Domestic Value Added and Employment Generated by Chinese Exports: A Quantitative Estimation+

Chen, Xikang *, Leonard .K. Cheng, K.C. Fung***, Lawrence. J. Lau****,**

YunWing Sung***, C. Yang*, K. Zhu*, J. Pei* and Z. Tang***

Revised: December 2008

+ We are indebted to very useful comments and suggestions by two anonymous referees and an editor of this journal. This paper is a substantially revised version of an earlier paper that was presented at the AEA meeting in Philadelphia, January 8, 2005. We would like to thank the General Administration of Customs, the Ministry of Commerce (and the former MOFTEC that later became part of the ministry), the National Bureau of Statistics of the People's Republic of China and the Census and Statistics Department of the Hong Kong Special Administrative Region for their assistance in constructing some datasets from unpublished raw data. We are also grateful to the financial support by Mr. C.H. Tung's Tung Foundation, the Chinese University of Hong Kong, and the Center for Economic Development at the Hong Kong University of Science and Technology.

*Academy of Mathematics and Systems Science, Chinese Academy of Sciences

**Hong Kong University of Science and Technology

***University of California, Santa Cruz

****Chinese University of Hong Kong and Stanford University

*****Chinese University of Hong Kong

Abstract

We develop an input-output methodology to estimate how Chinese exports affect the country's total domestic value added (DVA) and employment for 1995 and 2002. Total DVA generated by exports is obtained by subtracting all direct and indirect imported intermediate goods from the gross value of exports, and total employment is obtained by adding all direct and indirect employment generated by exports. To implement these estimations, we use hitherto unpublished Chinese government data to construct several completely new datasets, including an input-output table with separate input-output and employment-output coefficients for processing and non-processing exports. In 2002 (1995), for every US$1,000 dollar of Chinese exports, DVA and employment are estimated to be US$466 (US$545) and 0.242 (0.375) person-year, respectively.

1. Introduction

In this paper we aim to estimate two important effects of Chinese exports on the Chinese economy, namely, the domestic value added (DVA) and domestic employment generated by US$1,000 of Chinese exports to the world for 1995 and 2002. For China, which has a huge reserve of employable workers in the rural areas, employment and the associated wages generated by exports are clearly a key economic benefit. The non-wage income such as returns on capital and indirect taxes are also important sources of income generated in the Chinese economy. The wage and non-wage incomes together make up the total DVA generated by exports, which contribute directly to China's total gross domestic product (GDP).[1] Thus, DVA (or domestic content) and domestic employment generated by exports are two key measures of the welfare China derives from its export sector.

The basic methodology employed in our estimation is that of input-output tables, where inputs include both primary and intermediate inputs.[2] The biggest advantage of this methodology is its ability to estimate both the direct and indirect effects of exports on DVA and domestic employment by accounting for the inter-industry flow of the production process. In our implementation of the estimation methodology, we explicitly recognize the need to construct an input-output table for China that contains separate input-output and employment-output coefficients for "processing exports" and non-processing exports ("processing exports" refer to exports of the end products of assembling and/or processing imported intermediate inputs that are exempted from Chinese tariffs because the products will be eventually sold overseas; "non-processing exports" are ordinary exports to be distinguished from processing exports),[3] because

[1] Some of the returns on capital accrues to foreign investors, and is not part of China's welfare. However, to the extent that profits made by foreign investors are ploughed back in China, there is an additional form of benefits to China via an increase in foreign direct investment.

[2] In the input-output literature, the tables that include the "occupancy" of primary inputs such as labor force, capital and natural resource are called "input-occupancy-output tables" (see Chen, 1999) or extended input-output tables with assets (see Chen, Guo and Yang, 2005).

[3] There are two categories of processing exports: "processing-and-assembly" exports and "processing-with-imported materials" exports. In the former category, foreign firms owned both the imported inputs and the output produced from them. In the latter category, the imported inputs' ownership is transferred to the firms that produce exports with them. In both cases all of the imported inputs are required by law to be used only for producing exports.

there is anecdotal evidence that these two kinds of exports used significantly different technologies and imported inputs.

Our paper builds on Chen et al (2004), the first paper that developed an input-output methodology to estimate China's DVA and employment generated by its exports to the world and to the U.S. and used input and output data to create a 33-sector-input-output table with one set of input-output coefficients for processing exports and another set of input-output coefficients for non-processing exports.[4] However, it extends Chen et al (2004) in two major directions: (a) new results are obtained based on China's 2002 input-output table with 42 sectors -and these results are compared with earlier results based on China's 1995 input-output table, and (b) for the 2002 analysis not only are the input-output coefficients of processing exports estimated separately from the coefficients of non-processing exports, but also are the coefficients for non-processing exports further distinguished from those for products produced for domestic use on the basis of official input output data.

