

Dean, Judith; Fung, K. C.; Wang, Zhi

Working Paper

Measuring the vertical specialization in Chinese trade

Working Paper, No. 08-06

Provided in Cooperation with:

University of California Santa Cruz, Santa Cruz Institute for International Economics (SCIIE)

Suggested Citation: Dean, Judith; Fung, K. C.; Wang, Zhi (2008) : Measuring the vertical specialization in Chinese trade, Working Paper, No. 08-06, University of California, Santa Cruz Institute for International Economics (SCIIE), Santa Cruz, CA

This Version is available at:

<https://hdl.handle.net/10419/64058>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Measuring the Vertical Specialization in Chinese Trade

Judith Dean*

US International Trade Commission

K.C. Fung*

UC Santa Cruz and US International Trade Commission

Zhi Wang*

US International Trade Commission

This version: December 2008

*This paper was completed when K.C. Fung was an advisor and an academic collaborator at the US International Trade Commission. He is grateful to the hospitality of the USITC and he appreciates a U.S. government federal research grant provided by the USITC. This is part of a USITC project on U.S.-China Trade: Implications for U.S.-Asia Pacific Trade and Investment Trends, which consists of three fact finding investigations legally requested on September 21, 2006 by the *Committee on Ways and Means*, U.S. House of Representatives, under authority of section 332 (g) of the Tariff Act of 1930. The authors are grateful for helpful suggestions from Michael Ferrantino, Will Martin, Alex Hammer, the participants in the USITC Research Division Seminar, and the participants in the Conference on China's Integration in the World Economy, National Bureau of Statistics, Beijing, China (October 2006). The views expressed in this paper are those of the authors alone. They do not necessarily reflect the views of the US International Trade Commission, or any of its individual Commissioners.

Measuring the Vertical Specialization in Chinese Trade

Judith Dean*

US International Trade Commission

Judith.Dean@usitc.gov

K.C. Fung*

UC Santa Cruz and US International Trade Commission

kcfung@ucsc.edu

Zhi Wang*

US International Trade Commission

Zhi.Wang@usitc.gov

December 2008

Abstract

In recent years, two important related developments have transformed the nature of world trade: the explosive growth of Chinese trade, and the growth of vertically specialized trade due to international production fragmentation. The literature in each of these two separate topics is large and growing. However, very few papers quantitatively assess these two trends together. In this paper, we measure the degree to which Chinese trade has become vertically specialized, using a new measure adapted from Hummels, Ishii and Yi (2001). By making use of the latest Chinese input-output tables, and a new detailed Chinese trade dataset which distinguishes processing trade from other forms of trade, we develop a new method of identifying intermediate goods imported into China. With this new method, we measure Chinese vertical specialization over time, and by sector, export destination, and input source. We find about 35 percent of the value of China's exports to the world is attributable to imported inputs. This vertical specialization exceeds 50% in some sectors, and is growing over time.

JEL Codes: F10, F14

Key Words: China, fragmentation, vertical specialization, trade growth

1. Introduction

In recent years, two interrelated important phenomena have occurred that transform the fundamental nature of global trade. The first phenomenon is the international fragmentation of production, where production processes are sliced thinner and thinner into many stages, and the resulting production fragments are carried out in different locations. The production of a finished product thus involves the participation of many economies, with countries specializing in different fragments of the vertical production chain. International trade is then increasingly dominated by trade in parts and components—fragments. While the international division of labor in the global economy is nothing new, the vast scope and the intricate nature of this pattern of global production sharing seems genuinely unprecedented.

The second phenomenon is the explosive growth of Chinese trade, and China's increasing importance in the global production chain. In current dollars, the value of China's exports plus imports rose from \$280.9 billion in 1995 to \$1422.1 billion in 2005--a growth of about 311%. China's policy regime of processing trade provides incentives for the import of intermediate goods, which are then transformed into finished goods for export. In 2005, processing trade accounted for 42 percent of China's imports from the world, and 55 percent of China's exports to the world. A similarly large proportion of China's imports from the U.S. (23 percent) and exports to the US (65 percent) were processing trade. This trade is concentrated in relatively high-tech products, and is carried out largely by foreign firms.

China's prominence in trade has raised numerous questions. How is it that China's trade can grow so rapidly? Has China's comparative advantage shifted to production of high-tech goods? How does this rapid growth and new composition of trade affect China's gains from trade? Increasingly, it appears that the answers to these questions may be found by studying the impact of international production fragmentation on China's trade. Because the splitting of the production process leads to products crossing borders many more times than in ordinary trade, production fragmentation across borders could account for rapid growth in trade (Yi, 2003). While China's final

good exports may appear far more high-tech than traditional comparative advantage would predict (Rodrik, 2006; Schott, 2006), fragmentation theory suggests that the fragments which make up the production chain are likely to be allocated across countries in a way that reflects traditional comparative advantage (Jones and Kierzkowski, 2001). Finally, the global gains from trade may be enlarged because international production fragmentation allows more finely defined production processes to be allocated across countries more efficiently (Yi, 2003).¹ Unlike intra-industry trade, this “intra-product” trade might particularly foster the growth of trade between industrial and developing countries (Jones, et al., 2005).²

