Unveiling the Value-Added of Cross-Strait Trade: The Global Value Chains Approach

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Abstract

With global value chains pervasive over the recent years, larger and larger bulk of imported intermediate components and raw materials from other countries are entangled in Taiwan's exports to Mainland China, leading to odd cross-trait bilateral trade amounts and surplus favorable toward Taiwan. The purpose of this paper is to extricate value-added exports earned by Taiwan from China and decompose Taiwan's gross exports to China into various meaningful components. The two issues are related to trade in value added and value added in trade respectively. Specifically, the former explores the value added embedded in source country's exports to absorbing country as final demand, irrespective of whether those goods are directly or indirectly through other countries arriving at the absorbing country. The latter investigates the value-added contents within the bilateral trade.

The empirical results indicate that Taiwan's export values to Mainland China shrink 64.3% when bilateral trades are measured in value-added terms. Taiwan's trade surplus toward China will also decrease by 65.2%. From the viewpoint of value added in trade, the share of value added embodied in Taiwan's gross exports to China continued to decrease and reached 50.9% in 2011, while the components of foreign value added and pure double counted terms kept growing in recent years.

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1. Introduction

As the tension eases across Taiwan Strait, the economic ties between Taiwan and Mainland China are strengthened over the recent years. Powered by China's vast consumer market and rapid industrial demand, the cross-trait bilateral trades soared drastically. According to customs statistics by the Ministry of Finance, Taiwan's exports to Mainland China (including Hong Kong) amounted to US$ 121.2 billion in 2013, which was higher than exports to the traditional U.S. market and accounted for 39.7% of Taiwan's total exports. Taiwan enjoyed a US$ 77.0 billion surplus toward China, which was more than double of Taiwan's overall surplus. Despite the close economic relationship between Taiwan and China, concerns about too much reliance on China deepen in Taiwan's society. Indeed, these superficial trade statistics from the conventional methodology has gradually revealed deficiencies in signaling external competitiveness and tends to exaggerate China's influence on Taiwan. As such, the purpose of this paper is to unveil the true value of cross-strait trade.

According to the existing practices of custom statistics, the exported and imported goods are recorded every time they enter or exit the border. With global value chains (GVC) flourishing in recent years, this conventional trade statistics not only fails to highlight the vertical specialization among different countries, but also distorts the measurement of a country's competitiveness (Backer and Miroudot, 2012).

Value chain is an activity that manufacturers adopt to transform the products from their initial state to end use (Gereffi and Fernandez-Stark, 2011). In the past, most producers used to conduct all production process in one location. Nowadays, more and more firms split their value chains into various many parts such as design, production, sale and so on, and relocate them to different regions. The main drivers of GVCs are declining transport, information and communication costs, the sharp increase in technological progress and lower political and economic barriers to trade and capital flow in the last two decades. The rise of GVC has contributed to widespread geographical fragmentation of production and outsourcing in world economy. As every country specializes in only one task instead of conducting the whole production steps, exported goods may require significant intermediate imports. So, much of the

revenue, or value added, from selling the exported goods may accrue abroad to reflect purchases of intermediate imports used in production, leaving only marginal benefits in exporting economy. Under such situation, it is obvious that gross recording of trade flows can be misleading when one crudely relates it with domestic value added and national income, or its components such as profit or wage and by extension, employment.

A well-known case study that clearly illustrates the aforementioned issue relates to the production of an Apple iPod (Dedrick *et al.*, 2010). This study showed that of the US$ 144 Chinese factory-gate price of an iPod, less than 10% contributed to Chinese value added, with bulk of the components being imported from Japan, U.S. and Korea. As a final assembler of such products as iPod, China's export values embody those intermediate imports, leading to high export amounts and huge surplus with US. A recent WTO report calculated that the US-China trade balance would be about 40% lower if estimated in value-added terms.

Similar phenomenon takes place in Taiwan's trades with Mainland China. This paper tries to uncover the value added acquired by Taiwan in its exports to China and decompose that export values into various meaningful components. The two issues are related to trade in value added and value added in trade respectively (Stehrer, 2012). In specific, the former explores the value added embedded in source country's exports to absorbing country as final demand, irrespective of whether those goods directly or indirectly going through other countries arrive at the absorbing country. The latter investigates the value-added contents within the bilateral trade.

To attain the objectives of this paper, we use the inter-country input-output (ICIO) table rather than the trade statistics as the latter not only lack information on value-added coefficients but also are unable to track how an importing country uses its imported goods. Instead, the ICIO table endows with cost structures of industries as well as trade information, facilitating in keeping track of the flow of products and value-added (IDE-JETRO, 2006, GTAP database, OECD, 2012 and the World Input-Output Database by Timmer *et al*. 2012).

The value added exports can be easily calculated by applying the Leontief's forward-linkage based effect. Johnson and Noguera (2012) proposed the value-added exports to gross exports ratio, or VAX ratio, as a measure of international production sharing.

As to decomposing export values, Koopman *et al.* (2014) first broke down the gross exports into nine items. While Koopman *et al.* (2014) already has many useful application, an important limitation of that approach is that the gross trade decomposition is only done at the aggregate level. Wang *et al.* (2013) provide a new and comprehensive methodological framework that decomposes bilateral sector level gross exports into detailed 16 items which can also be grouped

as four main categories, ie. the domestic value added absorbed (DVA), value added first exported but eventually returned home (RDV), foreign value added (FVA) and pure double counted terms (PDC). In this paper, we apply the methodology of Wang *et al.* (2013) on analyzing the components within the cross-strait trade.

The empirical results indicate that the Taiwan's export values to Mainland China shrink 64.3% when bilateral trades are measured in value-added terms. Taiwan's trade surplus toward China will also decrease by 65.2%. From the viewpoint of value added in trade, the share of value added embodied in Taiwan's gross exports to China continued to decrease and reached 50.9% in 2011, while the components of foreign value added and pure double counted terms kept growing in recent years.

The structure of this study is as follows: the second section introduces the WIOD, the third section explains the methods of estimating value-added exports and the decomposition of gross exports. Then we elaborate the data source and the result analysis in the fourth and fifth sections, finally we conclude in the final section.

2. The structure of global input-output table

To better understand how the Leontief insight is applied in this paper, we first assume there are *G* countries in the world, and each country produces *N* differentiated tradable goods which can be used as final demands or intermediate inputs. The *G* countries by *N* products system can be expressed by equation (1).

$$\begin{bmatrix} \mathbf{X}^1 \\ \vdots \\ \mathbf{X}^r \\ \vdots \\ \mathbf{X}^G \end{bmatrix} = \begin{bmatrix} \mathbf{A}^{11} & \cdots & \mathbf{A}^{1r} & \cdots & \mathbf{A}^{1G} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{A}^{r1} & \cdots & \mathbf{A}^{rr} & \cdots & \mathbf{A}^{rG} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \mathbf{A}^{G1} & \cdots & \mathbf{A}^{Gr} & \cdots & \mathbf{A}^{GG} \end{bmatrix} \begin{bmatrix} \mathbf{X}^1 \\ \vdots \\ \mathbf{X}^r \\ \vdots \\ \mathbf{X}^G \end{bmatrix} + \begin{bmatrix} \mathbf{Y}^{11} + \cdots \mathbf{Y}^{1r} + \cdots \mathbf{Y}^{1G} \\ \cdots \quad \cdots \quad \cdots \quad \cdots \\ \mathbf{Y}^{r1} + \cdots \mathbf{Y}^{rr} + \cdots \mathbf{Y}^{rG} \\ \cdots \quad \cdots \quad \cdots \quad \cdots \\ \mathbf{Y}^{G1} + \cdots \mathbf{Y}^{Gr} + \cdots \mathbf{Y}^{GG} \end{bmatrix}, \qquad (1)$$

where **Xr** is a *N* × *1* gross output vector of country *r*, *r* =1, 2,...,G. **Asr** is a *N* × *N* intermediate input coefficient matrix of country r from country s. **Ysr** is a *N* × *1* final demand vector absorbed by country *r* from country *s*. Therefore, the final demand vector of country *r* is the summation of both domestic and foreign demand of final goods $\sum_{s=1}^{G} \mathbf{Y^{sr}}$, and the final goods produced by country *r* comprise of sales to domestic and foreign market $\sum_{u=1}^{G} \mathbf{Y^{ru}}$.

Next, let **V** represent the primary input coefficient vector of the global input-output table,

ie. $\mathbf{V} = [\mathbf{V}^1, \mathbf{V}^2, \cdots, \mathbf{V}^G]$. where $\mathbf{V}^r$ is a $1 \times N$ primary input coefficient vector of country r, r =1, 2,...,G. Assume **A** denotes the $GN \times GN$ global intermediate input coefficient matrix shown in the first term on the RHS of equation (1), then **V** can also be written as $\mathbf{V} = \mathbf{i}'(\mathbf{I}-\mathbf{A})$ where i is a $GN \times 1$ unit vector and **I** identity matrix.

One of the distinguished differences between the world and classical IO table lies on how to express the exports of goods and services. Specifically, within the world IO table, the intermediate sector encompasses exports of intermediate products while final demand sectors includes only exports of final products, ie., $\mathbf{Y}^{sr}$, $s \neq r$. In the classical IO table, final demand sectors comprise exports of both final and intermediate products.

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

$$\mathbf{E}^{sr} = \mathbf{Y}^{sr} + \mathbf{A}^{sr}\mathbf{X}^{r}, \qquad s, r = 1,2,\dots,G, \; s \neq r \tag{2}$$

where $\mathbf{E}^{sr}$ is a $N \times 1$ vector, the elements of which are products exported from country s to country r. $\mathbf{Y}^{sr}$ and $\mathbf{A}^{sr}\mathbf{X}^{r}$ represents vector of final and intermediate goods respectively absorbed by Country r from country s.