The input-output methodology initiated by Chen et al (2004) for the study of China's DVA and employment generated by its exports was subsequently adopted, directly or indirectly, and with variations, by other researchers working on similar and related topics. The latter's works include Dean et al (2007, 2008), Feenstra and Hong (2007), Koopman et al (2008), and Lau et al (2006). While Dean et al's focus was on the "vertical specialization" of China's exports in 2002,[5] the results obtained by them using an official Chinese 122-sector-input-output table (which did not have different coefficients for processing and non-processing exports) indirectly yield results on China's DVA generated by its exports because the share of "vertical specialization" and the share of DVA in exports add up to unity. Koopman et al. (2008) used a computational algorithm to generate two sets of input-output coefficients, one for processing exports and another for non-processing exports, by combining information from trade statistics and the available official input-output table that does not make a distinction between processing and non-processing exports.

[4] Its findings were circulated as a working paper from 2001 after presented at an international conference in 1999.

[5] The measure of vertical specialization was pioneered by Hummels et al (2001).

The findings about DVA, or domestic content, of exports have implications for the growing debate on the changing sophistication of Chinese exports as well as the impact of Yuan's revaluation on China's foreign trade.[6] In contrast, Feenstra and Hong (2007)'s focus was on the contribution of China's export growth to its employment growth. They showed that using China's employment/export ratios from earlier years to forecast the country's employment growth from 1997 to 2005 would result in serious overestimates, because the employment/export ratios changed significantly due to changes in wages, technological progress, and changes in export composition, etc.

Lau et al's (2006) focus was on the U.S.-China bilateral trade balance measured in terms of value-added. To obtain such trade balances, they calculated the DVA of China's exports to the U.S. with a China input-output table that features different input-output coefficients for products produced for domestic use, processing exports, and ordinary exports, and the DVA of U.S.' exports to China with a standard U.S. input-output table.

Here is a roadmap for the remainder of the paper. The methodology of input-output tables, its limitation, and the development of new data sets and data conversion that are required to implement the methodology are described in Section 2. In that section we start out by presenting two alternative (namely, direct and indirect) methods of estimating the DVA, then explain intuitively why they are equivalent. A numerical example of the two methods' equivalence is given for illustration before the basic equations used for the estimation are introduced; a mathematical proof of the equivalence is given in the appendix. The data requirements related to the basic estimation equations are then described, which include two data conversion methods (one of them is a conversion matrix that enables the conversion of data from international trade classifications into data for input-output sectors) and the construction of three new data sets. In Section 3, the estimates of economy-wide and sector-specific DVA and domestic employment generated by processing exports, non-processing exports, and aggregate exports are presented and interpreted. In order to better understand these results which are

[6] A higher domestic content may signify a higher quality of domestic input supplies. In addition, how much domestic inputs are used in the production of exports may affect how export prices will change with the Yuan's exchange rate. For papers on these issues, see Amiti and Freund (2008), Rodrik (2006), Schott (2005), Dean, Fung and Wang (2008), U.S. Congressional Budget Office (2008) etc.

obtained from the input-output analysis and expressed according to input-output sectors, the conversion (or decomposition) of US$1,000 of textile exports (according to international trade classifications) into a number of outputs (according to input-output sectors, one of which is textile production), whose value sum up to exactly US$1,000, is presented for illustration before the sector-specific estimates are presented. Finally, some concluding remarks are offered in Section 4.

2. Methodology and Data

The most straightforward way to estimate the total DVA generated by exports (or their increase) is to sum up all the direct and indirect DVA generated by export demand (or its increase). There is a distinction of the direct (or first round) DVA and the total (or cumulated) DVA because the first round value added will lead to further rounds of production and thus further rounds of indirect value added that must be added to the direct DVA to obtain the total DVA. This is called the "direct method," not to be confused with the direct value-added and direct employment effects of exports.

There is another, less direct method of estimating the total DVA. Since the domestic content share and the foreign content share must sum up to one, the share of total DVA in exports is one minus the foreign content share, where the foreign content share is given by the sum of direct and all rounds of indirect imported intermediate inputs required for every unit of exports, say US$1,000, as a fraction of the value of exports. In the appendix a mathematical proof is given that this "indirect method" (not to be confused with the indirect value-added and indirect employment effects of exports) yields the same results as the direct method.[7] To estimate the impact on domestic employment, however, we must sum up all the direct and indirect employment generated by US$1,000 of Chinese exports.