Yet in both the academic and policy literature, the phenomena of international production fragmentation and China’s growth in trade have been studied quite separately. Much of the recent literature studying the growth of Chinese trade has focused on the role of foreign direct investment, trade liberalization, WTO accession, incentives, and the composition of China’s exports.³ Most of the recent literature on fragmentation has focused on developing and testing various theories of the firm’s decision to fragment production across borders.⁴ A few studies have attempted to measure the importance of trade in parts and components in global trade and East Asian trade, and found it to be large (Yeats, 2001; Ng and Yeats 2001, 2003). Athukorala and Yamashita (2006) find that parts and components accounted for about one-third of China’s exports in 2003, and nearly 40% of the growth in China’s exports between 1992 and 2003.⁵ Baldwin (2006) documents the growing importance of

¹ An individual country’s gains from trade might also be enlarged if fragmentation lowers adjustment costs to trade liberalization, by allowing displaced workers to find new employment in a different stage of production within the same sector (Deardorff, 2001; Jones and Kierzkowski, 2001). Deardorff (2005) argues that in a world of fragmentation, the gains from trade result will likely hold. However, it is unclear if some factors of production like unskilled workers may or may not be hurt by fragmentation. See also Markusen (2005).

² It is however somewhat unclear to what extent such intra-product trade between the United States and China has contributed to a rise in wage inequality in the U.S. For an important discussion, see Krugman (2008)

³ Some recent examples include Bhattasali, et al. (2004), Dean, Lovely and Wang (2006), Wang (2003), Schott (2006), Rodrik (2006), Hammer (2006), Amiti and Javorcik (2005).

⁴ Examples in the first group include Antras (2003, 2005), Antras and Helpman (2005), Grossman and Helpman (2004, 2005), McLaren (2000), Feenstra and Hanson (2005), and Feenstra and Spencer (2005). For an excellent survey of both theoretical and empirical work see Spencer (2005).

⁵ See also Athukorala (2006). These studies, as well as Yeats (2001) and Ng and Yeats (2003), are confined to a limited number of SITC sectors where parts and components are easily identified.

China in East Asian trade in parts and components. But little work has been done exploring the degree to which China's trade has become vertically specialized due to production fragmentation.

This paper fills this void by measuring the vertical specialization in Chinese trade. We make three contributions. First, we use a new detailed Chinese trade dataset which distinguishes processing and ordinary imports, as well as the United Nations Broad Economic Categories (BEC) classification of capital, intermediate, and consumer goods, to more accurately identify Chinese imports of intermediate goods. Second, we combine these newly identified intermediate import data with the 1997 and 2002 Chinese benchmark IO tables, to construct an improved version of the Hummels, Ishii and Yi (2001) (HIY) measure of vertical specialization. Third, we use this new measure of vertical specialization to quantify the foreign content in Chinese global exports and bilateral exports, from 1996-2005, and disaggregate these results by source country and by firm type. We then quantify Chinese vertical specialization for 122 sectors over the same time period.

Our approach surmounts some of the technical difficulties encountered in two recent studies which examine fragmentation in China's trade. Chen, Cheng, Fung and Lau (2004) use Chinese data to measure the value of Chinese exports net of imported intermediate goods used for the production of such exports. However, their study is limited to a single year (1995) and 33 sectors. Ping (2005) uses Chinese data to calculate the HIY measure over time, by source country and by sector. However, he is only able to use one benchmark IO table (1997), which ultimately limits his results to 40 sectors.⁶ In addition, he is unable to isolate processing imports and exports in measuring intermediate input use.

Our results show that in 2002, the vertical specialization share (VS share) in Chinese trade with the US and with the world was 30.8 percent and 35.9 percent, respectively. That is, imported

⁶ The year 2000 is a non-benchmark year for the construction of the Chinese input-output table and it has only 40 sectors. In contrast, 1997 is the year with a benchmark input-output table and it has 124 sectors. In addition, Ping computes his estimates of VS shares using aggregate IO data, which tends to underestimate the actual VS share as pointed by Yi (2003).

intermediate inputs made up 30.8 cents (35.9 cents) of every dollar's worth of Chinese exports to the US (to the world) in 2002. These are significantly higher estimates of China's VS share than in previous studies. We also see strong evidence of the Asian network of suppliers to China studied by Baldwin (2006) and Athukorala (2006). Disaggregating VS share by source, we find Japan and the Four Dragons accounted for more than half of the value of imported inputs in China's exports, both at the beginning and the end of the ten year period. However, the US and EU together accounted for an additional 16-17%.

Our evidence also suggests that China's trade is becoming more vertically specialized over time. Between 1997 and 2002, China's VS share increased by about 23%. China's VS share with individual trading partners shows growth over time, with considerable acceleration in the VS share of exports to the US and to the EU. The most vertically specialized sectors in China's trade are plastics, steel processing, communications equipment, industrial machinery, metal products, and electronic computers. In these sectors, imported intermediate goods account for between 52 percent and 76 percent of the value of Chinese exports. Not surprisingly, we find that wholly-owned foreign firms and joint ventures have the most vertically specialized trade.

2. Methodology

2.1 The HIY measure

To measure the extent of vertical specialization of China, we begin with the method used by HIY. Consider Figure 1 for illustration.⁷ In this figure, A is the amount of imported textile inputs. D is the amount of domestic sales of apparel, while E is the amount of exports of apparel to the United States. The measure of vertical specialization (VS) is given as $(A / (D+E)) * E$ or $(E / (D+E)) * A$. Conceptually, this $(E / (D+E))$ is the proportion of exports to total sales. When multiplied by A, the VS index measures the dollar value of imported inputs "contained" in Chinese exports. To get the

⁷ Figure 1 is adapted from Hummels, Ishii and Yi (2001).

share of imported inputs contained in one dollar worth of Chinese exports—VS share--we divide VS by E.