Equation (1) goes through Leontief's inverse operation,

$$\begin{bmatrix} \mathbf{X}^1 \\ \vdots \\ \mathbf{X}^r \\ \vdots \\ \mathbf{X}^G \end{bmatrix} = \begin{bmatrix} \mathbf{I}-\mathbf{A}^{11} & \cdots & -\mathbf{A}^{1r} & \cdots & -\mathbf{A}^{1G} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ -\mathbf{A}^{r1} & \cdots & \mathbf{I}-\mathbf{A}^{rr} & \cdots & -\mathbf{A}^{rG} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ -\mathbf{A}^{G1} & \cdots & -\mathbf{A}^{Gr} & \cdots & \mathbf{I}-\mathbf{A}^{GG} \end{bmatrix}^{-1} \begin{bmatrix} \sum_{u=1}^{G}\mathbf{Y}^{1u} \\ \vdots \\ \sum_{u=1}^{G}\mathbf{Y}^{ru} \\ \vdots \\ \sum_{u=1}^{G}\mathbf{Y}^{Gu} \end{bmatrix}$$

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

Denote the $GN \times GN$ Leontief's inverse matrix in (3) as **B**, then the element $\mathbf{B}^{sr}$ of which represents the overall production effects of country s induced by unit final demand increase of country r. When the primary input coefficient vector **V** is multiplied by the Leontief's inverse matrix **B**, it turns out as follows:

$$\mathbf{VB} = \mathbf{i}'(\mathbf{I}-\mathbf{A})(\mathbf{I}-\mathbf{A})^{-1} = \mathbf{i}'.$$

(4)

3. Value-added exports and decomposition of exports

3.1 Value-added exports

Value-added exports refer to the amount of domestic value added embedded in source country's gross exports to absorbing country as final demand, irrespective of whether those goods directly or indirectly going through other countries arrive at the absorbing country. This subsection briefly discusses the ways of using Lenotief's forward-linkage based measure to derive the value-added exports.

To clarify the concept of value-added exports, the authors assume there is a "two countries by one product" world IO table in which the final demand sector can be expressed by following 2 × 2 matrix:

$$\mathbf{Y} = \begin{bmatrix} y_{11} & y_{12} \\ y_{21} & y_{22} \end{bmatrix},$$

where y_{11} denotes demand of country 1 for final goods produced by itself, y_{12} gives demand of country 2 for final goods produced and exported by country 1. By the same token, y_{21} denotes demand of country 1 for final goods produced and exported by country 2 and y_{22} demand of country 2 for final goods produced by itself.

Similar to classical input-output analysis, by seeing **Y** as an exogenous variable, we can easily use the following equation to solve the elements related to value added.

$$\widehat{\boldsymbol{V}}\boldsymbol{B}\boldsymbol{Y} = \begin{bmatrix} v_1 b_{11} y_{11} + v_1 b_{12} y_{21} & v_1 b_{11} y_{12} + v_1 b_{12} y_{22} \\ v_2 b_{21} y_{11} + v_2 b_{22} y_{21} & v_2 b_{21} y_{12} + v_2 b_{22} y_{22} \end{bmatrix}, \quad (5)$$

where the main diagonal elements are domestic value added earned by each country due to selling goods it produces. Take the first element of the first row for an example, $v_1 b_{11} y_{11}$ is value added induced by production of country 1 to satisfy its own domestic final demand, meanwhile $v_1 b_{12} y_{21}$, also value added of country 1, results from exporting intermediate goods to country 2 which, in turns, uses those imported products to produce final goods and sell back to country 1.

The off-diagonal elements in equation (5) represent the value-added exports of each country. For example, the first term, $v_1 b_{11} y_{12}$, in the second element of the first row represents value added earned by country 1 embodied in its exports of final goods to country 2, and the second term, $v_1 b_{12} y_{22}$, is country 1's value added embodied in its exports of intermediate goods to

country 2. By the same token, the first element of the second row, $v_2 b_{21} y_{11} + v_2 b_{22} y_{21}$, is country 2's value added embedded in its exports of intermediate and final goods to country 1.

If the number of countries exceeds two and each country produces *N* differentiated products in the world IO table, then, by using the elements from the outcome of the multiplication $\widehat{\mathbf{V}}\mathbf{B}\mathbf{Y}$, we can denote the value-added exports earned by country *s* from country *r* as

$$\mathrm{VAX}^{\mathrm{sr}} = \widehat{\boldsymbol{V}^{\boldsymbol{s}}}\boldsymbol{B}^{\boldsymbol{ss}}\boldsymbol{Y}^{\boldsymbol{sr}} + \widehat{\boldsymbol{V}^{\boldsymbol{s}}}\boldsymbol{B}^{\boldsymbol{sr}}\boldsymbol{Y}^{\boldsymbol{rr}} + \widehat{\boldsymbol{V}^{\boldsymbol{s}}}\sum_{\boldsymbol{t\neq s,r}}^{\boldsymbol{G}}\boldsymbol{B}^{\boldsymbol{st}}\boldsymbol{Y}^{\boldsymbol{tr}}, \qquad s,r = 1,2,\dots,G, s \neq r.$$

The first and second term on the right hand side are value added induced because country *r* directly absorbs the final and intermediate goods exported from country *s*. The third term on the right hand side comprises value added indirectly created because the intermediate goods produced by country *s* go through processing first in other countries and then are exported to country *r* for final absorption.

Generally speaking, the net trade in value added on bilateral country or bilateral sectors (ie. value-added exports minus value-added imports) does not equal to the net exports of conventional gross trades. However, once aggregating over all trading partners and traded goods, the two differently-defined net values come to equivalence. This means that in estimating a country's domestic products (GDP) from expenditure side, the results won't change if gross exports and imports of products and services are replaced by value-added exports and imports respectively. With our "two countries by one product" case in the subsection, this indicates

$\mathrm{VA}X^{12} - \mathrm{VA}X^{21} = \boldsymbol{E^{12}} - \boldsymbol{E^{21}}$.[1]

Johnson and Noguera (2012) used the value-added exports to gross exports ratio, or the VAX ratio, as inverse measure of the importance of vertical specialization in the world produc-

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[1] Proof as follows,

$$\begin{aligned}
\mathrm{VAX}^{12} - \mathrm{VAX}^{21} &= v_1 b_{11} y_{12} + v_1 b_{12} y_{22} - v_2 b_{21} y_{11} - v_2 b_{22} y_{21} \\
&= v_1 b_{11} y_{12} + v_1 b_{12} y_{22} - (1 - v_1 b_{11}) y_{11} - (1 - v_1 b_{12}) y_{21} \\
&= v_1 [b_{11}(y_{11} + y_{12}) + b_{12}(y_{21} + y_{22})] - y_{21} - y_{11} \\
&= v_1 x_1 - y_{21} - y_{11} \\
&= v_1 x_1 + y_{12} - y_{21} - y_{11} - y_{12} \\
&= v_1 x_1 + y_{12} - y_{21} + a_{11} x_1 + a_{12} x_2 - x_1 \\
&= a_{12} x_2 + y_{12} - (1 - a_{11} - v_1) x_1 - y_{21} \\
&= a_{12} x_2 + y_{12} - a_{21} x_1 - y_{21} \\
&= E^{12} - E^{21}.
\end{aligned}$$

The fourth equalization utilizes the property of Leontief's inverse for inducing production of x_1 , and the sixth equalization uses the distribution property of x_2 as summation of intermediate and final demand in world IO table.

tion. As the value-added exports of an industry include the value-added contribution embodied in exports of its downstream industries, this may cause some problems in practical application of the VAX ratio. For example, the service of transportation is one of the intermediate inputs to automobile or mobile phone's production. Thus, the value-added exports of transportation include the value-added contribution embodied in the exports of those two sectors. However, in one case the sector of transportation has no direct gross exports, this may lead to the VAX ratio of transportation sector undefined. In another case the gross exports of the transportation sector are small, then, the VAX ratio is not bounded under one.

This subsection emphasizes the residence of exported goods in calculating value-added exports, ie. the source of bilateral value-added exports comprising those value-added contribution embodied in not only direct exports, but also exports via other countries to the final absorbing partner. As the boundary of value-added exports includes the indirect trades, the bilateral value-added exports are not guaranteed to be less than the conventional gross export value. Unlike this property of value-added exports, the value-added content resulted from decomposing gross exports by means of Wang *et al.* (2013) belongs to one part of gross exports and thus is definitely less than the value of bilateral gross exports. However, value-added content within gross exports includes a portion of value added that is contributed by third-party countries. In the next subsection, we will introduce the decomposition methodology developed by Wang *et al.* (2013).

3.2 Decomposition of exports

Equation (2) reveals gross exports consist of two terms: final and intermediate goods exports. We explain how to decompose these two terms sequentially as follows.

3.2.1 Decomposition of final goods exports

In this subsection, we explain the decomposition of final goods exports vector **Ysr** shown in the first term on the right hand side of equation (2). According to equation (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 s^{th} column of matrix **B** and multiply it by vector **V**. This results in a $1 \times G$ vector with unity elements as follows.

$$\sum_{t=1}^{G}\mathbf{V}^{t}\mathbf{B}^{ts}=\begin{bmatrix}1 & 1 & \cdots 1\end{bmatrix}_{(1\times G)}=\mathbf{V}^{s}\mathbf{B}^{ss}+\mathbf{V}^{r}\mathbf{B}^{rs}+\sum_{t\neq s,r}^{G}\mathbf{V}^{t}\mathbf{B}^{ts}. \quad (6)$$

While transposing equation (6), the three terms on its right hand side: $(\mathbf{V^{s}B^{ss}})'$,$(\mathbf{V^{r}B^{rs}})'$ and $(\sum_{t=1}^{G}\boldsymbol{V^{t}B^{ts}})'$, can be seen as weight vectors with summation of element on the same position of each vector equalizing 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 as follows.

$$\mathbf{Y}^{sr}=\begin{bmatrix}1\\ \vdots\\ 1\end{bmatrix}\#\mathbf{Y}^{sr}=\left((\mathbf{V}^{s}\mathbf{B}^{ss})'+(\mathbf{V}^{r}\mathbf{B}^{rs})'+(\sum_{t\neq s,r}^{G}\mathbf{V}^{t}\mathbf{B}^{ts})'\right)\#\mathbf{Y}^{sr}$$

$$=\underbrace{(\mathbf{V}^{s}\mathbf{B}^{ss})'\#\mathbf{Y}^{sr}}_{1^{\text{st}}}+\underbrace{(\mathbf{V}^{r}\mathbf{B}^{rs})'\#\mathbf{Y}^{sr}}_{2^{\text{nd}}}+\underbrace{(\sum_{t\neq s,r}^{G}\mathbf{V}^{t}\mathbf{B}^{ts})'\#\mathbf{Y}^{sr}}_{3^{\text{rd}}}. \quad (7)$$

To better understand each term on the right hand side of equation (7), 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 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* now turns to third country 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 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 classical input-output model. We will discuss how Wang *et al*. (2013) decomposed the intermediate goods exports into various components in the next subsection.

