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Revealed Comparative Advantage Based on Value Added Exports: An Analysis for China

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Abstract: The index of revealed comparative advantage (RCA) proposed by Balassa is always used in many international trade researches to measure whether a country has a revealed comparative advantage in some industries. This paper points out traditional RCA ignores domestic and international production sharing and presents a new measure of RCA which substitutes domestic value added exports for gross exports. The new RCA of an industry excludes foreign value added and includes indirect exports of the industry's value added through other forward industries' exports. Based on WIOD database, we calculate the comparative advantage of Chinese 35 industries based on both concepts. Further mechanism analysis reveals that forward linkage and vertical specialization significantly increase the future probability of an industry to have RCA. In other words, when a sector has a larger vertical specialization share and its forward sectors have comparative advantages in exporting, this sector is more likely to have RCA based on value added trade.

Keywords: Revealed comparative advantage; Input-output analysis; Value added exports

1. Introduction

One of the most powerful propositions of classical trade theory is that a country with the comparative advantage in a given commodity exports, and the other with comparative disadvantage imports. Thus, a question has been how to measure the comparative advantage in empirical analyses. The notion of comparative advantage usually takes into account autarkic variables, such as relative prices, production costs and factor endowment, which are not observable. Thus, as the second-best methodology, indices of revealed comparative advantage (RCA) are constructed based on post-trade variables.

One of the first attempts to measure comparative advantage was done by Balassa(1965) which is so far the most widely used index in analyzing trade performance. In standard applications, it is defined as the share of an industry in a country's total gross exports relative to the world average of the same industry in world exports. Despite it was widely used by researchers, Balassa's RCA index has been under critique for its alleged incomparability and inconsistency. Therefore, several other attempts to measure RCA have been taken place, for example, Lafay index (Lafay,1992), symmetric RCA index (Dalum et al., 1998), weighted RCA index (Proudman and Redding, 2000), additive RCA index (Hoen and Oosterhaven, 2006) and normalized RCA (Yu et al., 2009).

Balassa's RCA index and all the adapted indexes are based on gross exports of an industry or country. However, under the background of international fragmentation, this paper points out that the RCA based on gross exports ignores both international and domestic production sharing. First, it ignores the fact that a country-industry's value may be exported indirectly via the country's exports in other sectors. In a conceptually correct measure, indirect exports of a sector's value should be included in its comparative advantage. Second, it ignores the fact that a country-industry's gross exports partly include foreign value. Since the late 1980s, production processes have become more and more internationally fragmented. A good is produced in two or more sequential stages. Countries increasingly link sequentially to produce goods. A

country imports intermediate goods to make goods or goods-in-process which are then exported to another country. Two or more countries provide value added during the production of the good and a country-industry's gross exports include foreign value. A typical example is the distribution of value in the Apple's global networks. China, who exports the final Apple product, is artificially credited with having created all of its value. In reality, it only assembles ready-made part and just captures 1.8% of value (Kraemer et al., 2011). In this case, the Balassa's RCA index based on Customs statistics will overestimate the comparative advantage of China's Apple exports.

Taking account of the fact that the final good is the product of a joint effort, Pascal Lamy (the former Director-General of the WTO) proposed jointly with the OECD "trade in value added" as a better approach for the measurement for international trade. Actually, "trade in value added" has been a hot research topic in international trade (e.g. Dean et al., 2011, Johnson and Noguera, 2012, Koopman et al., 2012, Chen et al., 2012). Koopman et al. (2014) decomposed gross exports into three parts (value added exports, domestic content in intermediate exports that finally return home and foreign content) and pointed out the decomposition could be applied to the measure of RCA. In this paper, we adopt a simpler method to calculate the value added exports rather than the KWW decomposition. Then we propose the new RCA based on value added exports since it excludes foreign value added and includes indirect exports via other sectors. We compute both the traditional and new RCA index at the country-sector level for all the countries and sectors in the WIOD database (see Dietzenbacher et al., 2013). For the purpose of our analysis, we focus on the case of China and mainly present the results of China in this paper.

We define a forward and backward linkage factor to reflect domestic production sharing and use vertical specialization share to measure international production sharing. Then, we empirically analyze how vertical specialization, forward and backward linkage factor affect the new RCA of Chinese industries. The results reveal that forward linkage and vertical specialization significantly increase the future probability of an industry to have RCA. In other words, for those industries in the

global production chain, a higher vertical specialization share implicates a larger RCA. For those with low vertical specialization, if their forward sectors have comparative advantage in exporting, there is also strong possibility for them to have high RCA based on value added trade.

The rest of the paper is organized as follows. In section 2, we present the measurement of RCA based on gross exports and our measurement based on value added exports. We calculate the RCA of Chinese 35 industries and present the results in section 3. Section 4 discusses potential factors that affect the new RCA. The paper concludes with Section 5.