Given that we will be dealing with many inputs and many exports, we follow HIY and write our VS share index for China in matrix notation as:

$$\text{VS share} = \mathbf{u} \mathbf{A}^M [\mathbf{I} - \mathbf{A}^D]^{-1} \mathbf{X} / x_k \quad (1)$$

where \mathbf{u} is a $1 \times n$ vector of 1's, \mathbf{A}^M is an $n \times n$ imported coefficients matrix, \mathbf{I} is the identity matrix, \mathbf{A}^D is the $n \times n$ domestic coefficient matrix, \mathbf{X} is the $n \times 1$ export vector and x_k is a scalar that denotes the amount of exports from country k , which in our case, is China. The numerator of equation (1) measures all the imported inputs, iterated over the economy's production structure, that are needed to produce the exports of China from all n sectors. Dividing this by the amount of Chinese exports yields the total (both direct and indirect) share of Chinese exports attributable to imported inputs (VS share).

There are at least two concepts used in the literature which are related to VS share. One is the domestic content share, which is the gross value of exports minus the value of all imported intermediate goods used in their production divided by export value. A second term used is “domestic value added share”, which is not often used in the academic literature, but is identical in definition to the domestic content share. It can be shown that $(1 - \text{VS share})$ is equal to the domestic value added ratio or the domestic content ratio. We highlight this equivalence in Appendix I.⁸

2.2 *A new measure of vertical specialization*

To improve our ability to identify imported intermediate goods, we make use of detailed data on Chinese processing trade. In China's customs statistics, processing trade consists of two types—trade associated with processing and assembly and trade associated with processing with imported inputs. The Chinese government provides special incentives for enterprises engaged in processing trade, allowing them to import raw materials and other inputs duty free as long as these inputs are

⁸ The proof is first given in Chen, Cheng, Fung and Lau (2004) in their appendix 1. However, they did not realize the link between their domestic value-added measure and HIY's VS share measure.

used to produce final goods or further processed inputs solely for export. Trade associated with processing and assembly means that ownership of the imported inputs is retained by the foreign exporting firm. Processing with imported materials means that ownership of the imported inputs is transferred to a local presence.

Processing trade is highly concentrated by sector, by origin, and by firm type. In 2005, more than two-thirds of this trade was found in 3 key sectors: Electrical Machinery (HS85), Machinery (HS84), and Optical, Medical and Precision Instruments (HS90). More than three-quarters of imported processing inputs originated in the Four Dragons, Japan, and other Southeast Asian economies. In addition, foreign-invested enterprises (FIEs) accounted for 84 percent of China's processing exports and imports.⁹

Our basic approach in measuring imported Chinese inputs is to classify all processed imports as imported intermediate goods. Within ordinary Chinese imports there may also be some amount of imported intermediate goods used for the production of exports. This is particularly true for information technology products, as China joined the Information Technology Agreement (ITA) in 2003, which provides importers with duty free imports in this category. To capture these imported intermediate goods, we apply the United Nations BEC (Broad Economic Categories) classification to all Chinese non-processed imports, and include as intermediates any goods labeled as such by the BEC. For ease of exposition, we call this two-step approach the Dean-Fung-Wang (DFW) approach.

To identify the coefficients in the A^M matrix, we use our new estimates of total sectoral imported intermediates, and assume that these imported inputs are used in each industry in the same proportion as indicated in the original input-output table. The coefficients in the A^D matrix are then obtained as residuals by subtracting the coefficients in the A^M matrix from the coefficients in the original input-output table.

⁹ Throughout this paper, FIE will refer to three types of foreign-owned firms: wholly foreign-owned, equity joint venture and contractual joint venture.

All data on processing imports and exports, and on ordinary trade used in the estimates of VS share are taken from a new USITC Chinese trade database. This database was purchased from China Customs, and contains official Chinese export and import data from 1995-2005 at the HS 8-digit level, differentiated by customs regime, region, source, destination, firm ownership, incentives, port, and transport mode. The two Chinese input-output tables that we use are from 1997 and 2002.¹⁰ Both years are benchmark years, which means they include more detailed sectors than otherwise: 124 sectors in 1997 and 122 sectors in 2002.¹¹

2.3 Alternative methods for identifying intermediate inputs

To test the robustness of our results, we will also utilize two other methods to codify imported intermediate inputs. One is to simply use the BEC identification for all Chinese imports, and single out those that are intermediate goods under this UN classification. We shall call this the BEC approach. A second alternative approach is to assume that the ratio of imported intermediate inputs to total imports is the same as the ratio of total intermediate inputs to total absorption. This is a standard method used to deduce the extent of imported inputs in the input-output literature. Both Ping (2005) and Chen, Cheng, Fung and Lau (2004) used this basic approach in their calculations.¹² We will label this alternative as the IO approach.

Essentially these are three alternative ways to identify intermediate goods from total imports for each sector. To clarify the differences, define the share of total imports (i.e. imports of intermediate goods and imports of final goods) accounted for by intermediate goods in sector i as $INTSH_i$, where the subscript denotes sector i . Then imports used as intermediate inputs, $IMPINT_i = INTSH_i * \text{total imports}$. The three methods use different rules to identify $INTSH_i$.