3.2.2 Decomposition of intermediate goods exports

In decomposing the intermediate goods exports vector $\mathbf{A}^{sr}\mathbf{X}^{r}$ shown in the second term on the right hand side of equation (2), 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 equation (7), the intermediate goods exports vector $\mathbf{A}^{sr}\mathbf{X}^{r}$ can undergo the following decomposition steps.

$$\begin{aligned}
\mathbf{A}^{sr}\mathbf{X}^{r} &= \begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix} \#(\mathbf{A}^{sr}\mathbf{X}^{r}) = \left((\mathbf{V}^{s}\mathbf{B}^{ss})' + (\mathbf{V}^{r}\mathbf{B}^{rs})' + (\sum_{t\neq s,r}^{G} \mathbf{V}^{t}\mathbf{B}^{ts})' \right) \#(\mathbf{A}^{sr}\mathbf{X}^{r}) \\
&= \left((\mathbf{V}^{s}\mathbf{L}^{ss})' + (\mathbf{V}^{s}\mathbf{B}^{ss})' - (\mathbf{V}^{s}\mathbf{L}^{ss})' + (\mathbf{V}^{r}\mathbf{B}^{rs})' + (\sum_{t\neq s,r}^{G} \mathbf{V}^{t}\mathbf{B}^{ts})' \right) \#(\mathbf{A}^{sr}\mathbf{X}^{r}) \\
&= (\mathbf{V}^{s}\mathbf{L}^{ss})' \#(\mathbf{A}^{sr}\mathbf{X}^{r}) + \left(\mathbf{V}^{s}\mathbf{B}^{ss} - \mathbf{V}^{s}\mathbf{L}^{ss} \right)' \#(\mathbf{A}^{sr}\mathbf{X}^{r}) + (\mathbf{V}^{r}\mathbf{B}^{rs})' \#(\mathbf{A}^{sr}\mathbf{X}^{r}) \\
&\quad + (\sum_{t\neq s,r}^{G} \mathbf{V}^{t}\mathbf{B}^{ts})' \#(\mathbf{A}^{sr}\mathbf{X}^{r}). \qquad (8)
\end{aligned}$$

The right hand side of the third equalization has been inserted the $\pm(\mathbf{V}^{s}\mathbf{L}^{ss})'$ 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 pertaining to $\mathbf{X}^{r}$, the gross outputs produced by country *r*. First, by using the elements within the Leontief's inverse matrix **B** shown in equation (3), $\mathbf{X}^{r}$ is the overall output induced by domestic and foreign final demands and, hence, can run through the following transformation:

$$\begin{aligned}
\mathbf{X}^{r} &= \sum_{t=1}^{G} \mathbf{B}^{rt} \sum_{u=1}^{G} \mathbf{Y}^{tu} = \mathbf{B}^{rr} \sum_{u=1}^{G} \mathbf{Y}^{ru} + \mathbf{B}^{rs} \sum_{u=1}^{G} \mathbf{Y}^{su} + \sum_{t\neq r,s}^{G} \mathbf{B}^{rt} \sum_{u=1}^{G} \mathbf{Y}^{tu} \\
&= \mathbf{B}^{rr}\mathbf{Y}^{rr} + \mathbf{B}^{rr}\mathbf{Y}^{rs} + \mathbf{B}^{rr} \sum_{t\neq r,s}^{G} \mathbf{Y}^{rt} + \mathbf{B}^{rs}\mathbf{Y}^{ss} + \mathbf{B}^{rs} \sum_{t\neq s}^{G} \mathbf{Y}^{st} + \sum_{t\neq r,s}^{G} \mathbf{B}^{rt}\mathbf{Y}^{ts} \\
&\quad + \sum_{t\neq r,s}^{G} \mathbf{B}^{rt}\mathbf{Y}^{tt} + \sum_{t\neq r,s}^{G} \sum_{u\neq s,t}^{G} \mathbf{B}^{rt}\mathbf{Y}^{tu}. \qquad (9)
\end{aligned}$$

Secondly, from equation (3), $\mathbf{X}^{r}$ must be used as either an intermediate or final goods at home or abroad, ie.

$$\mathbf{X}^{r} = \mathbf{A}^{rr}\mathbf{X}^{r} + \mathbf{Y}^{rr} + \sum_{t\neq r}^{G} (\mathbf{A}^{rt}\mathbf{X}^{t} + \mathbf{Y}^{rt}), \qquad (10)$$

where the third term is country *r*' aggregated gross exports to all other countries. Denoting this term as $\mathbf{E}^{r*}$, then, equation (10) can undergo further transformation as follows

$$\mathbf{X}^r = (\mathbf{I} - \mathbf{A}^{rr})^{-1}(\mathbf{Y}^{rr} + \mathbf{E}^{r*}) = \mathbf{L}^{rr}\mathbf{Y}^{rr} + \mathbf{L}^{rr}\mathbf{E}^{r*} \tag{11}$$

With equation (9) and (11) in hand, we can make replacement of $\mathbf{X}^r$ on the right hand side of the last equalization in equation (8): substituting $\mathbf{X}^r$ in the 1st term with equation (8), and both 3th and 4st term with equation (11). Finally, equation (8) turns out to be

$$\begin{aligned}
\mathbf{A}^{sr}\mathbf{X}^r = {} & \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\mathbf{L}^{rr}\mathbf{Y}^{rr})}_{1^{\text{st}}} + \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\mathbf{B}^{rr}\mathbf{Y}^{rs})}_{2^{\text{nd}}} \\
& + \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\mathbf{B}^{rr}\sum_{t\neq r,s}^{G}\mathbf{Y}^{rt})}_{3^{\text{rd}}} + \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\mathbf{B}^{rs}\mathbf{Y}^{ss})}_{4^{\text{th}}} \\
& + \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\mathbf{B}^{rs}\sum_{t\neq s}^{G}\mathbf{Y}^{st})}_{5^{\text{th}}} + \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\sum_{t\neq r,s}^{G}\mathbf{B}^{rt}\mathbf{Y}^{ts})}_{6^{\text{th}}} \\
& + \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\sum_{t\neq r,s}^{G}\mathbf{B}^{rt}\mathbf{Y}^{tt})}_{7^{\text{th}}} + \underbrace{(\mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\sum_{t\neq r,s}^{G}\sum_{u\neq s,t}^{G}\mathbf{B}^{rt}\mathbf{Y}^{tu})}_{8^{\text{th}}} \\
& + \underbrace{(\mathbf{V}^s\mathbf{B}^{ss} - \mathbf{V}^s\mathbf{L}^{ss})'\#(\mathbf{A}^{sr}\mathbf{X}^r)}_{9^{\text{th}}} + \underbrace{(\mathbf{V}^r\mathbf{B}^{rs})'\#(\mathbf{A}^{sr}\mathbf{L}^{rr}\mathbf{Y}^{rr})}_{10^{\text{th}}} \\
& + \underbrace{(\mathbf{V}^r\mathbf{B}^{rs})'\#(\mathbf{A}^{sr}\mathbf{L}^{rr}\mathbf{E}^{r*})}_{11^{\text{th}}} + \underbrace{(\sum_{t\neq s,r}^{G}\mathbf{V}^t\mathbf{B}^{ts})'\#(\mathbf{A}^{sr}\mathbf{L}^{rr}\mathbf{Y}^{rr})}_{12^{\text{th}}} \\
& + \underbrace{(\sum_{t\neq s,r}^{G}\mathbf{V}^t\mathbf{B}^{ts})'\#(\mathbf{A}^{sr}\mathbf{L}^{rr}\mathbf{E}^{r*})}_{13^{\text{th}}}.
\end{aligned} \tag{12}$$

Equation (12) 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.

The 1st term, $(\boldsymbol{V^sL^{ss}})'\#(\boldsymbol{A^{sr}L^{rr}Y^{rr}})$, is country *s*' domestic value added embodied in its intermediate exports which is used by country *r* (direct importer) to produce final goods and

consumed in *r*. The 2nd term, $(\boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr} B^{rr} Y^{rs}})$, is country *s'* domestic value added embodied in its intermediate exports to country *r* (direct importer), who produce final goods to be returned to country *s* instead of being consumed in *r*. In other words, this term reflects value added that originates at home (country *s*) rather than from foreign countries. The 3rd term, $(\boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr} B^{rr}} \sum_{t\neq r,s}^{G} \boldsymbol{Y^{rt}})$, is country *s'* domestic value added embodied in its intermediate exports to country *r* (direct importer) to produce final goods which are further shipped to third country *t*.

The 4th term, $(\boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr} B^{rs} Y^{ss}})$, is country *s*' domestic value added in its intermediate exports to country *r* (direct importer) who uses them to produce intermediate goods to be shipped back to country *s* for producing final goods to satisfy its own final demands. As the final goods are consumed at home (country *s*) in the end, the value added of this term originates domestically in country *s* instead of being earned from foreign countries. The 5th term, $(\boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr} B^{rs}} \sum_{t\neq r,s}^{G} \boldsymbol{Y^{st}})$, is country *s*' domestic value added in its intermediate exports to country *r* who uses them to produce intermediate goods to be returned to country *s* for producing final goods to meet demand from foreign countries including country *r*. The value added of this term are already counted once in first term of equation (7) and thus belong to double counted part.

The 6th term, $(\boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr}} \sum_{t\neq r,s}^{G} \boldsymbol{B^{rt} Y^{st}})$, is country *s*' domestic value added in its intermediate exports used by direct importer (country *r*) to produce intermediate exports to third country *t* for further production of final goods that are shipped back to country *s*. As the final goods are consumed at home (country *s*), the value added of this term belongs to returned part.

The 7th term, $(\boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr}} \sum_{t\neq r,s}^{G} \boldsymbol{B^{rt} Y^{tt}})$, is country *s'* domestic value added in its intermediate exports used by direct importer (country *r*) to produce intermediate exports to third country *t* for further production of final goods which are consumed at country *t*. The value added of this term is earned by country *s* indirectly from third country t instead of country *r*. The 8th term, $(\boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr}} \sum_{t\neq r,s}^{G} \sum_{u\neq s,t}^{G} \boldsymbol{B^{rt} Y^{tu}})$, is country *s'* domestic value added in its intermediate exports used by direct importer (country *r*) to produce intermediate exports to third country *t* for further production of final goods which are shipped to other countries including direct importer (*r*) except country *s*. The value added of this term is earned by country *s* from abroad.