Let us start with a simple illustration of US$1,000 of textiles exports in 1995. Using the "direct method," the direct domestic value-added generated is US$177.7. The first round indirect DVA is US$174.9, the second round indirect DVA is US$119.2, and the third round indirect DVA is US$74.1. The higher is the round, the smaller is the magnitude of indirect VA. After

[7] The first rigorous proof of this equivalence result was given in Chen et al (2004).

adding up the direct and infinitely many rounds of indirect DVA, the total DVA generated by US$1,000 of textiles export is US$657.0.

Using the "indirect method," the value of direct imports required in producing US$1,000 of textiles exports is US$300.5. The value of the first round of indirect imports is US$19.7. The value of the second round of indirect imports is US$9.1. The value of the third round of indirect imports is US$5.4. After adding up the direct and infinitely many rounds of indirect imports, the value of total imports is US$343.0. Because the share of total DVA in exports is one minus the share of total imports, by the indirect method total DVA is equal to US$1,000 – US$343.0 = US$657.0, which is exactly equal to that obtained using the direct method.[8]

Formally, the basic equations used for estimation are as follows:

$$\mathbf{B_V = A_V\,(I - A^D)^{-1}} \qquad \mathbf{(1)}$$

$$\mathbf{B_M = A^M\,(I - A^D)^{-1}} \qquad \mathbf{(2)}$$

$$\mathbf{B_V = i - B^M} \qquad \mathbf{(3)}$$

$$\mathbf{B_L = A_L\,(I - A^D)^{-1}} \qquad \mathbf{(4)}$$

where B_V is a row vector of total (direct and indirect) DVA coefficients, A_V is a row vector of DVA coefficients, I is an identity matrix, A^D is the direct input coefficients matrix of domestic products, B_M is a row vector of the total import coefficients, A^M is a row vector of direct import coefficients, i is a row vector of 1's, B_L is a row vector of total employment generated by the Chinese exports of US$1,000 by each of the n sectors, and A_L is a row vector of direct labor force coefficients whose j^{th} element is sector j's labor force input coefficient.

[8] Applying the "direct method" to US$1,000 of textiles export in 2002, the direct domestic value-added generated is US$164.4. The first round indirect DVA is US$58.2, the second round indirect DVA is US$16.7, and the third round indirect DVA is US$5.9. The total DVA generated by US$1,000 of textiles export is US$605.3. Using the "indirect method," the value of direct imports required for producing US$1,000 of textiles for exports is US$326.3. The value of the first round of indirect imports is US$43.3. The value of the second round of indirect imports is US$14.4. The value of the third round of indirect imports is US$4.5. The value of total imports is US$394.7. Thus, the value of total DVA obtained from the direct method, US$605.3, is exactly equal to the that obtained from the "indirect method," namely, the difference between US$1,000 and US$394.7, the latter being the value of total imports required to produce US$1,000 of textiles export.

Equation (1) states that the total DVA vector generated by exports from various sectors is the product of the direct DVA vector and the matrix $(I - A^D)^{-1}$, where $(I - A^D)^{-1}$ is the familiar Leontief inverse. Equation (2) states that the total import vector generated by exports from various sectors is the product of the direct import vector and the matrix $(I - A^D)^{-1}$. Equation (3) states that the share of total DVA in a sector's export is 1 minus the share of the value of total imports in the production of exports. Equation (4) states that the total employment vector of exports from various sectors is the product of the direct labor force vector and the matrix $(I - A^D)^{-1}$. Equation (4) captures both direct employment for exports and indirect employment as a result of rounds of production of domestic intermediate inputs required for the production of exports.

As pointed out in the introductory section, an advantage of the input-output methodology is its ability to estimate both the direct and indirect effects of exports on DVA and domestic employment by accounting for the inter-industry flow of the production process. However, this methodology does have its limitations. Among other things, it assumes fixed input-output coefficients.[9] As a result, using results on DVA and domestic employment obtained from the input-output table of any given year to forecast results in future years is prone to errors. One way to overcome this difficulty is to estimate changes in the input-output coefficients across years based on changes in factor prices and composition of products, etc., as in Feenstra and Hong (2007). Another way is to use input-output tables from different years to directly estimate the changes in DVA and domestic employment for those years. In this paper, we use input-output tables from 1995 and 2002 to derive results for these two years. In doing so, we use the actual input-output coefficients instead of estimating the coefficients based on some theoretical and empirical models about the underlying changes in the coefficients.