¹⁰ The Chinese input-output tables are of the competitive import type, which means that the tables do not differentiate between domestic intermediate goods and imported intermediate goods. To achieve the objective of our project, we need to convert the input-output tables into the non-competitive type, i.e. to separate out imported inputs and domestic inputs. As discussed earlier, the main method we used is the DFW approach.

¹¹ These sectors are listed in tables 3 and 4. For example, the study by Chen, Cheng, Fung and Lau (2004) used the 1995 Chinese input-output table, which had only 33 sectors.

¹² Hummels et al. (2001) also appears to use this method, but the exact method is not stated explicitly in the paper.

For the DFW case, $INTSH_i = ((\text{Processing imports}_i + \text{Intermediates identified by the BEC classification for non-processing imports}_i) / \text{total imports}_i)$. For the BEC case: $INTSH_i = (\text{Intermediates identified by the BEC classification from all imports}_i / \text{total imports}_i)$. For the IO case: $INTSH_i = \text{total intermediate use (domestic and imports) for sector } i / \text{total absorption for sector } i$ (both domestic and imports) as given in the conventional input-output tables.

These three methods yield significantly different estimates of the sectoral shares of imported intermediate goods. For illustration, we present two tables in Appendix II, showing these shares for Chinese imports from the world and Chinese imports from the United States for the year 2002 (the year of the most recent Chinese benchmark input-output table). In general, we can see that the BEC method yields shares that are less than or equal to the DFW method, since the DFW method counts all processing imports as imported intermediates. Since the IO method uses the average inputs to absorption ratio as the share of imported intermediate goods, it will tend to be lower (higher) than the DFW method in sectors where processed imports are high (low). Figure 2 illustrates the significant differences in the shares of imported intermediates generated by the three methods. It is clear from these simple regressions that the IO shares are very different from the other estimates while the BEC shares and the DFW shares are more closely correlated.¹³

We believe that the DFW method is conceptually and economically an improvement over the alternative methods of identifying intermediate imports. Fundamental economic principles teach us that economic agents do respond to incentives. When Chinese firms or foreign firms import intermediate goods into the country for processing, there is every incentive for these economic agents to declare that these inputs are used for processing. For sectors such as information technology, agreements like the ITA may have reduced these incentives. But it seems that there is relatively little cost for these processing firms to still declare them as such. Furthermore, even if they do not declare these imported inputs as used for processing purposes, the BEC method should still be able to catch

¹³ Note that if we draw a 45 degree line in the graph relating the BEC and the DFW shares, we can show that the BEC shares are no higher than the DFW shares.

these outliers. At worst, it seems to us that the DFW method is no better than the BEC method.¹⁴ In contrast, the IO method uses a very strong assumption. While this may be necessary when detailed data on processing trade are not available, it is easy to see why the two alternative methods should yield better results.

3. Results

3.1. Vertical Specialization in China's Exports to the World

3.1.1 Over time. In measuring the aggregate vertical specialization shares for China's exports to the world, we have two benchmark years, 1997 and 2002. The results for both direct VS shares and total VS shares for each year, using the DFW method of measurement are shown in Table 1. For comparison, the results for the same years, using the BEC and IO approaches are also shown. From Table 1, we can see that using the DFW method, the aggregate intermediate import content (total VS share) of China's exports was 29.3% in 1997, and 35.9% in 2002. In general, the direct shares are less than half of the total VS shares, but they show a similar large increase during this period. This increase in VS shares suggests that the fragmentation of China's exports to the world has been rising significantly. These trends are robust when we examine the results from the two alternative methods. Table 1 indicates that both the BEC method and the IO methods yield total VS share values of similar magnitude, though slightly smaller than the DFW method. Each of these three methods shows a rise in VS of about 6.5 percentage points between 1997 and 2002.

3.1.2 By Source Country. As discussed above, China's imports of intermediate inputs appear to be sourced for the most part from other Asian economies. Using the DFW method of identifying imported inputs, we can disaggregate China's total VS, to assess the extent of imported intermediate

¹⁴ Because of these incentives, it is possible that producers will report more imports as processing imports than is actually true, implying that China official customs statistics will overstate the amount of processing imports. This may be one of the reasons that only about 85 percent of processing imports were identified by UN BEC classification as intermediate inputs. On the other hand, the BEC method may underestimate the portion of imported intermediates in processing trade for some double end use commodities which are entered as processing trade in Chinese Custom statistics.

goods from the United States and other countries, for each dollar of China's exports to the world. We again use both the 1997 and the 2002 input-output tables and extend our analysis to other years. The results for 1996 and for 2005 are shown in figure 3.¹⁵

In Figure 3 we can see that Japan and the Four Dragons (Hong Kong, Taiwan, South Korea, Singapore) constituted more than half of China's total VS share in 1996, with an additional 6% from the rest of Southeast Asia. Thus, these economies could be seen as an Asian supply network for China's global production-sharing. Japan was the largest single country source of inputs, accounting for 20% of China's intermediate inputs. The United States and the EU15, supplied roughly similar shares of 8% and 9%, respectively. Though much smaller than the Asian network, they still constituted important sources of intermediate inputs for China's fragmented trade. Interestingly, China's sourcing patterns do not change much by 2005. Within the Asian supply network, the focus has shifted away from Japan somewhat and more toward other Southeast Asian countries. But this network still accounts for 58% of China's aggregate VS share in 2005. Similarly, the United States and EU15 still supply about 16% of China's intermediate inputs for exports.