The 9th term, $(\boldsymbol{V^s B^{ss}} - \boldsymbol{V^s L^{ss}})'\#(\boldsymbol{A^{sr} X^r})$, is value added of country *s*' intermediate exports

to country *r* that return home as intermediate imports and are used for production of country *s'* intermediate exports. It is a domestic double counted portion caused by the back and forth intermediate goods trade but to produce intermediate goods exports in country *s*.

The 10th term, $(\boldsymbol{V^s B^{rs}})'\#(\boldsymbol{A^{sr} L^{rr} Y^{rr}})$, is direct importing country *r'* domestic value added embodied in country *s*' intermediate exports to country *r* who uses them to produce final goods for its own domestic demand. The reason why the value added of this term belongs to direct importer is due the fact that country *s* turns back to country r for intermediate goods for sake of producing the exported products.

The 11th term, $(\boldsymbol{V^s B^{rs}})'\#(\boldsymbol{A^{sr} L^{rr} E^{r*}})$, is value added attributed to importing country r but embodied in country s' intermediate exports to country *r* who uses them to produce its final and intermediate exported goods to be sold to the world. The value added of this term comes to direct importer *r* because country *s* turns to country *r* for intermediate goods for sake of producing its exported products. However, this term is classified as a double counted part in the country *s'* gross exports originated from country *r* as country *r* has collected this amount of value added in its direct bilateral exports to country *s*.

The 12th term, $\left(\sum_{t\neq s,r}^{G} \boldsymbol{V^t B^{ts}}\right)' \#(\boldsymbol{A^{sr} L^{rr} Y^{rr}})$, is value added attributed to third country t but embodied in country *s*' intermediate exports to country *r*, which are then used by country *r* to produce its domestic final goods. The reason why the value added of this term comes to third country *t* is due the fact that country *s* turns to that country for intermediate goods for sake of producing its exported products.

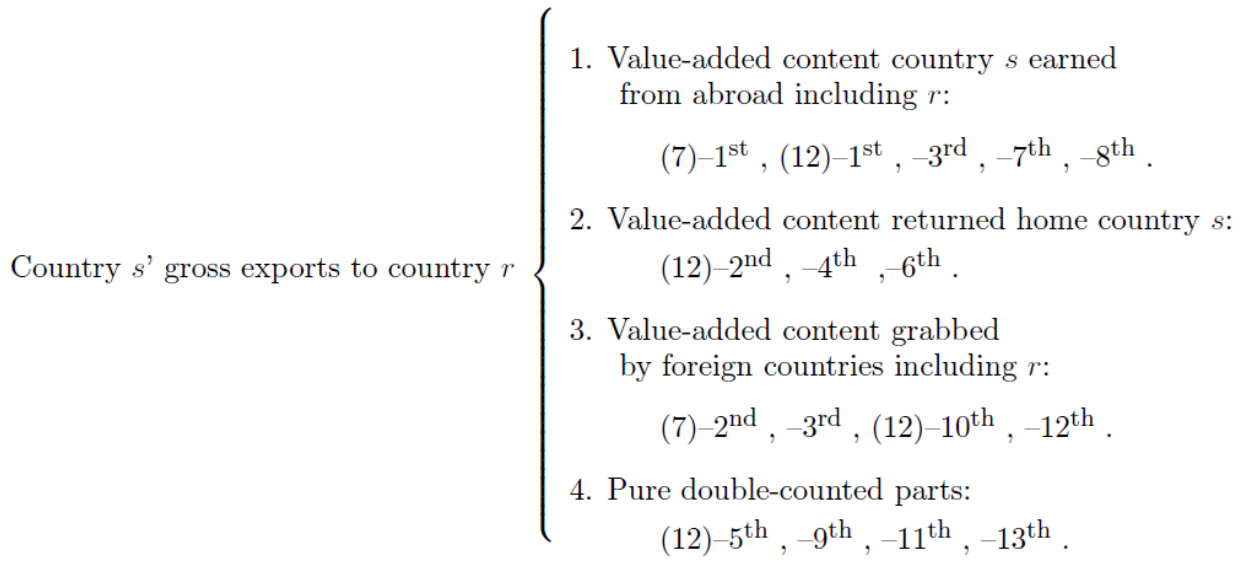
The 13th term, $\left(\sum_{t\neq s,r}^{G} \mathbf{V^t B^{ts}}\right)' \#(\boldsymbol{A^{sr} L^{rr} E^{r*}})$, is value added attributed to third country *t* but embodied in country *s*' intermediate exports to country *r* who uses them to produce its final and intermediate exported goods to the world. The value added of this term comes to third importer t because country *s* turns to country *t* for intermediate goods for sake of producing its exported products. However, this term is classified as a double counted part in country *s'* gross exports originated from country *t* as each country *t* has collected this amount of value added in its direct bilateral exports to countries.

3.2.3 Summary

Adding up the final goods exports, equation (7), as well as the intermediate goods, equation (12), it turns out that the gross exports of a country can be decomposed into the sum of sixteen terms. To highlight the economic interpretations, Wang *et al.* (2013) divided them into four major

categories: value-added content earned from abroad, value-added content returned home country, value-added content grabbed by foreign countries, and pure double-counted parts (see Figure 1).

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



Note: (7)and(12) correspond to the equation number in the main text respectively. The ordinal number after "–" represents the term on RHS of the equation.

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

with the valued-added exports which is equivalent to the amount exporting country obtains from its direct trading partner (see Section 3.1).

In addition, 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, (7)–1st , results from exporting final goods, whereas the remaining four, intermediate goods. A country with high proportion of value-added content from final goods exports largely plays the role of downstream activities in global value chains. In contrast, higher proportion of value added from intermediate goods exports represents more emphasis on upstream 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 bilateral country or bilateral sectors (ie. value added in exports minus value added in imports) does not equal the net exports of

conventional gross trades. However, once aggregating over all trading partners and traded goods, the two differently-defined net values come to equivalence, which is also equal to net value-added exports.[1]

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*. (2012) and Dietzenbacher *et al*. (2013) gives detailed description of its compiling methodology the World Input-Output Table (WIOT). Panel data is one of WIOT's major characteristics. The data series range annually from 1995 to 2011 with forty countries and the RoW 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 35 sectors (see Appendix 1).

The major reason why WIOT can offer time serial data lies in its compiling methodology, ie., it adopts the supply and use tables (SUTs) as the source in the beginning rather than the purified input-output table. As the supply and use tables are directly linked to the national income data, the former data thus can be easily adapted to the frequent modification of the latter. Besides, the national income data serves as a control amount in balancing procedure of updating the supply and use tables. In connecting the bilateral trades among these countries, WIOD adopts the UN COMTRADE database, with exception for Taiwan retrieving from OECD as it has no UN membership. The COMTRADE database offers HS 6-digit code of product classification, helpful to distinguish the semi-finished product, finished products or investment etc. The final step in construction of the symmetric IO table, TIOT used the so-called "fixed product-sales structure" assumption staying that each product has its own specific sales structure irrespective of the industry where it is produced. This assumption is most widely used, not only because it is more realistic than its alternatives, but also because it requires a relative simple mechanical procedure. Furthermore, it does not generate any negatives in the IO table that would require manual rebalancing.

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[1] A simple proof is: Continuing the case of 2 country × 1productin section3.1(no third country exists),the net of value-added content of the first country is simplified as, $v_1 b_{11} y_{12} + v_1 l_{11} a_{12} b_{22} y_{22} - v_2 b_{22} y_{21} - v_2 l_{22} a_{21} b_{11} y_{11}$, where, $l_{11} = (1 - a_{11})^{-1}$, $l_{22} = (1 - a_{22})^{-1}$. From $(I - A)B = \begin{bmatrix} 1 - a_{11} & -a_{12} \\ -a_{21} & 1 - a_{22} \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{bmatrix} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ = ,we obtain $(1 - a_{11})b_{12} - a_{12} b_{22} = 0$, and $-a_{21} b_{11} + (1 - a_{22})b_{21} = 0$. Inserting the relation about a_{12} and a_{21} into the above net equation leads to the same result asfootnote1. With country number above two, proving process become more tedious.

(a)Taiwan's trades with China

(b)Taiwan's exports to China : share of Taiwan's exports and China's imports

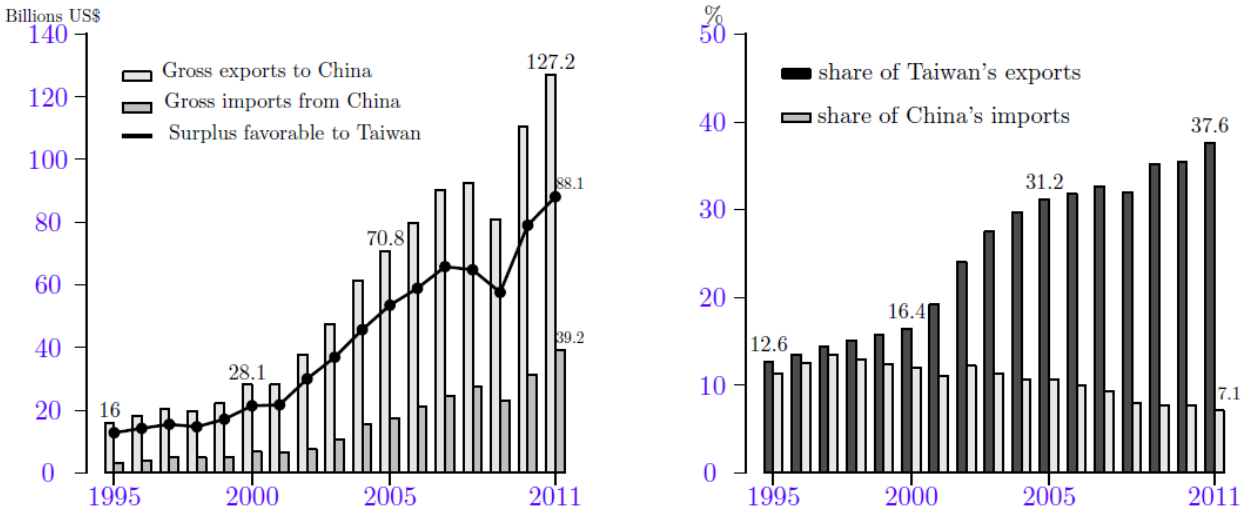


Figure 2: Conventional Trades between Taiwan and Mainland China

5. Result analysis

5.1 Value-added exports between Taiwan and China

Before distinguishing the value-added exports from gross exports, we analyze the conventional bilateral trade statistics between Taiwan and Mainland China over the past years. Figure 2(a) and panel (a) of Appendix 2 show that gross exports from Taiwan to China amounted to US$ 127 billion in 2011, up from US$ 16 billion in 1995, while the gross imports from China to Taiwan increased from US$ 3.2 billion to US$ 39.2 billion. The trade surplus of Taiwan toward China reached US$ 88.1 billion in 2011, nearly double that of Taiwan's overall trade surplus in that year. Figure 2(b) reveals 37.6% of Taiwan's exports went to Mainland China. However, Taiwan's exports as a percentage of the import market share in China continued to decrease to 7.1% in 2011.

