization, Governance & Competitiveness, Duke University, North Carolina, USA.

Hummels, D., J. Ishii and K. M. Yi (2001), "The nature and growth of vertical specialization in world trade," *Journal of International Economics,* 54, 75-96.

IDE-JETRO (2006), Asian International Input-Output Table 2000, IDE-JETRO, Tokyo, Japan.

Johnson, R. C. and G. Noguera (2012), "Accounting for intermediates：production sharing and trade in value added." *Journal of International Economics,* 87, 105-111.

Koopman, R., Z. Wang and S.J. Wei (2014), "Tracing value-added and double counting in gross exports," *American Economic Review,* 104：2, 459-94.

Liou, R. W，H.C. Lin, C. C. Chang and S. H. Hsu (2016), "Unveiling the true value of across-strait trade：The global value chain approach," *China Economic Review*, 41, 159-180.

Miroudot, S., R. Lanz and A. Ragoussis (2009), *Trade in intermediate goods and services*, OECD Trade Policy Working Papers, No. 93. OECD publishing.

OECD (2012)，*Trade in value-added：concepts, methodologies and challenges*, Paris：Organization for Economic Co-operation and Development. (Joint OECD-WTO Note)

OECD (2013), *Trade in intermediate goods and international supply chains in CEFTA*, CEFTA Issues Paper 6.

Stehrer, R. (2012), *Trade in Value Added and the Value Added in Trade*, WIOD Working Paper 8, 1-19.

Sturgeon, T. J. and O Memedovic (2010), *Mapping Global Value Chains：Inter-mediate Goods Trade and Structural Change in the World Economy*, United Nations Industrial Development Organization, Working Paper 05/2010.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015), "An illustrated user guide to the World input-output database：the case of global automotive production," *Review of International Economics*, 23, 575-605.

Trefler, D. and S. C. Zhu (2010), "The structure of factor content predictions," *Journal of International Economics*, 82, 195-207.

United Nations (2009), *United Nations COMTRADE*, International Trade Statis-tics Yearbook，New York.

Wang, Z., S. J. Wei, and K. Zhu (2013), *Quantifying international production sharing at the bilateral and sector levels*, NBER Working Paper 19677.

World Input-Output Database (2011), *World Input-Output Tables. World Input-Output database*, funded by the European Commission. Downloadable at：http：//www.wiod.org/new_site/database/with.htm