2. Measurement of Revealed Comparative Advantage

2.1 Measurement of RCA based on gross exports

The major innovation with regard to how to measure comparative advantage was achieved by Balassa (1965). He proposed using the ratio of export shares as an index for revealed comparative advantage, which is so far the most widely used traditional index. Using E to denote exports, i a specific country, j a specific commodity and w the world, the traditional RCA index (TRCA) can be written as follows:

$$TRCA = \frac{E_{ij}}{E_i} \Big/ \frac{E_{wj}}{E_w} \tag{1}$$

where E_{ij} denotes the export of good j of country i. E_i is the total export country i. E_{wj} denotes the export of good j of all the countries. E_w is the total export of the world. It is noteworthy that: $E_i = \sum_j E_{ij}$; $E_{wj} = \sum_i E_{ij}$; $E_w = \sum_i \sum_j E_{ij}$.

A given country i is said to have comparative advantage in commodity j, when the share of commodity j's gross exports in country i's total gross exports is greater than the commodity j's world exports market size in terms of the world total exports market size, i.e. when the TRCA exceeds one. Similarly interpreting, when TRCA is less than one, the country is said to have comparative disadvantage in that commodity.

The traditional RCA was widely used to analyze the manufacturing industries, agriculture and services, probably because of its simplicity and convenience in calculating in empirical researches, although there must be many other reasons to use it. However, with the model of international specialization has experienced the transition from inter-industry to intra-product division, the production for exports requires more imports of raw materials, parts and components. Therefore, the TRCA, which based on gross exports, ignores the fact that a country-industry's gross exports partly reflect foreign contents. If the production of a sector's production requires quite a high share of imports, a high TRCA can't represent a strong comparative advantage. On the other hand, it ignores the fact that a country-industry's value may be exported indirectly via the country's exports in other sectors. In a conceptually correct measure, indirect exports of a sector's value should be included in its comparative advantage. A conceptually correct measure of comparative advantage needs to exclude foreign value but include indirect exports of a sector's value through other sectors. In other words, it should take into account both international specialization and domestic production sharing.

2.2 New measurement of RCA based on value added exports

In our measure, we will use a world input-output table(WIOT) to construct a new RCA, which based on domestic value added exports. For the empirical application, we will use the WIOTs from 1995 to 2011 that were constructed in the WIOD project. They are inter-country input-output (IO) tables covering 40 countries/regions and the rest of the world as a 41st one. 35 industries are included in these IO tables.

Table 1. The world input-output table

		Intermediate use		Final use		Gross
	Country	S	R	S	R	Output
Intermediate input	S	Z^{ss}	Z^{sr}	F^{ss}	F^{sr}	X^{s}
	R	Z^{rs}	Z^{rr}	F^{rs}	F^{rr}	X^{r}
Value added		V^{s}	V^{r}			
Total input		$X^{s'}$	$X^{r'}$			

In this section, we will outline the measurement using a much smaller case as an example. Without loss of generality we will employ a WIOT that consists of two countries. The WIOT is given in table 1.

For example, Z^{sr} is a matrix and its typical element z_{ij}^{sr} indicates the delivery of intermediate inputs from industry i in country S to industry j in country R. Note that $i, j = 1, 2, \cdots, m$ where m is the number of industries. In case $S = R$, the matrix Z^{ss} and Z^{rr} indicate domestic intermediate inputs. In case $S \neq R$, the matrix Z^{sr} indicates the exports of country S to industries in country R. V^s is an *m*-element vector and its typical element gives the value added. F^{sr} is an *m*-element vector and its typical element f_i^{sr} indicates the exports of final goods and services produced by industry i in country S to final users in country R. Similarly, when $S = R$, F^{ss} and F^{rr} mean domestic final use. Final use covers consumption expenditure by households, government and non-profit organizations, gross fixed capital formation, and changes in inventories. X^s is an *m*-element vector and its typical element indicates the gross output.

Final goods and services can be classified into two categories: the first is to meet domestic user's demand, it is marked as F^D. The other is to be exported to meet foreign user's demand, it is marked as F^E. The relationship can be written as:

$$F = \begin{bmatrix} F^{ss} + F^{sr} \\ F^{rs} + F^{rr} \end{bmatrix} = F^D + F^E = \begin{bmatrix} F^{ss} \\ F^{rr} \end{bmatrix} + \begin{bmatrix} F^{sr} \\ F^{rs} \end{bmatrix} \tag{2}$$

As usual, we define $A = Z(\hat{X})^{-1}$ as the direct input matrix. Similarly, it can be divided into domestic (A^D) and foreign (A^E) consumption:

$$A = \begin{bmatrix} A^{ss} & A^{sr} \\ A^{rs} & A^{rr} \end{bmatrix} = A^D + A^E = \begin{bmatrix} A^{ss} & 0 \\ 0 & A^{rr} \end{bmatrix} + \begin{bmatrix} 0 & A^{sr} \\ A^{rs} & 0 \end{bmatrix} \tag{3}$$