We now turn to the analysis of value-added trade between both sides of the Taiwan Strait. Figure 3 and panel (b) of Appendix 2 show the value-added exports of Taiwan to China reached US$ 45.4 billion in 2011, up from US$ 8.2 billion in 1995. Exempting the trade of intermediate products, the value-added exports of Taiwan to China accounted for only 35.7% of the gross

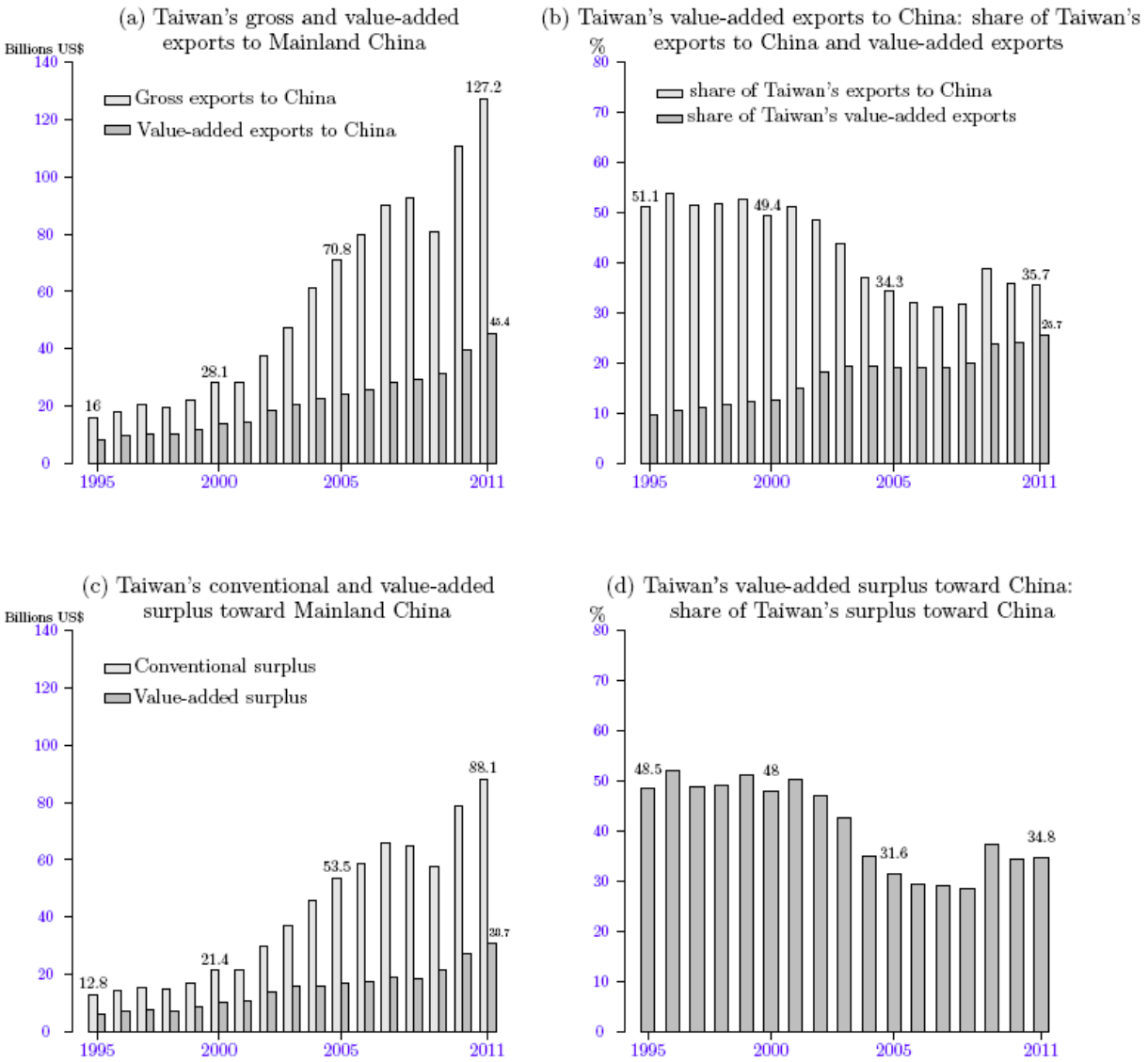


Figure 3: Value-added Trades between Taiwan and Mainland China

Table 1: Trades of Electrical and Optical Equipment

Units: Billions US$; %

	(a) Conventional trades between Taiwan and China			(b) Value-added trades between Taiwan and China			Relative proportion		
	Exports (1)	Imports (2)	Surplus (3)	Exports (4)	Imports (5)	Surplus (6)	(4)/(1)	(5)/(2)	(6)/(3)
1995	4.0	1.0	3.0	1.0	0.2	0.7	25.0	20.0	23.3
1996	3.9	1.1	2.8	1.0	0.2	0.8	25.6	18.2	28.6
1997	4.4	1.5	2.9	1.1	0.3	0.8	25.0	20.0	27.6
1998	4.9	1.6	3.3	1.3	0.3	0.9	26.5	18.8	27.3
1999	6.4	1.7	4.8	1.7	0.4	1.4	26.6	23.5	29.2
2000	9.9	2.5	7.4	2.5	0.5	2.0	25.3	20.0	27.0
2001	10.7	2.6	8.1	2.6	0.6	2.1	24.3	23.1	25.9
2002	16.8	3.3	13.5	4.2	0.7	3.6	25.0	21.2	26.7
2003	23.7	5.1	18.5	5.4	0.9	4.5	22.8	17.6	24.3
2004	32.9	6.5	26.4	6.0	1.0	5.0	18.2	15.4	18.9
2005	39.6	8.0	31.5	6.2	1.1	5.1	15.7	13.8	16.2
2006	47.4	9.8	37.6	6.8	1.2	5.6	14.3	12.2	14.9
2007	54.6	11.9	42.7	7.7	1.3	6.4	14.1	10.9	15.0
2008	55.5	13.4	42.1	8.1	1.5	6.6	14.6	11.2	15.7
2009	51.8	12.1	39.6	8.7	1.4	7.3	16.8	11.6	18.4
2010	69.3	16.1	53.3	10.7	1.7	8.9	15.4	10.6	16.7
2011	75.8	17.9	57.9	11.8	1.9	9.9	15.6	10.6	17.1

Note: Because of rounding, surplus is not exactly equal to exports minus imports.

counterparts in 2011. The value-added surplus of Taiwan toward China dramatically decreased to US$ 30.7 billion in 2011, approximately 65.2% lower than the current statistics released by the customs office. However, benefited from strong momentum in China's economic growth during the past decades, Taiwan's value-added exports to China kept growing steadily. In 2011, 25.7% of Taiwan's total value-added exports went to China, significantly lower than the conventional exports share to China which was 37.6%, see Figure 2(b).

In Taiwan, electronic components and products, computers, optical products, and electrical power equipment, etc. are the driving forces of exports. These products correspond to the electrical and optical equipment sector of WIOD. We particularly pay attention to analyzing the trades of electrical & optical equipment between Taiwan and China. Panel (a) of Table 1 indicates that regarding the electrical & optical equipment, Taiwan's gross export and import values with China reached US$ 75.8 and 17.9 billion respectively in 2011, both of which accounted for 59.6% and 45.7% of Taiwan's bilateral trades with China. So, Taiwan possessed favorable trade surplus of US$ 57.9 billion from trade of this sector with China which amounted

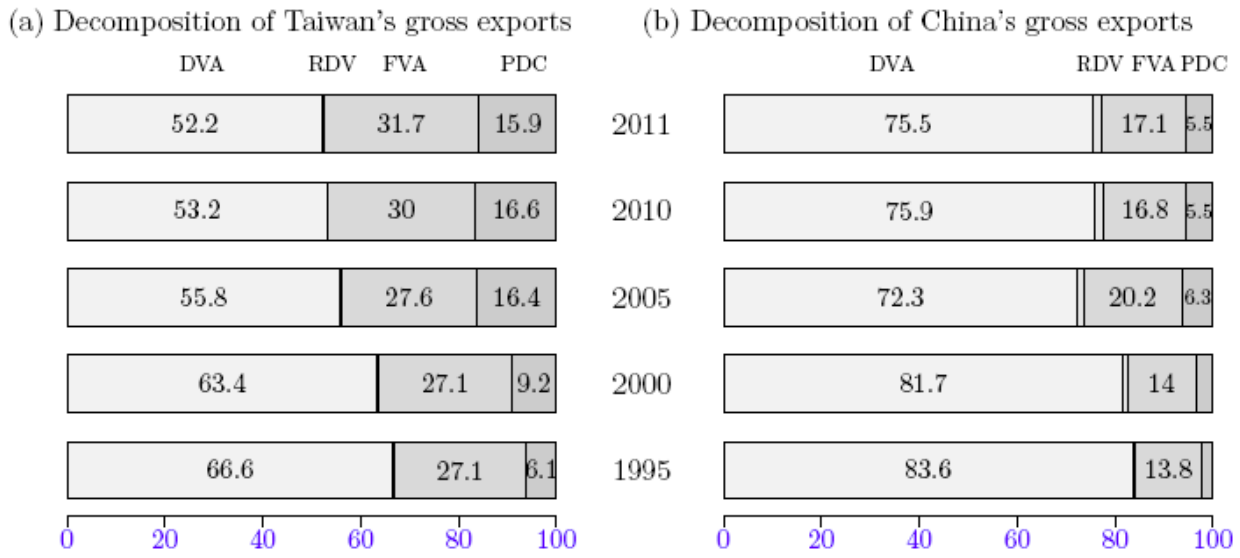
to the lion's share of foreign exchange Taiwan earned from China in 2011. Turning to aspect of value-added trade, the value-added exports and imports of Taiwan with China shrank to US$ 11.8 and 1.9 billion in 2011 respectively, both which accounted for merely 15.6% and 10.6% of Taiwan's bilateral gross trades of this sector with China. The value-added surplus of this sector Taiwan possessed diminished to US$ 9.9 billion. The modest proportion of value added to gross measure of Taiwan's exports of electrical and optical equipment reflected its relatively low value-added input rate in Taiwan which was only 24.3% in 2011, compared with 61.0% of US, 32.0% of Japan and 26.7% of Korea. Furthermore, Taiwan's electrical and optical products are oriented to exporting directly, without much help to support developments of other domestic downstream industries owing to its low forward-linkage effects. These industries are therefore unable to bring much benefits of indirect value-added exports to the electrical and optical sector in Taiwan.