3.2. China's Vertical Specialization by Sector

Tables 2 and 3 show how the direct and total VS shares vary with different sectors using our own DFW methods as well as the two alternative methods. Table 2 shows sectoral results using the 1997 benchmark input-output table, and table 3 uses the 2002 benchmark input-output table. To highlight the sectors with the highest total VS shares, figures 4 and 5 show the sectors with total VS (by DFW method) of 25% or more, for 1997 and 2002 respectively.

In 1997, seventeen industrial manufacturing products had total VS shares of 25% or more (Figure 4). In three of these sectors, the value of imported inputs was greater than 50% of the value of exports: metal products (65%), steel processing (59%) and other electric machinery and equipment (53%). Cotton textiles and wearing apparel had VS shares of between 40% and 50%. Other sectors

¹⁵ The results in Figure 3 are estimated by using the DFW method only.

with relatively high total VS shares included plastic products, petroleum refining, other general industrial machinery , motor vehicles, and other special industrial equipment.

By 2002, the mix of products with the highest total VS shares had changes somewhat (Figure 5). Now a total of 21 sectors had total VS shares exceeding 25%. Six manufacturing sectors now had total VS shares exceeding 50% of exports: plastic products (76 %), steel processing (69 %), communication equipment (59%), other general industrial machinery (58 %), metal products (55 %), and electronic computers (52.1 percent). In an additional six sectors, the value of imported inputs was between 40% and 50% of the value of exports.

These results are fairly robust across the three methods, though there are some minor variations. For example, for motor vehicles for the year 2002, the IO approach, the BEC approach and the DFW approach yielded respectively total VS shares of 35.1%, 31.9% and 34.0%. We expect that the BEC method, which applies the United Nations classification of intermediate goods uniformly for processing as well as non-processing imports, would yield the lowest estimates of the VS shares, and this is borne out in figures 2 and 3. We also expect that the IO method would underestimate VS in sectors with a high level of processing trade and overestimate it in sectors with a low level of processing trade. This is borne out to some degree in the two figures.

Figure 6 shows the change in VS shares from 1997-2002 for selected sectors. It is immediately evident that in most of these sectors, VS shares have grown significantly. While imported inputs constituted 39 cents of every US dollar worth of plastic products exported by China in 1997, this nearly doubled to 76 cents of each dollar of exports by 2002. Total VS more than doubled in communication equipment and sawmills and wood products, and grew by at least one-third in electronic computers, and general industrial machinery. Interestingly, VS shares in cotton textiles and wearing apparel actually fell.

3.3. China's Vertical Specialization in Exports by Trading Partner

In measuring the vertical specialization shares of China's exports to the United States, we again utilize the two benchmark input-output tables, which provide us with two matrices of

coefficients of imported intermediates, one for 1997 and one for 2002. To get results for other years, we assume these import matrices to be unchanged, but we allow China's exports to the United States to vary. Using the 1997 matrix, we extrapolate the calculations for the years 1996 to 2001. Similarly we can measure the VS shares of China's exports to the United States using the 2002 input-output tables and extrapolate our measurements to the years 2001-2005 by changing the export vector for each year. To save space, we present only results with our DFW method. These VS shares are presented in Table 4.

From Table 4 we can see that both the direct and total VS shares are rising over time for China's exports to the United States. This suggests that China's exports to the United States contain an increasing share of imported intermediate goods over time. China appears to be increasingly enmeshed in the global network of production fragmentation, whether we consider its trade with the world or its trade with the United States. Figure 5 shows the fragmentation of China's exports to a number of trading partners over time, using the DFW measure.¹⁶ The vertical specialization of China's exports to the United States and the EU15 show a similar trajectory, beginning a little above 25% in 1996, and rising to about 30% in 2005, with an acceleration starting in 2000. China's exports to Japan are less vertically specialized, though the pattern over time is not too different from that of the United States or the EU.

We might expect that China's exports to India would be less fragmented, since it is a country at a similar level of development. Figure 5 suggests that this is the case. China's exports to India begin with a total VS of only 20%, which does rise rapidly to about 27% at the end of the period, but remains significantly below the level of VS for the industrialized economies. Interestingly, the VS for China's exports to Singapore and Taiwan follow a similar pattern to that of the US and the EU15.

3.4. Vertical Specialization by Chinese Exporting Firms

Our rich Chinese trade data also allow us to differentiate a variety of Chinese exporting firms and we measure the degree of fragmentation in their exports as well. Table 5 shows results for 2002

¹⁶ In the figure, the VS value for 2001 is based on the results using the 2002 matrix.

for Chinese firms exporting to the world, and for firms exporting to the United States.¹⁷ For exports going to the world, we can see that the highest VS share was for wholly-owned foreign firms, followed by joint ventures, collectives, state-owned enterprises and others. For exports to the United States, the total VS share was highest again with the wholly-owned foreign firms, followed by collectives, joint ventures, state-owned enterprises and then others. Not surprisingly, the FIEs showed more fragmentation than state-owned firms.

5. Conclusion

While trade fragmentation and China's rapidly growing trade have been recognized as important economic phenomena, the importance of fragmentation in China's trade growth has been left unexamined until recently. In this paper, we provide the most up-to-date and comprehensive measures of the degree of vertical specialization in China's trade, using a new detailed Chinese dataset which allows us to distinguish processing imports and exports from ordinary trade. We further utilize the United Nations Broad Economic Categories (BEC) system to identify non-processed imported intermediates from imports of final goods. These data are incorporated into the Hummels, et al. (2001) measure of vertical specialization, using both the 1997 and 2002 benchmark Chinese IO tables. We then quantify vertical specialization over time, by source, by trading partner, sector, and type of firm.