The exports of country S to country R contain final goods and services (F^{sr}) and intermediate product (Z^{sr}). The exports of country R to country S also contain these

two parts. Therefore, the export matrix E can be written as:

$$E = A^E X + F^E = \begin{bmatrix} 0 & A^{sr} \\ A^{rs} & 0 \end{bmatrix} \begin{bmatrix} X^s \\ X^r \end{bmatrix} + \begin{bmatrix} F^{sr} \\ F^{rs} \end{bmatrix} \tag{4}$$

The Leontief model can be written as follows:

$$X = (I - A)^{-1} F = BF = \begin{bmatrix} B^{ss} & B^{sr} \\ B^{rs} & B^{rr} \end{bmatrix} \begin{bmatrix} F^{ss} + F^{sr} \\ F^{rs} + F^{rr} \end{bmatrix} \tag{5}$$

where $\begin{bmatrix} B^{ss} & B^{sr} \\ B^{rs} & B^{rr} \end{bmatrix} = \begin{bmatrix} I - A^{ss} & -A^{sr} \\ -A^{rs} & I - A^{rr} \end{bmatrix}^{-1}$ denotes the Leontief inverse.

In our analysis, we are not so much interested in the gross export levels but in the value added exports. A country-industry's value added can be absorbed directly by final goods and services and we can write these expression as $\hat{V}F^E$ and $\hat{V}F^D$, where $\hat{V}$ denotes the diagonal matrix of value added coefficients vector. $\hat{V}F^D$ is created by domestic final demand and it doesn't cross the border. So the value added exports should be $\hat{V}F^E$ or $\hat{V}F - \hat{V}F^D$. A country-industry's value added can also be absorbed by final goods and services through the first round of intermediate inputs and we can write these expression as $\hat{V}A^DY^D$, $\hat{V}A^DY^E$, $\hat{V}A^EY^D$ and $\hat{V}A^EY^E$. $\hat{V}A^DY^E$ and $\hat{V}A^EY^D$ cross the border once and $\hat{V}A^EY^E$ cross the border twice, while $\hat{V}A^DY^D$ doesn't cross the border. Therefore, in this round, the value added exports should be $\hat{V}A^DF^E + \hat{V}A^EF^D + \hat{V}A^EF^E$ or $\hat{V}AF - \hat{V}A^DF^D$. Similarly, in the next round, the value added exports can be written as $\hat{V}AAF - \hat{V}A^DA^DF^D$, and so forth. Aggregating all these items, we can deduce the total value added exports(VAE) as follows(see Appendix 1 for more details):

$$\begin{aligned} VAE &= \hat{V}F - \hat{V}F^D + \hat{V}AF - \hat{V}A^DF^D + \hat{V}AAF - \hat{V}A^DA^DF^D + ... \\ &= (\hat{V}F + \hat{V}AF + \hat{V}AAF + ...) - (\hat{V}F^D + \hat{V}A^DF^D + \hat{V}A^DA^DF^D + ...) \\ &= \hat{V}(I - A)^{-1}F - \hat{V}(I - A^D)^{-1}F^D \\ &= \hat{V}(I - A^D)^{-1}E \end{aligned} \tag{6}$$

Finally, we define the new RCA index based on domestic value added exports as follows:

$$VRCA = \frac{VAE_{ij}}{VAE_i} \Big/ \frac{VAE_{wj}}{VAE_w} \tag{7}$$

where $VRCA$ denotes the new RCA index, VAE_{ij} is industry j 's total value added exports in country i. VAE_i indicates the value added embodied in country i 's total exports. VAE_{wj} indicates industry j 's total value added exports in the whole world and VAE_w is the value added embodied in the global export.

The new RCA is defined as the share of a country-industry's forward linkage based value added exports in the country's total value added embedded in exports relative to that industry's total domestic value added exports from all countries as a share of global value added in exports. The advantage of using value added exports rather than gross exports is that domestic value added exports exclude foreign value added and forward linkage based value added exports reflects the fact that a country-industry's value may be exported indirectly via the country's exports in other sectors.

3. Empirical results

In this section, we present some results from the empirical application. We intend to analyze the revealed comparative advantage of Chinese industries from the perspective of value added exports. In order to contextualize them, these results are compared to those obtained from the traditional RCA. Moreover, some comparative analysis between countries is made, better illustrating the RCA of industries in China and the role of Chinese industries in the global trading chain.