5.2 Decomposition of bilateral exports between Taiwan and China

This section explains the results of decomposing gross exports into various items, focusing on discussing the four major categories which are classified from their detailed sixteen components (see Appendix 3–4). First of all, Figure 4 highlights the comparison of decomposition of Taiwan and China's gross exports. In panel 4(a), we can see proportion of the value-added content within Taiwan's gross exports tended to decrease annually, up from 66.6% in 1995 to 52.2% in 2011. In contrast, the share of value-added content grabbed by foreign countries and pure double-counted parts kept growing, up from 27.1% and 6.1% in 1995 to 31.7% and 15.9% in 2011 respectively. The value-added content returned home displays slight change.

Figure 4(b) shows that similar to Taiwan, the trend of value-added content earned from abroad within China's gross exports is diminishing. However, its decreasing pace is much slower than Taiwan. The share of this category reached 75.5%, 23.3 percentage point higher than that Taiwan's 52.2%. Conversely, the proration of China's value-added content grabbed by foreign countries and pure double-counted parts are much smaller than those of Taiwan.

A possible reason why Taiwan and China show different composition structure of four major exporting categories is that Taiwan's exports are highly concentrated on few star industries, mainly providers of OEM service for foreign firms and relying on importing key raw materials



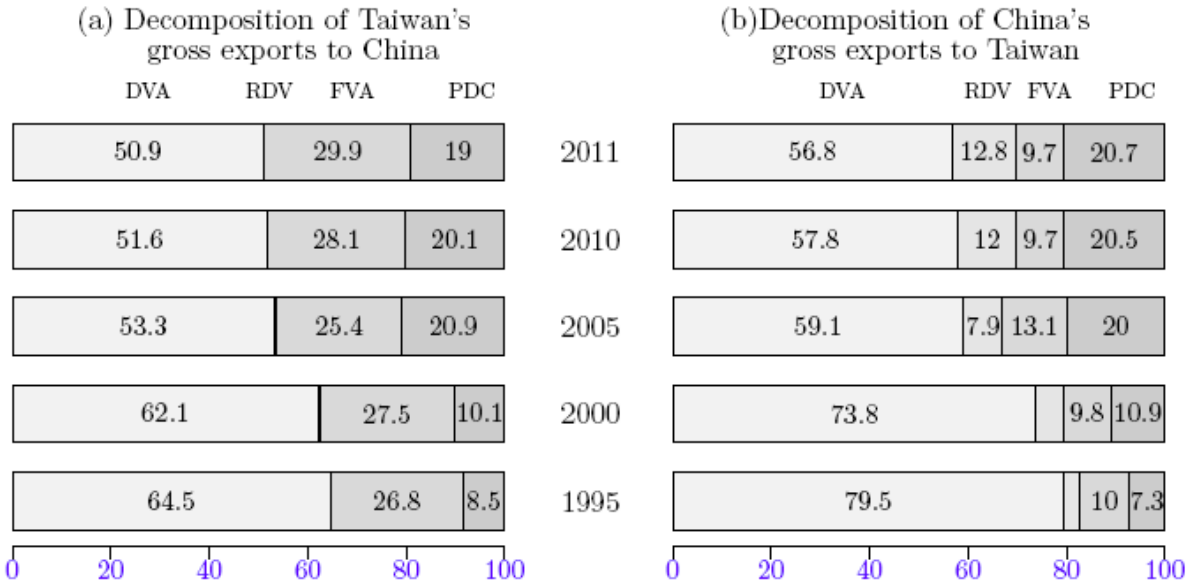
Note: DVA represents share of value-added content earned from abroad. RDV represents share of value-added content returned home country. FVA represents share of value-added content grabbed by foreign countries. PDC represents share of pure double-counted parts.

Figure 4: Decomposition of Taiwan and China's Gross Exports

and components. In contrast, China exhibited high diversity of industrial development, and devoted much efforts to attracting foreign direct investments in recent years, greatly helping to boost its value-added content from abroad. The same trend of foreign value-added content and pure double-counted part reflects involvement in vertical specialization of both Taiwan and China is increasing.

Next, we compare the four major categories of mutual exports between Taiwan and China. Figure 5(a) exhibits the decomposition of Taiwan's gross exports to China, the pattern of which is similar to Figure 4(a). This common trend is due to the fact that exports to China's market have become the the dominant role of Taiwan export. In 2011, the value-added content from abroad accounted for 50.9% in Taiwan's exports to China, whereas foreign value-added and pure double-counted parts accounted for 29.9% and and 19.0% respectively.

On the other hand, we find the share of value-added content from abroad to display a decreasing trend, reaching 56.8% in 2011, but higher than that of Taiwan's exports to China. The most obvious characteristics in China's exports to Taiwan was the tendency for shares of value-added content returned home and pure double-counted parts to increase, reaching 12.8% and 20.7% in 2011. This shows mutual processing is becoming common between both sides, which is also the key factor causing the tendency for the conventional methodology to "inflate"



Note: variable definition is the same as Figure 4.

Figure 5: Decomposition of Bilateral Trade between Taiwan and China

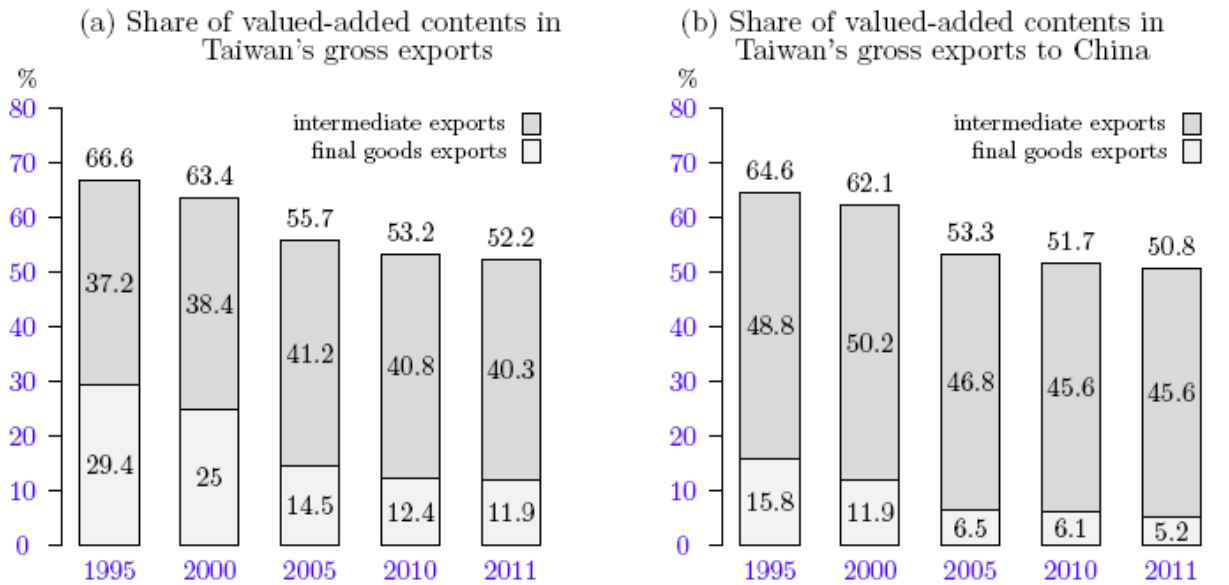


Figure 6: Share of Valued-Added Contents in Gross Exports

trade statistics.

Figure 6 further presents the sources of value-added content from abroad in Taiwan's gross exports. The impressive characteristics is intermediate exports get the lion's share of value-added from abroad, comparing with final goods exports. This represents that Taiwan lies on the upstream position in global value chains. However, Taiwan also relies on imports of intermediate inputs for processing exports. Thus, further eliminating the import control measures is sure to strengthen Taiwan's external competitiveness which may enhance Taiwan's role in global value chains.

6. Conclusion

With global value chains pervasive over the recent years, larger and larger bulk of imported intermediate components and raw materials from other countries are entangled in Taiwan's exports to Mainland China, leading to odd cross-trait bilateral trade amounts and surplus favorable toward Taiwan. The purpose of this paper is to extricate the value-added exports earned from China by Taiwan and decompose Taiwan's gross exports to China into various meaningful components. The two issues are related to trade in value added and value added in trade respectively. Specifically, the former explores the value added embedded in source country's exports to absorbing country as final demand irrespective of whether those goods going directly or indirectly through other countries arrive at the absorbing country. The latter investigates the value-added contents within the bilateral trade.

The empirical results indicate that the Taiwan's export values to Mainland China shrink 64.3% when bilateral trades are measured in value-added terms. Taiwan's trade surplus toward China will also decrease by 65.2%. From the viewpoint of value added in trade, the share of value added embodied in Taiwan's gross exports to China continued decreasing and reached 50.9% in 2011, while the components of foreign value added and pure double counted terms kept growing in recent years.