Our results show that the vertical specialization in China's exports to the world was more than 30% in 2002. In the sectors with the most fragmented trade--plastic products, steel processing, communication equipment, industrial machinery, metal products and computers—vertical specialization exceeded 50%. Not surprisingly, the firms with the most fragmented trade are the foreign-invested enterprises. There is strong evidence of the importance and persistence of an Asian supplier network to China. About 58% China's aggregate vertical specialization in 2002 was attributable to imports from Japan, Taiwan, South Korea and other Southeast Asian economies.

¹⁷ Here we present only results measured by the IO approach. In future work we will include estimates using the BEC and DFW approaches.

Among bilateral partners, China's vertical specialization was high (about 30%) with not only the US, the EU 15, and Canada, but also with Taiwan and Singapore. Our evidence also suggests that the fragmentation in China's global trade is growing, particularly its trade with the US and the EU.

Our results are generally robust to the use of alternative methods of measurement. However, for some specific sectors, there can be some variations across methods. For example, in 1997, for motor vehicles, the extent of fragmentation was 34% using our own DFW method, but it was 31.9% using the BEC method and 35% using the IO approach. These variations could become important for our future work since we intend to econometrically determine the how the VS shares can vary with different variables as suggested in the theoretically literature. The alternative measures give us an opportunity to test the robustness of our future estimates.

References:

- Amiti, M. and B. Javorcik. 2005. "Trade Costs and the Location of Foreign Firms in China," IMF Working Paper No. 05/55.
- Antras, P. 2003. "Firms, Contracts, and Trade Structure," *Quarterly Journal of Economics*, 118: 1375-1418.
- _____. 2005. "Incomplete Contracts and the Product Cycle," *American Economic Review*, 95: 1054-1073.
- Antras, P. and E. Helpman. 2004. "Global Sourcing," *Journal of Political Economy*, 112: 552-580.
- Arndt, S. and H. Kierzkowski, eds. 2001. *Fragmentation*. Oxford: Oxford University Press.
- Athukorala, P. and Y. N. Yamashita. 2006. "Production fragmentation and Trade Integration: East Asia in a Global Context," *North American Journal of Economics and Finance*, 17: 233-256.
- Athukorala, P. 2006. "Multinational Production Networks and the New Geoeconomic Division of Labour in the Pacific Rim," ANU, Economics, RSPAS Working Paper No. 2006-09.
- Baldwin, R. 2006. "Managing the Noodle Bowl: the Fragility of East Asian Regionalism," CEPR Discussion Paper No. 5561.
- Bhattasali, D., S. Li, and Will Martin, eds. 2004. *China and the WTO*. Washington: the World Bank and Oxford University Press.
- Chen, X., L. Cheng, K.C. Fung and L. J. Lau. 2004. "The Estimation of Domestic Value-Added and Employment Induced by Exports: An Application to Chinese Exports to the United States," mimeo, Stanford University.
- Chen, X., Guo Ju'e and c. Yang. (2005), "Extending the Input-Output Model with Assets," *Economic Systems Research*, 17: 211-226.
- Dean, J., M. Lovely and H. Wang. 2006. "Foreign Direct Investment and Pollution Havens: Evaluating the Evidence from China," Revision of World Bank Working Paper No. 3505.
- Deardorff, A. 2001. "Fragmentation Across Cones," in S. Arndt and H. Kierzkowski, eds., *Fragmentation*, Oxford: Oxford University Press.
- _____. 2005. "Gains from Trade and Fragmentation," mimeo, University of Michigan, Ann Arbor.
- Feenstra, R. and G. Hanson. 2005. "Ownership and Control in Outsourcing to China: Estimating the Property-Rights Theory of the Firm," *Quarterly Journal of Economics*, May, 729-761.
- Feenstra, R. and B. Spencer. 2005. "Contractual versus Generic Outsourcing: The Role of Proximity," University of British Columbia, mimeo.