The results for the RCA based on gross exports and value added exports of Chinese 35 industries are presented in Table 2 for three years (see Appendix 2 for industry description). Both the TRCA and VRCA show that Chinese 'Textiles and Textile Products' (C04) and 'Leather and Footwear' (C05) have strong comparative

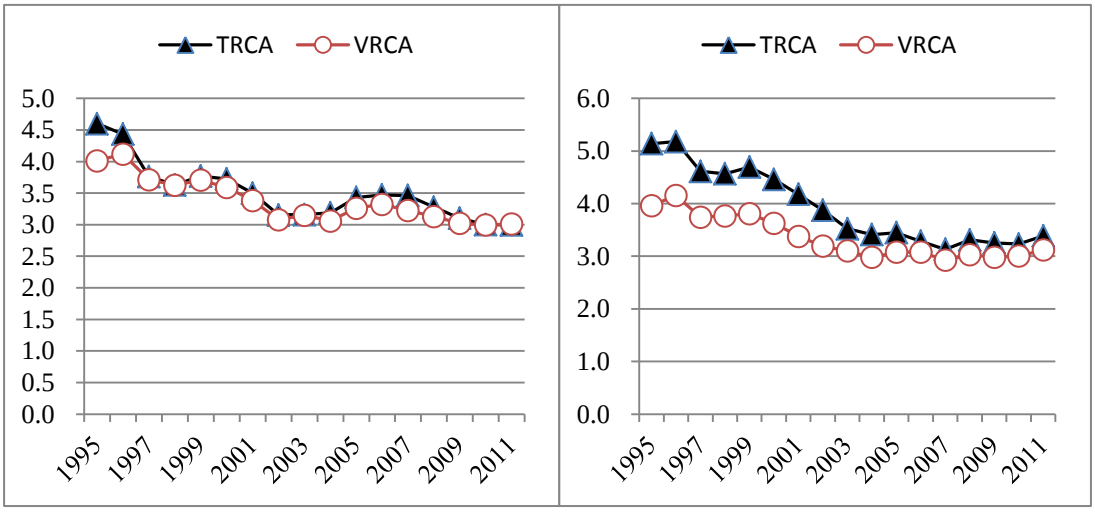
advantage. ‘Machinery’ (C13), ‘Transport Equipment’ (C15) and ‘Renting and other Business Activities’ (C30) have comparative disadvantage.

Table 2. The TRCA and VRCA of Chinese 35 industries

	TRCA			VRCA		
	1995	2002	2011	1995	2002	2011
C01	1.25	0.65	0.33	2.82	1.91	1.67
C02	0.48	0.35	0.05	0.90	0.69	0.41
C03	0.96	0.63	0.49	1.26	1.04	1.00
C04	4.60	3.15	3.00	4.01	3.08	3.01
C05	5.14	3.87	3.39	3.96	3.19	3.12
C06	1.60	0.80	0.93	1.57	1.25	1.68
C07	0.38	0.35	0.26	0.60	0.79	0.85
C08	0.32	0.50	0.14	1.15	1.05	0.63
C09	0.26	0.47	0.65	0.81	0.93	1.13
C10	1.85	1.50	1.57	1.44	1.54	1.59
C11	1.78	1.31	1.46	2.18	1.99	1.65
C12	1.02	0.90	0.81	1.07	1.03	1.31
C13	0.39	0.62	1.07	0.68	0.85	1.09
C14	1.37	1.69	2.56	1.02	1.43	1.81
C15	0.15	0.18	0.49	0.26	0.36	0.60
C16	1.21	1.85	1.40	1.06	1.72	1.45
C17	1.00	0.49	0.22	1.16	1.57	1.49
C18	1.70	1.20	1.50	0.43	0.39	0.29
C19	0.00	0.00	0.00	0.00	0.00	0.00
C20	0.00	1.83	1.10	0.78	1.26	1.13
C21	0.00	2.23	1.40	0.38	0.61	0.57
C22	3.41	1.96	1.08	1.96	1.61	1.43
C23	0.76	0.79	0.44	1.21	1.30	0.94
C24	0.53	1.30	1.30	0.61	2.40	1.86
C25	1.01	1.11	1.23	0.93	1.07	0.85
C26	2.09	0.39	0.31	1.09	0.19	0.34
C27	0.86	0.77	0.89	0.54	0.97	1.13
C28	0.09	0.02	0.03	0.86	0.61	0.86
C29	0.00	0.00	0.00	0.62	0.40	0.72
C30	0.16	0.54	0.65	0.15	0.31	0.43
C31	0.32	0.36	0.15	0.08	0.10	0.11
C32	0.83	0.36	0.24	0.75	0.59	0.71
C33	1.47	0.00	0.69	0.40	0.78	1.43
C34	2.03	3.24	0.86	0.86	1.39	0.86
C35	0.00	0.00	0.00	0.00	0.00	0.00

From 1995 to 2011, the traditional RCA of Chinese 'Textiles and Textile Products' and 'Leather and Footwear' maintained between 3 and 5.2 (shown in figure 1). The RCA based on value added exports maintained between 3 and 4. Both RCA indexes show strong comparative advantage. However, the strength of the TRCA has been decreasing in these years, indicating the export share of Chinese textile products, leather and footwear has been decreasing. With labor cost in China rising, the manufacturing advantage of Chinese labor-intensive industries may be slowly weakening. Some of these industries may be transferred to other countries or regions with lower labor cost. Figure 1 also shows that the VRCA is always lower than the TRCA, mainly because the value added rate of Chinese textile products, leather and footwear is low (maintained between 0.2 and 0.3).