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Appendix 1

WIOD's Classification of Sectors and Countries

Sector code	Description of sector	Country code
C1	Agriculture, hunting, forestry and fishing	AUS
C2	Mining and quarrying	AUT
C3	Food, beverages and tobacco	BEL
C4	Textiles and textile products	BGR
C5	Leather, leather and footwear	BRA
C6	Wood and products of wood and cork	CAN
C7	Pulp, paper, printing and publishing	CHN
C8	Coke, refined petroleum and nuclear fuel	CYP
C9	Chemicals and chemical products	CZE
C10	Rubber and plastics	DEU
C11	Other non-metallic mineral	DNK
C12	Basic metals and fabricated metal	ESP
C13	Machinery, Nec	EST
C14	Electrical and optical equipment	FIN
C15	Transport equipment	FRA
C16	Manufacturing, Nec; recycling	GBR
C17	Electricity, gas and water supply	GRC
C18	Construction	HUN
C19	Sale, maintenance and repair of motor vehicles	IDN
	and motorcycles; retail sale of fuel	IND
C20	Wholesale trade and commission trade, except of	IRL
	motor vehicles and motorcycles	ITA
C21	Retail trade, except of motor vehicles and motorcycles;	JPN
	Repair of household goods	KOR
C22	Hotels and restaurants	LTU
C23	Inland transport	LUX
C24	Water transport	LVA
C25	Air transport	MEX
C26	Other supporting and auxiliary transport activities;	MLT
	Activities of travel agencies	NLD
C27	Post and telecommunications	POL
C28	Financial intermediation	PRT
C29	Real estate activities	ROU
C30	Renting of M&Eq and other business activities	RUS
C31	Public admin and defence; compulsory social security	SVK
C32	Education	SVN
C33	Health and social Work	SWE
C34	Other community, social and personal services	TUR
C35	Private households with employed persons	TWN
		USA
		RoW

Appendix 2

Taiwan's Conventional and Value-Added Trades

Units: Billions US$; %

	(a) Conventional trades									(b) Value-added trades								
	Gross exports	to China	Share	Gross imports	from China	Share	Total surplus	toward China	Share	VA exports	to China	Share	VA imports	from China	Share	Total VA surplus	toward China	Share
	(1)	(2)	(2)/(1)	(3)	(4)	(4)/(3)	(5)	(6)	(6)/(5)	(7)	(8)	(8)/(7)	(9)	(10)	(10)/(9)	(11)	(12)	(12)/(11)
1995	126.9	16.0	12.6	115.5	3.2	2.8	11.4	12.8	112.4	84.6	8.2	9.7	73.1	2.0	2.7	11.4	6.2	54.5
1996	133.8	18.0	13.5	117.0	3.8	3.2	16.8	14.2	84.5	90.5	9.7	10.7	73.7	2.3	3.1	16.8	7.4	43.9
1997	141.5	20.4	14.4	126.4	5.0	3.9	15.1	15.5	102.1	94.3	10.5	11.1	79.1	2.9	3.7	15.1	7.6	50.0
1998	129.6	19.6	15.1	118.7	4.9	4.1	10.9	14.7	135.4	86.3	10.1	11.7	75.5	2.9	3.8	10.9	7.2	66.6
1999	140.6	22.1	15.7	125.2	5.0	4.0	15.3	17.1	111.4	94.1	11.6	12.3	78.8	2.9	3.7	15.3	8.7	56.9
2000	171.7	28.1	16.4	155.1	6.7	4.3	16.6	21.4	129.0	108.8	13.9	12.7	92.2	3.6	3.9	16.6	10.3	61.9
2001	145.9	28.1	19.2	123.7	6.4	5.2	22.2	21.7	97.6	95.2	14.4	15.1	73.0	3.5	4.8	22.2	10.9	49.0
2002	156.6	37.6	24.0	128.6	7.6	5.9	28.0	30.0	107.2	101.0	18.3	18.1	73.0	4.1	5.6	28.0	14.1	50.5
2003	173.0	47.6	27.5	142.9	10.7	7.5	30.0	36.9	122.9	106.8	20.8	19.5	76.8	5.0	6.6	30.0	15.7	52.4
2004	206.3	61.3	29.7	185.1	15.6	8.4	21.2	45.7	215.7	117.6	22.8	19.4	96.4	6.7	7.0	21.2	16.1	75.7
2005	226.7	70.8	31.2	200.9	17.3	8.6	25.8	53.5	207.3	126.4	24.3	19.2	100.6	7.4	7.4	25.8	16.9	65.4
2006	250.9	79.9	31.8	218.7	21.0	9.6	32.2	58.9	182.6	134.3	25.6	19.0	102.0	8.3	8.1	32.2	17.3	53.7
2007	277.1	90.3	32.6	235.8	24.4	10.4	41.3	65.8	159.5	148.5	28.3	19.0	107.2	9.2	8.6	41.3	19.1	46.3
2008	288.8	92.5	32.0	258.0	27.7	10.8	30.7	64.8	210.9	146.9	29.4	20.0	116.1	11.0	9.5	30.7	18.4	59.9
2009	229.9	80.8	35.2	189.3	23.2	12.3	40.6	57.6	141.9	131.2	31.3	23.9	90.6	9.7	10.7	40.6	21.6	53.2
2010	311.6	110.5	35.4	269.0	31.4	11.7	42.6	79.0	185.4	165.7	39.8	24.0	123.1	12.5	10.2	42.6	27.3	64.0
2011	338.2	127.2	37.6	293.7	39.2	13.3	44.5	88.1	197.8	176.7	45.4	25.7	132.2	14.8	11.2	44.5	30.7	68.9

Note: Because of rounding, surplus is not exactly equal to exports minus imports.

Appendix 3

Decomposition of Taiwan's Gross Exports — Item's Value

Units: Billions US$

	Value-added content from abroad						Returned value-added				Foreign value-added content					Pure double-counted parts					Total
	Sum	7.1st	12.1st	12.3rd	12.7th	12.8th	Sum	12.2nd	12.6th	12.4th	Sum	7.2nd	7.3rd	12.10th	12.12th	Sum	12.11th	12.13th	12.5th	12.9th	
1995	84.6	37.4	33.7	5.8	6.4	1.3	0.2	0.1	0.0	0.1	34.4	2.4	15.1	2.2	14.7	7.7	0.1	0.1	0.9	6.7	126.9
1996	90.5	37.6	37.1	6.7	7.6	1.5	0.3	0.1	0.0	0.1	34.5	2.3	14.6	2.3	15.3	8.6	0.1	0.1	1.0	7.3	133.8
1997	94.3	36.3	41.2	7.2	8.0	1.6	0.3	0.2	0.0	0.1	37.6	2.5	14.8	2.7	17.6	9.4	0.1	0.2	1.0	8.1	141.5
1998	86.3	35.0	35.6	6.3	7.7	1.6	0.3	0.2	0.0	0.1	34.2	2.2	14.7	2.2	15.1	8.7	0.1	0.1	0.9	7.6	129.6
1999	94.1	38.2	38.0	7.2	8.8	1.9	0.4	0.2	0.0	0.1	36.1	2.4	15.7	2.3	15.7	10.0	0.1	0.2	1.1	8.6	140.6
2000	108.8	42.9	42.2	9.6	11.3	2.8	0.5	0.3	0.1	0.2	46.6	3.1	20.6	2.9	20.0	15.8	0.2	0.3	2.0	13.2	171.7
2001	95.2	39.3	35.9	7.7	10.0	2.4	0.4	0.2	0.0	0.1	38.0	2.7	17.0	2.4	15.9	12.4	0.2	0.2	1.6	10.4	145.9
2002	101.0	36.3	40.9	9.3	11.8	2.8	0.4	0.2	0.0	0.1	40.2	2.5	16.5	2.7	18.5	14.9	0.2	0.3	1.9	12.5	156.6
2003	106.8	35.6	43.3	10.8	13.7	3.4	0.5	0.3	0.0	0.2	46.0	2.5	17.6	3.6	22.3	19.7	0.2	0.4	2.7	16.4	173.0
2004	117.6	33.3	48.9	14.8	16.2	4.5	0.6	0.3	0.1	0.2	57.8	2.7	19.7	5.4	30.1	30.3	0.2	0.6	4.3	25.1	206.3
2005	126.4	32.9	52.3	17.1	18.9	5.3	0.6	0.3	0.1	0.2	62.6	2.7	20.1	6.4	33.4	37.1	0.2	0.8	5.7	30.4	226.7
2006	134.3	34.8	54.2	18.6	20.7	6.0	0.6	0.3	0.1	0.2	71.7	3.3	22.3	8.3	37.8	44.4	0.2	0.9	7.4	35.9	250.9
2007	148.5	34.2	61.4	22.1	23.8	7.0	0.6	0.3	0.1	0.2	77.3	3.1	22.7	9.2	42.2	50.8	0.2	1.0	8.4	41.1	277.1
2008	146.9	34.4	61.7	21.5	22.7	6.6	0.5	0.3	0.1	0.2	88.1	3.8	23.8	12.8	47.8	53.3	0.2	0.7	10.7	41.6	288.8
2009	131.2	30.1	60.3	17.1	19.0	4.8	0.4	0.2	0.0	0.1	64.7	2.7	16.4	9.0	36.6	33.6	0.1	0.6	5.9	27.0	229.9
2010	165.7	38.5	73.6	23.2	23.8	6.6	0.6	0.3	0.1	0.2	93.5	3.9	25.1	12.5	52.0	51.8	0.2	1.0	9.2	41.4	311.6
2011	176.7	40.2	81.8	24.2	24.1	6.5	0.6	0.3	0.1	0.2	1,07.2	3.9	27.7	14.3	61.4	53.7	0.2	0.8	9.3	43.4	338.2

Note: Column name represents the term on the RHS of equation (7) or (12).