- Grossman, G. and E. Helpman. 2004. "Managerial Incentives and International Organization of Production," *Journal of International Economics* 63: 237-262.
- _____. 2005. "Outsourcing in a Global Economy," *Review of Economic Studies*, 72: 135-160.
- Hammer, A. 2006. "The Dynamic Structure of U.S.-China Trade, 1995-2004," USITC Working Paper No. 2006-07A.
- Hummels, D., J. Ishii and K. Yi. 2001. "The Nature and Growth of Vertical Specialization in World Trade," 54: 75-96.
- Jones, R.W., and H. Kierzkowski. 2001. "A Framework for Fragmentation," in S. Arndt and H. Kierzkowski, eds., *Fragmentation*, Oxford: Oxford University Press.
- Jones, R.W., H. Kierzkowski and C. Lurong. 2005. "What does evidence tell us about fragmentation and outsourcing?" *International Review of Economics & Finance*, 14:305-316.
- Krugman, P., 2008, "Trade and Wages, Reconsidered," Brookings Papers on Economic Activity, Spring, forthcoming.
- Lau L.J., X. Chen, L. K. Cheng, K. C. Fung, Y. Sung, C. Yang, K. Zhu, J. Pei and Z. Tang. 2006. "A New Type of Input-Holding-Output Model of the Non-Competitive Imports Type Capturing China's Processing Exports," *Chinese Social Science*, forthcoming.
- McLaren, J. 2000. "Globalization and Vertical Structure," *American Economic Review*, 90: 1239-1254.
- Markusen, J. 2005. "Modeling the Offshoring of White-Collar Services: From Comparative Advantage to the New Theories of Trade and FDI," NBER Working Paper No. 11827.
- Miller, R. E. and P. D. Blair. 1985. *Input-Output Analysis: Foundations and Extensions*. Englewood Cliffs, New Jersey: Prentice Hall.
- Ng, F. and A. Yeats. 2001. "Production sharing in East Asia: who does what for whom, and why?" In L. K. Cheng & H. Kierzkowski (Eds.), *Global production and trade in East Asia*. Boston: Kluwer Academic Publishers.
- _____. 2003. "Major trade trends in Asia — What are implications for regional cooperation and growth," World Bank Policy Research Working Paper 3084.
- Ping, X. 2005. "Vertical Specialization, Intra-Industry Trade and Sino-U.S. Trade Relationship," China Center for Economic Research, Peking University Working paper No. C2005005.
- Rodrik, D. 2006. "What's So Special About China's Exports?" NBER Working Paper No. 11947.
- Schott, P. 2005. "The Relative Sophistication of Chinese Exports," NBER Working Paper No. 12173.
- Spencer, B. 2005. "International Outsourcing and Incomplete Contracts," Sauder School of Business, University of British Columbia.

- Wang, Z. 2003. "WTO accession, the "Greater China" Free Trade Area, and Economic Integration Across the Taiwan Strait," *China Economic Review*, 14: 316-349.
- Yeats, A. 2001. "Just How Big is Global Production Sharing," in S. Arndt and H. Kierzkowski, eds., *Fragmentation*, Oxford: Oxford University Press.
- Yi, K., 2003. "Can Vertical Specialization Explain the Growth of World Trade?" *Journal of Political Economy*, vol. 111, 1: 52-102.

Figure 1

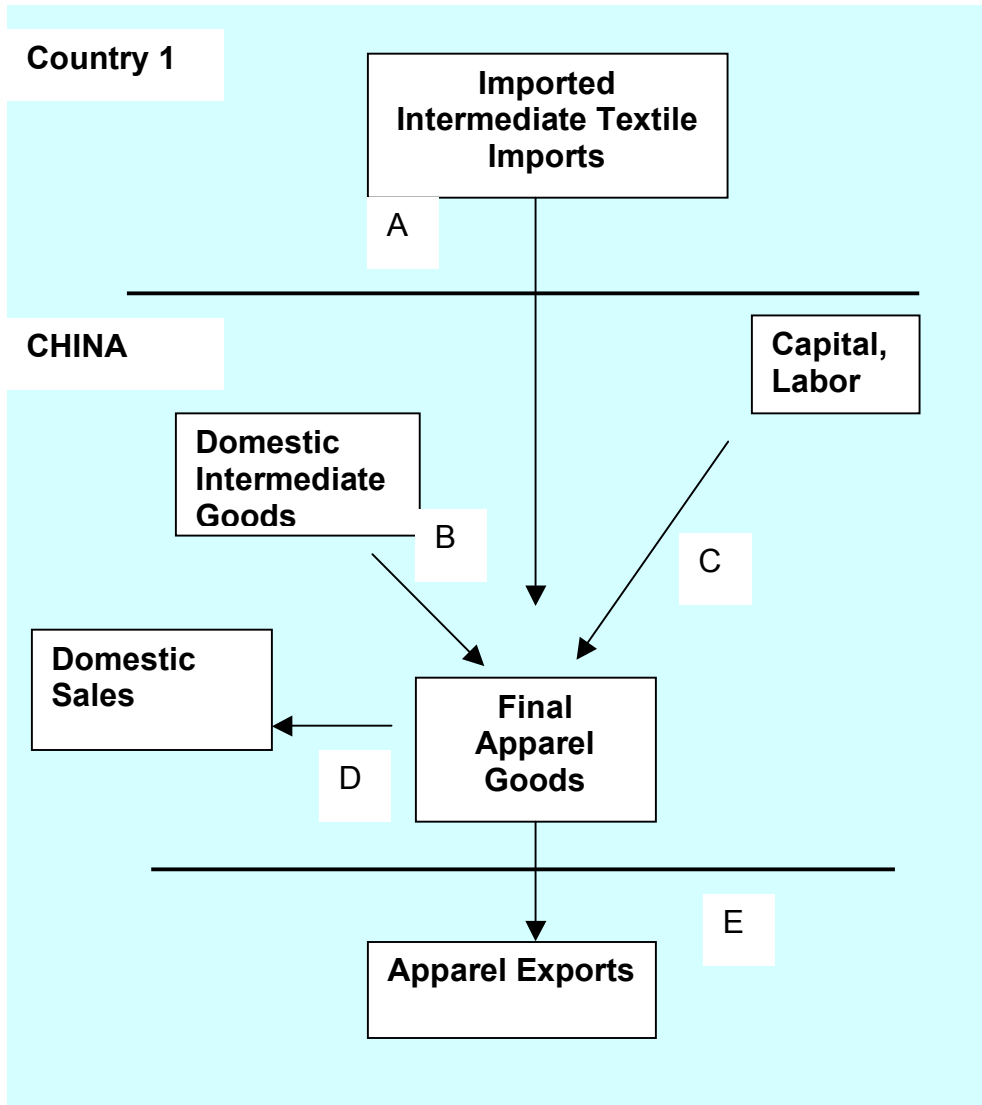


Figure 2. Comparing Intermediate Shares Calculated by the Three Methods for 2002:

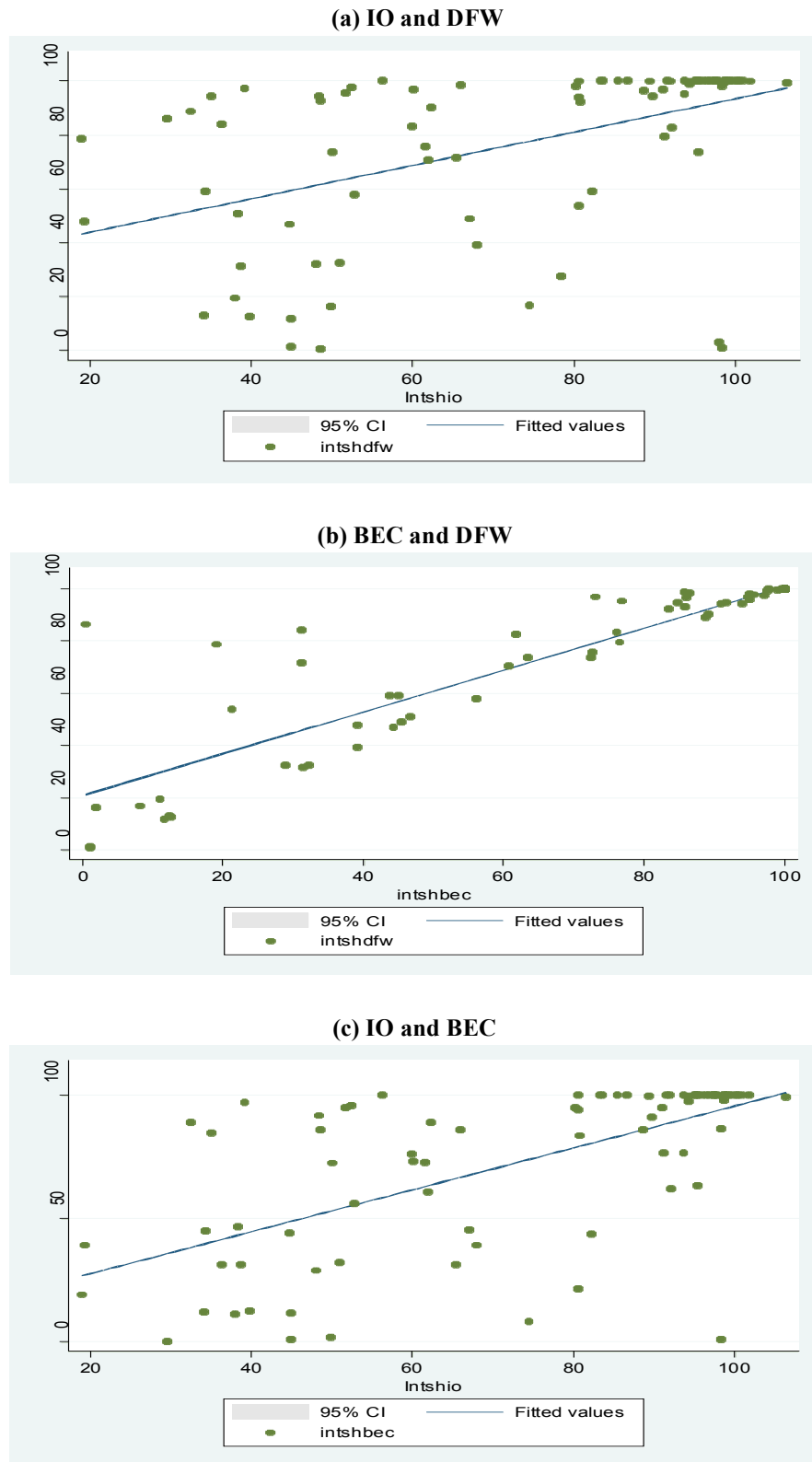
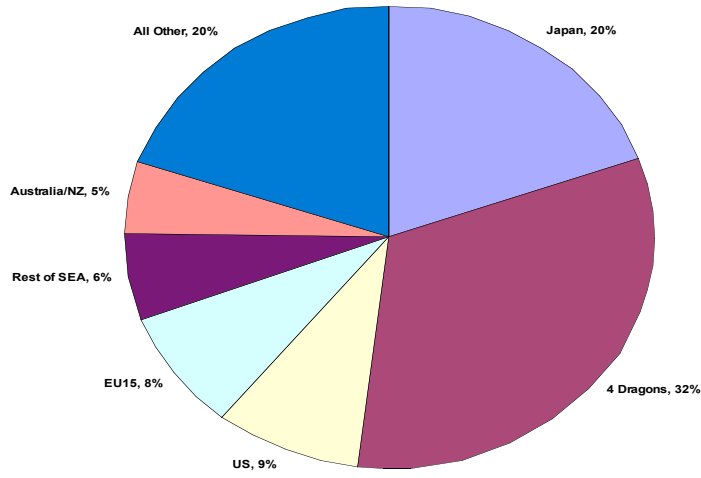


Figure 3. China's Vertical Specialization by Source Country

China's Vertical Specialization by Source Country, 1996



China's Vertical Specialization by Source Country, 2005