Figure 1. RCA indexes of Chinese C04(left) and C05(right)



The time series profiles of the RCA for Chinese 'Agriculture, Hunting, Forestry and Fishing' (C01) , computed by both methods, are presented in figure 2. If we look at the traditional RCA, this is an obviously comparative disadvantage sector for China, with the RCA below 0.9 since 1997. In contrast, the new RCA takes on a much higher value, exceeding 2 in most years. The new RCA indicates that 'Agriculture, Hunting, Forestry and Fishing' is a comparative advantage sector for China. An important reason why the VRCA is much higher is that the value added rate of Chinese agriculture is always higher than that of other countries. On the other hand, the value

added of Chinese agriculture can be exported indirectly via other preponderant downstream industries such as 'Textiles and Textile Products' and 'Leather and Footwear' which have high export share.

The traditional RCA underestimates the comparative advantage of Chinese agriculture, while it overestimates that of Chinese 'Electrical and Optical Equipment' (C14). If we look at the TRCA in figure 3, electrical and optical equipment has progressively became a strong comparative advantage sector for China, with the TRCA exceeding 2.0 since 2004. However, the new RCA takes a much lower value, between 1.4 and 1.8 since 2002. Meanwhile, if we have a look at the case of USA and Japan in figure 4, we will find the TRCA underestimates their comparative advantage. Both the TRCA and VRCA of Japan maintained between 1 and 2, indicating comparative advantage for all these 17 years. As for the case of USA, we see a big divergence between the traditional and new RCA. The TRCA shows that electrical and optical equipment has gradually became a comparative disadvantage for USA since 2002. However, the new RCA shows that this sector has always been a comparative advantage sector for USA and the VRCA has actually been increasing in these years.

In the global production chain of electrical and optical equipment, developed countries such as USA and Japan always specialize in those production processes with

Figure 2. RCA indexes for C01 in China

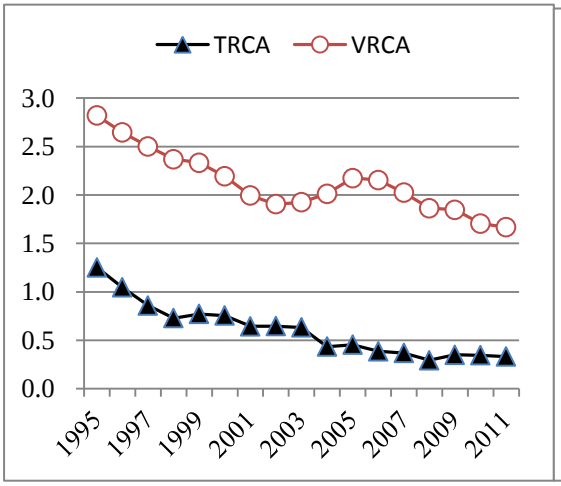
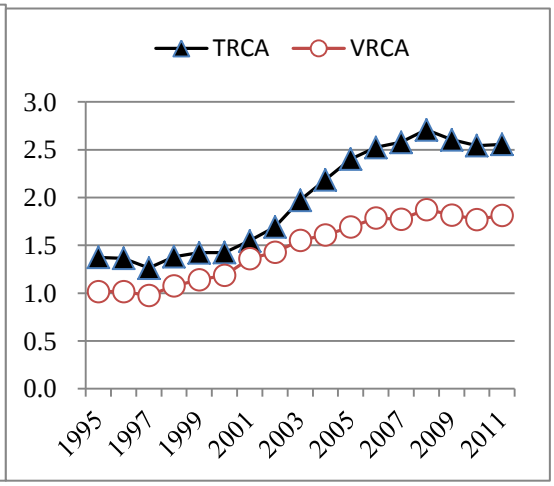
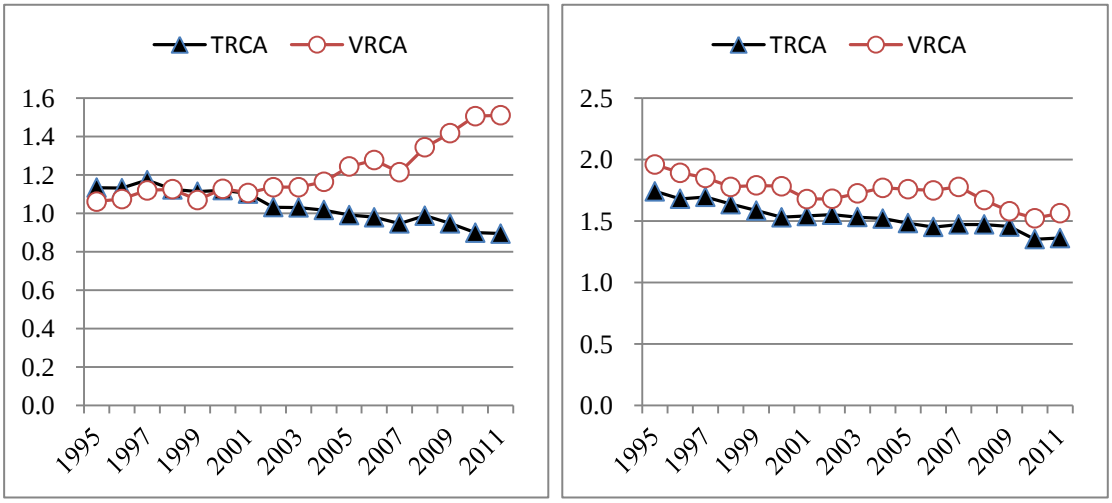