Appendix 4

Decomposition of Taiwan's Gross Exports — Item's Proportion

Units: %

	Value-added content from abroad						Returned value-added				Foreign value-added content					Pure double-counted parts					Total
	Sum	7.1st	12.1st	12.3rd	12.7th	12.8th	Sum	12.2nd	12.6th	12.4th	Sum	7.2nd	7.3rd	12.10th	12.12th	Sum	12.11th	12.13th	12.5th	12.9th	
1995	66.6	29.4	26.6	4.6	5.0	1.0	0.2	0.1	0	0.1	27.1	1.9	11.9	1.8	11.6	6.1	0.1	0.1	0.7	5.3	100.0
1996	67.6	28.1	27.7	5.0	5.7	1.1	0.2	0.1	0	0.1	25.7	1.7	10.9	1.7	11.5	6.4	0.1	0.1	0.8	5.5	100.0
1997	66.6	25.7	29.1	5.1	5.7	1.1	0.2	0.1	0	0.1	26.6	1.8	10.5	1.9	12.4	6.6	0.1	0.1	0.7	5.7	100.0
1998	66.6	27.0	27.5	4.9	6.0	1.2	0.2	0.1	0	0.1	26.4	1.7	11.3	1.7	11.7	6.7	0.1	0.1	0.7	5.9	100.0
1999	67.0	27.2	27.0	5.1	6.3	1.4	0.3	0.1	0	0.1	25.7	1.7	11.2	1.6	11.1	7.1	0.1	0.1	0.8	6.1	100.0
2000	63.4	25.0	24.6	5.6	6.6	1.6	0.3	0.2	0	0.1	27.1	1.8	12.0	1.7	11.6	9.2	0.1	0.2	1.2	7.7	100.0
2001	65.2	26.9	24.6	5.3	6.9	1.6	0.3	0.1	0	0.1	26.0	1.8	11.6	1.6	10.9	8.5	0.1	0.2	1.1	7.1	100.0
2002	64.5	23.2	26.1	5.9	7.5	1.8	0.3	0.1	0	0.1	25.7	1.6	10.6	1.7	11.8	9.5	0.1	0.2	1.2	8.0	100.0
2003	61.7	20.6	25.0	6.3	7.9	2.0	0.3	0.1	0	0.1	26.6	1.4	10.2	2.1	12.9	11.4	0.1	0.2	1.6	9.5	100.0
2004	57.0	16.1	23.7	7.2	7.9	2.2	0.3	0.2	0	0.1	28.0	1.3	9.5	2.6	14.6	14.7	0.1	0.3	2.1	12.2	100.0
2005	55.8	14.5	23.1	7.5	8.3	2.3	0.3	0.1	0	0.1	27.6	1.2	8.9	2.8	14.7	16.4	0.1	0.3	2.5	13.4	100.0
2006	53.5	13.9	21.6	7.4	8.2	2.4	0.2	0.1	0	0.1	28.6	1.3	8.9	3.3	15.1	17.7	0.1	0.4	2.9	14.3	100.0
2007	53.6	12.4	22.1	8.0	8.6	2.5	0.2	0.1	0	0.1	27.9	1.1	8.2	3.3	15.2	18.3	0.1	0.3	3.0	14.8	100.0
2008	50.9	11.9	21.4	7.4	7.9	2.3	0.2	0.1	0	0.1	30.5	1.3	8.2	4.4	16.5	18.4	0.1	0.3	3.7	14.4	100.0
2009	57.1	13.1	26.2	7.4	8.3	2.1	0.2	0.1	0	0.1	28.1	1.2	7.1	3.9	15.9	14.6	0.1	0.3	2.6	11.7	100.0
2010	53.2	12.4	23.6	7.4	7.7	2.1	0.2	0.1	0	0.1	30.0	1.3	8.1	4.0	16.7	16.6	0.1	0.3	2.9	13.3	100.0
2011	52.2	11.9	24.2	7.1	7.1	1.9	0.2	0.1	0	0.1	31.7	1.2	8.2	4.2	18.1	15.9	0.1	0.2	2.7	12.8	100.0

Note: Column name represents the term on the RHS of equation (7) or (12).

Appendix 5

Decomposition of Taiwan's Gross Exports to China — Item's Value

Units: Billions US$

	Value-added content from abroad						Returned value-added				Foreign value-added content					Pure double-counted parts					Total
	Sum	7.1st	12.1st	12.3rd	12.7th	12.8th	Sum	12.2nd	12.6th	12.4th	Sum	7.2nd	7.3rd	12.10th	12.12th	Sum	12.11th	12.13th	12.5th	12.9th	
1995	10.4	2.5	5.3	0.8	1.5	0.2	0	0	0	0	4.3	0	1.3	0.1	2.9	1.4	0.0	0.0	0.0	1.3	16.0
1996	11.9	2.6	6.6	0.9	1.6	0.2	0	0	0	0	4.6	0	1.2	0.1	3.3	1.4	0.0	0.0	0.1	1.3	18.0
1997	13.4	1.9	8.2	1.2	1.9	0.2	0.1	0	0	0	5.2	0	0.9	0.2	4.1	1.8	0.0	0.0	0.1	1.6	20.4
1998	12.8	2.2	7.5	1.0	1.8	0.3	0.1	0	0	0	5.1	0.1	1.1	0.2	3.7	1.7	0.0	0.0	0.1	1.5	19.6
1999	14.5	2.6	8.4	1.2	2.0	0.3	0.1	0	0	0	5.6	0.1	1.3	0.2	4.1	1.8	0.0	0.0	0.1	1.7	22.1
2000	17.4	3.4	9.6	1.5	2.5	0.5	0.1	0	0	0	7.7	0.1	1.9	0.3	5.4	2.8	0.0	0.1	0.1	2.6	28.1
2001	17.9	3.6	9.8	1.5	2.5	0.5	0.1	0	0	0	7.5	0.1	1.9	0.3	5.1	2.6	0.0	0.1	0.2	2.4	28.1
2002	23.3	4.8	12.3	2.1	3.5	0.7	0.1	0.1	0	0	10.1	0.2	2.6	0.5	6.9	4.0	0.0	0.1	0.3	3.6	37.6
2003	28.0	5.4	13.7	2.9	5.0	1.0	0.1	0.1	0	0	12.9	0.3	3.2	0.7	8.6	6.6	0.1	0.1	0.5	5.9	47.6
2004	33.3	4.5	16.1	4.6	6.6	1.5	0.2	0.1	0	0.1	16.6	0.3	3.3	1.1	11.9	11.2	0.1	0.2	1.0	10.0	61.3
2005	37.8	4.6	17.1	5.7	8.6	1.8	0.2	0.1	0	0.1	18.0	0.4	3.4	1.2	13.0	14.8	0.1	0.3	1.3	13.1	70.8
2006	41.1	4.4	18.1	6.7	9.7	2.1	0.2	0.1	0	0.1	20.2	0.4	3.3	1.6	14.8	18.4	0.1	0.4	2.0	16.0	79.9
2007	46.3	4.5	20.3	7.7	11.3	2.4	0.2	0.1	0	0.1	22.5	0.5	3.4	2.0	16.5	21.3	0.1	0.4	2.5	18.3	90.3
2008	45.7	5.4	20.5	7.2	10.4	2.2	0.2	0.1	0	0.1	25.9	0.6	3.9	2.4	18.9	20.8	0.1	0.3	2.6	17.8	92.5
2009	44.6	4.3	23.4	6.1	9.0	1.8	0.2	0.1	0	0.1	21.6	0.4	2.5	2.6	16.1	14.5	0.1	0.3	2.1	12.0	80.8
2010	57.0	6.7	28.0	8.4	11.4	2.4	0.2	0.1	0	0.1	31.0	0.7	4.7	3.4	22.2	22.2	0.1	0.5	3.2	18.4	110.5
2011	64.8	6.7	33.9	9.4	12.3	2.6	0.2	0.1	0	0.1	38.0	0.9	4.9	4.6	27.7	24.2	0.1	0.4	3.8	19.9	127.2

Note: Column name represents the term on the RHS of equation (7) or (12).

Appendix 6

Decomposition of Taiwan's Gross Exports to China — Item Proportion

Units: %

	Value-added content from abroad						Returned value-added				Foreign value-added content					Pure double-counted parts					Total
	Sum	7.1st	12.1st	12.3rd	12.7th	12.8th	Sum	12.2nd	12.6th	12.4th	Sum	7.2nd	7.3rd	12.10th	12.12th	Sum	12.11th	12.13th	12.5th	12.9th	
1995	64.5	15.8	33.2	5.0	9.5	1.1	0.2	0.1	0	0.1	26.8	0.3	8.1	0.5	17.9	8.5	0.1	0.1	0.3	8.1	100.0
1996	66.3	14.7	36.7	4.8	9.0	1.1	0.2	0.1	0	0.1	25.8	0.3	6.7	0.6	18.2	7.7	0.1	0.1	0.3	7.2	100.0
1997	65.7	9.2	40.2	5.7	9.5	1.2	0.3	0.1	0	0.1	25.3	0.2	4.3	0.9	19.9	8.7	0.1	0.1	0.4	8.0	100.0
1998	65.4	11.3	38.3	5.3	9.2	1.3	0.3	0.1	0	0.1	25.8	0.3	5.5	1.0	19.0	8.5	0.1	0.1	0.4	7.8	100.0
1999	65.8	11.9	38.2	5.3	9.1	1.4	0.2	0.1	0	0.1	25.6	0.3	5.7	0.9	18.6	8.3	0.1	0.1	0.4	7.7	100.0
2000	62.1	11.9	34.1	5.5	8.9	1.7	0.3	0.1	0	0.1	27.5	0.4	6.7	1.1	19.3	10.1	0.1	0.2	0.5	9.2	100.0
2001	63.8	13.0	34.9	5.3	8.9	1.7	0.2	0.1	0	0.1	26.6	0.5	6.7	1.2	18.3	9.4	0.1	0.2	0.6	8.5	100.0
2002	62.0	12.7	32.6	5.5	9.4	1.8	0.3	0.1	0	0.1	27.0	0.5	6.9	1.3	18.3	10.7	0.1	0.2	0.7	9.7	100.0
2003	58.9	11.4	28.8	6.0	10.5	2.1	0.3	0.2	0	0.1	27.0	0.7	6.7	1.5	18.1	13.8	0.1	0.3	1.1	12.3	100.0
2004	54.2	7.3	26.2	7.5	10.8	2.4	0.3	0.2	0	0.1	27.1	0.6	5.3	1.8	19.4	18.3	0.1	0.4	1.6	16.2	100.0
2005	53.3	6.5	24.1	8.0	12.1	2.6	0.3	0.2	0	0.1	25.4	0.5	4.8	1.7	18.4	20.9	0.1	0.5	1.9	18.5	100.0
2006	51.4	5.5	22.6	8.4	12.1	2.7	0.3	0.1	0	0.1	25.3	0.5	4.2	2.1	18.5	23.0	0.1	0.5	2.5	20.0	100.0
2007	51.3	5.0	22.5	8.6	12.5	2.7	0.2	0.1	0	0.1	24.9	0.5	3.8	2.3	18.3	23.6	0.1	0.5	2.8	20.2	100.0
2008	49.4	5.8	22.2	7.7	11.2	2.4	0.2	0.1	0	0.1	27.9	0.6	4.3	2.6	20.5	22.4	0.1	0.4	2.8	19.2	100.0
2009	55.1	5.3	29.0	7.5	11.1	2.2	0.2	0.1	0	0.1	26.7	0.5	3.1	3.2	19.9	17.9	0.1	0.4	2.7	14.8	100.0
2010	51.6	6.1	25.4	7.6	10.4	2.2	0.2	0.1	0	0.1	28.1	0.7	4.2	3.1	20.1	20.1	0.1	0.4	2.9	16.6	100.0
2011	50.9	5.2	26.6	7.4	9.6	2.0	0.2	0.1	0	0.1	29.9	0.7	3.8	3.6	21.7	19.0	0.1	0.3	3.0	15.6	100.0

Note: Column name represents the term on the RHS of equation (7) or (12).