Figure3. RCA indexes for C14 in China



high value added such as development, design and marketing, while emerging economies such as China always specialize in those with low value added such as processing and assembling. Consequently, considering the unequal distribution of value added among the countries participating in the same production chain, the new RCA of China obviously decreased, while USA increased.

Figure 4. RCA indexes of Electrical and Optical Equipment for USA(left) and Japan(right)



The last several industries we want to illustrate are ‘Machinery’, ‘Transport Equipment’ and ‘Renting and other Business Activities’. Both indexes indicate they are comparative disadvantage sectors for China. However, the TRCA and VRCA of them have been progressively increasing and the RCA of Chinese machinery has exceeded 1 since 2008. In recent years, China has been promoting manufacturing industry upgrading to improve the competitiveness in the international market. Although some of machinery such as port machinery developed quite well in these years and have competitiveness in global market, their advantage is weakened and covered since their market share in the whole machinery industry is not high.

4. Effects of industrial linkage and vertical specialization on the new RCA

In section 2, we have interpreted the new RCA based on value added exports reflected both international specialization and domestic production sharing. In this

section, we will define a forward and backward linkage factor to reflect domestic production sharing and use vertical specialization share to measure international production sharing. Then, we will empirically analyze how vertical specialization, forward and backward linkage factor affect the new RCA of Chinese industries.

When studying industrial linkage, we should be careful to distinguish forward linkage and backward linkage. Likewise, we should consider the difference between them when we calculate a country-sector's value added exports. To illustrate the difference between them, we now turn to Chinese agriculture as an example. Forward linkage based value added exports takes into all value added that is originated in the Chinese agriculture, which contains both directly exported by the agriculture sector and indirectly exported by other Chinese sectors. Backward linkage based value added exports includes Chinese domestic value added from agriculture itself and other Chinese sectors.

Forward linkage based value added exports of sector i can be expressed as follows:

$$VAE\_F_i = V_i L_{i1} E_1 + V_i L_{i2} E_2 + \cdots V_i L_{ij} E_j + \cdots + V_i L_{im} E_m = V_i \sum_{k=1}^{m} L_{ik} E_k, i = 1, 2, \cdots, m \quad (8)$$

where VAE_F_i denotes the forward linkage based value added exports of sector i, V_i and E_j denote the value added coefficients and gross exports of sector i, j, separately. L_{ij} is typical element of national Leontief inverse.

Define α_F as the forward linkage factor, we can write its expression as follows:

$$\alpha_{Fi} = \frac{V_i \sum_{k \neq i} L_{ik} E_k}{VAE\_F_i}, i = 1, 2, \cdots, m \quad (9)$$

A larger α_{Fi} means sector i has a tighter forward linkage with other industries. It also means a higher share of indirectly exported by other sectors in sector i's value added exports.

Backward linkage based value added exports of sector i can be expressed as follows:

$$VAE\_B_i = V_1 L_{1i} E_i + V_2 L_{2i} E_i + \cdots V_j L_{ji} E_i + \cdots + V_m L_{mi} E_i = E_i \sum_{k=1}^{m} V_k L_{ki}, i = 1, 2, \cdots, m \quad (10)$$

where VAE_B_i denotes all domestic value added embedded in sector i's exports.

Define α_B as the backward linkage factor, we can write its expression as follows:

$$\alpha_{Bi} = \frac{E_i \sum_{k \neq i} V_k L_{ki}}{VAE\_B_i}, i = 1, 2, \cdots, m \quad (11)$$

A larger α_{Bi} means sector i has a tighter backward linkage with other industries. It also means a higher share of value added from other sectors in sector i's value added exports.

With a country specializing in particular stages of a good's production sequence, it will consume domestic inputs as well as imported inputs when producing goods that are exported. Therefore, a country-sector's gross exports include both domestic and foreign value added. Lawrence et al.(2010) have proved that a sector's gross exports is equivalent to the summation of its total domestic value added embedded in exports and the value of imported inputs embodied in its export. Hummels et al.(2001) defined the use of imported inputs in producing per unit of goods that are exported as vertical specialization share and gave the formula as follows:

$$VS = \mu' A^M (I - A^D)^{-1} \quad (12)$$

where μ' is a summation vector with ones. A^M and A^D denote the imported and domestic intermediate inputs coefficients matrix. Element a_{ij}^m of A^M denotes the imported inputs from sector i used to produce one unit of sector j's output. VS denotes vertical specialization share and it reflect the degree of participating in international fragmentation.

In order to better illustrate the effect of vertical specialization, forward and

backward linkage on the RCA of industries, we establish below an econometric regression model:

$$VRCA = \beta_0 + \beta_1 \alpha_F + \beta_2 \alpha_B + \beta_3 VS + \beta_4 TRCA \quad (13)$$

where $VRCA$ is the new RCA based on value added exports and $TRCA$ is the ratio of export shares. α_F and α_B denote the forward and backward linkage factor, separately. We use China's national IO tables from 1995 to 2011 in WIOD to calculate α_F, α_B and VS. We get 595 (17 years$\times$35 industries) observations and use 561 to regress in model (1) after deleting some null value. To make a robust test, we use 238 observations of manufacturing industries to regress in model (2). The results of parameter estimation are presented in table 3.

According to table 3, tight forward linkage and participating in vertical specialization significantly increase the future probability of an industry to have RCA. For those industries in the global production chain, a higher vertical specialization share implicates a larger RCA. For those with low vertical specialization, if their forward sectors have comparative advantage in exporting, there is also strong possibility for them to have high RCA based on value added trade. The sectors with high export share also tend to have advantage in value added export.

Table 3. Results of regressive equation (13)

	Model (1)	Model (2)
α_F	0.79*	0.92*
α_B	-0.56*	-0.9*
VS	1.50*	0.77*
TRCA	0.77*	0.87*
Observations	561	238
Adjusted R^2	0.63	0.95
D.W. stat	1.81	2.02

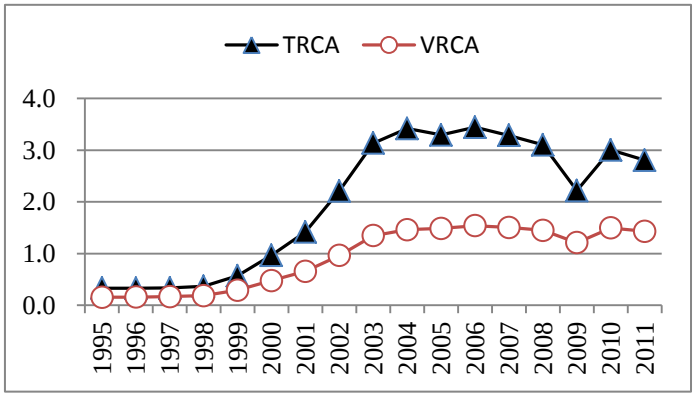
Notes: * denotes the coefficients are significant at 1% level.

Vertical specialization occurs when two or more countries provide value added during the production of a good and at least one country must use imported inputs in

its stage of the production process and some of the resulting output must be exported. Note that vertical specialization involves both an import side and an export side. High VS share sectors also tend to be the high export sectors, i.e. there is a positive correlation between sector VS shares and export ratios. Moreover, the technology spillover caused by participating in vertical specialization makes it possible for industries to upgrade and improve competitiveness in the global chains.

Next we report two examples to illustrate the positive effect of forward linkage on value added exports. The first is about 'Agriculture, Hunting, Forestry and Fishing' for China. As presented in sector 2, the ratio of export share of Chinese agriculture is quite low. However, its forward sectors such as 'Textiles and Textile Products' and 'Leather and Footwear' have strong comparative advantage in exporting. Therefore, by the new method, this sector is more likely to have RCA based on value added trade. For the second example, we look at the RCA for Indian 'Renting and other Business Activities'. The traditional and new measures of the RCA for India are presented in figure 5. The traditional RCA shows that India's business services exports are really fantastic due to business technology and IT consulting firm Infosys, Wipro, Cognizant and call centers. Interestingly, the strength of the new RCA is much weaker than the TRCA. For India, domestic business services contribute relatively little to the production and exports of other sectors and India's machineries, electrical equipment and transport equipment have no comparative advantage. With little indirect exports via other downstream sectors, India's business service value added exports become much less impressive.

Figure 5. RCA indexes of renting and other business activities for India



5. Concluding Remarks

The measurement of revealed comparative advantage, proposed by Balassa, has proven useful in many research and policy applications. However, the traditional computation of RCA based on official trade statistics could be misleading since it ignores both domestic and international production sharing. So, what is the conceptually correct measure of comparative advantage? The present paper aimed to contribute to this discussion, promoting a new measurement of RCA based on domestic value added in exports.

Since indirect exports should be included and foreign value should be excluded, the input-output methodology is especially suitable. In our measurement, we use a world input-output model to derive the value added in exports and then construct the new RCA. In the empirical application, we compute both the traditional and new RCA index at the country-sector level for all the countries and sectors in the WIOD database. For the purpose of our analysis, we focus on the case of China and mainly present the results of China in this paper.

In our results, we observed that Chinese labor-intensive industries, especially 'Textiles and Textile Products' and 'Leather and Footwear' have strong comparative advantage. 'Machinery', 'Transport Equipment' and 'Renting and other Business Activities' have comparative disadvantage. The traditional RCA underestimates the comparative advantage of Chinese agriculture because it ignores the fact that Chinese agriculture has a considerable part of indirect exports, while it overestimates that of Chinese 'Electrical and Optical Equipment' since it ignores the foreign value.

Finally, we analyze the effect of vertical specialization, forward and backward linkage on the new RCA. We found tight forward linkage and high vertical specialization significantly increase the future probability of an industry to have RCA. For those industries in the global production chain, a higher vertical specialization share implicates a larger RCA. For those with low vertical specialization, if their forward sectors have comparative advantage in exporting, there is also strong possibility for them to have high RCA based on value added trade.

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Appendix 1

Proof of eq.(6)

$$VAE = \hat{V}F - \hat{V}F^D + \hat{V}AF - \hat{V}A^DF^D + \hat{V}AAF - \hat{V}A^DA^DF^D + ...$$
$$= (\hat{V}F + \hat{V}AF + \hat{V}AAF + ...) - (\hat{V}F^D + \hat{V}A^DF^D + \hat{V}A^DA^DF^D + ...)$$
$$= \hat{V}(I-A)^{-1}F - \hat{V}(I-A^D)^{-1}F^D$$
$$= \hat{V}(I-A)^{-1}F - \hat{V}(I-A^D)^{-1}(F-F^E)$$

Define $B = (I-A)^{-1}$, then,

$$(I-A)B = I$$
$$B - A^DB - A^EB = I$$
$$(I-A^D)B - I = A^EB$$
$$B - (I-A^D)^{-1} = (I-A^D)^{-1}A^EB$$

Thus,

$$VAE = \hat{V}BF - \hat{V}(I-A^D)^{-1}(F-F^E)$$
$$= \hat{V}\left[B - (I-A^D)^{-1}\right]F + \hat{V}(I-A^D)^{-1}F^E$$
$$= \hat{V}(I-A^D)^{-1}A^EBF + \hat{V}(I-A^D)^{-1}F^E$$
$$= \hat{V}(I-A^D)^{-1}(A^EX + F^E)$$
$$= \hat{V}(I-A^D)^{-1}E$$

Appendix 2 List of the 35 industries:

Code	Industry Description
c1	Agriculture, Hunting, Forestry and Fishing
c2	Mining and Quarrying
c3	Food, Beverages and Tobacco
c4	Textiles and Textile Products
c5	Leather, Leather and Footwear
c6	Wood and Products of Wood and Cork
c7	Pulp, Paper, Paper , Printing and Publishing
c8	Coke, Refined Petroleum and Nuclear Fuel
c9	Chemicals and Chemical Products
c10	Rubber and Plastics
c11	Other Non-Metallic Mineral
c12	Basic Metals and Fabricated Metal
c13	Machinery, Nec
c14	Electrical and Optical Equipment
c15	Transport Equipment
c16	Manufacturing, Nec; Recycling
c17	Electricity, Gas and Water Supply
c18	Construction
c19	Sale, Maintenance and Repair of Motor Vehicles and Motorcycles; Retail Sale of Fuel
c20	Wholesale Trade and Commission Trade, Except of Motor Vehicles and Motorcycles
c21	Retail Trade, Except of Motor Vehicles and Motorcycles; Repair of Household Goods
c22	Hotels and Restaurants
c23	Inland Transport
c24	Water Transport
c25	Air Transport
c26	Other Supporting and Auxiliary Transport Activities; Activities of Travel Agencies
c27	Post and Telecommunications
c28	Financial Intermediation
c29	Real Estate Activities
c30	Renting of M&Eq and Other Business Activities
c31	Public Admin and Defence; Compulsory Social Security
c32	Education
c33	Health and Social Work
c34	Other Community, Social and Personal Services
c35	Private Households with Employed Persons