[9] The input-output methodology also assumes constant returns to scale. Thus, to the extent that the actual production technology deviates from constant returns to scale, our estimates would be either overestimates or underestimates. The assumption of lack of joint products, in our view, appears to be a good approximation of the production technology because our input-output tables are quite aggregate. The 1995 table divides China's economy into 33 sectors whereas the 2002 table divides China's economy into 42 sectors. The reason is that joint products across sectors at a low level of aggregation would be categorized as products primarily within the same sector at a high level of aggregation.

Because the input-output tables are the central part of our analysis of the effects of exports on total DVA and domestic employment, we must ensure that all of the data are categorized according to the sectors defined by these tables (33 sectors for 1995 and 42 sectors for 2002) and measured according to the input-output convention. Thus, to implement the estimation of equations (1) to (4), we need to construct completely new data sets and to create ways of operating across them. With the help of several ministries and agencies in the Chinese government and using hitherto unpublished official Chinese data, we have succeeded in constructing the following two data conversion methods and three new data sets.

First, we created conversion matrices to convert all the Chinese trade data (under the Harmonized System (HS) classifications) into data on demand according to the input-output sectors. [10] Second, we reconciled the basis upon which trade data and input-output values are measured (with exports being measured on a FOB basis, imports being measured on a CIF basis, input-output values being measured on a ex-factory producer price basis) by converting both exports and imports to the same basis as those used by the input-output tables, namely, ex-factory producer prices. [11]

To illustrate, suppose China exports US$1,000 of textiles, FOB, as recorded in the Chinese customs statistics. In China's 2002 input-output table, the US$1,000 of Chinese exports of textiles measured in FOB prices is represented in the exports vector measured in producer prices as follows: US$907.1 of textiles; US$53.8 of wholesale and retail trade, US$11.1 of transport and warehousing, US$7.6 of renting and commercial services, US $7.2 of other social services, US$6.5 of restaurant services, US$3.2 of finance and insurance, US$2.7 of information, communication and computer services, US$0.8 of post [12] This conversion of US$1,000 of

[10] The matching algorithms are available from the authors upon request. The 1995 matching classifications are contained in the appendix of Chen, Cheng, Fung and Lau (2004).

[11] The conversion matrices required are available from the authors upon request. FOB stands for "free on board," CIF stands for "cost insurance and freight." The conversion method for the 1995 data is contained in Chen et al (2004).

[12] To which sectors some of these input costs are allocated may vary under different approaches to data collection. For example, under the trade data approach, Chinese import data contain insurance costs (as well as shipping) since they are recorded on the CIF basis.

textiles exports, FOB, into the exports of the above nine goods and services, at producer prices, was necessary for the purpose of using equations (1)- (4) to compute the total DVA and employment of generated by the nine goods and services. However, for the purpose of presentation, we shall report our results by sector on the basis of FOB prices, i.e., the effects of total DVA and employment calculated from (1)-(4) are added back together under the export of textiles, FOB.

Third, since official Chinese input-output tables before 2007 do not differentiate between inputs that were domestically produced and inputs that were imported, we constructed the Chinese input-output table with information from the import matrix in order to obtain the imported input coefficients for the n sectors, i.e., b_j^M and B^M in (2) for the years 1995 and 2002. [13] Fourth, as the official input-output tables for 1995 and 2002 do not contain occupancy of labor force and capital, [14] we constructed extended tables for these years that include the labor requirement of each sector and got labor occupancy coefficient A_L. Lastly, because a substantial amount of China's exports are processing exports,[15] and processing exports are known to have different imported, domestic and employment requirements than non-processing exports, we constructed an extended input-output table that captures processing exports and non-processing exports and got two sets of coefficients b_j^M, B^M, A_L and A^D (one set for processing exports and another set for non-processing exports) for 1995 and 2002. With all these newly created data as well as match and conversion matrices, we empirically implemented equations (1) to (4) and report our results in the next section.

3. Estimates of Domestic Value Added and Employment Generated by Exports

[13] The official Chinese input-output tables lump domestic inputs and imported intermediate goods together. In the literature, such input-output tables are called "competitive-imports input-output tables." The tables we created are called "non-competitive-imports" input-output tables.

[14] As pointed out in footnote 2, in the input-output literature, use of primary inputs is called the occupancy of such inputs.

[15] In 2006, 53 percent of Chinese exports are processing exports.

The effects of aggregate Chinese exports to the world on China's economy-wide total DVA and domestic employment are given in Table 1.[16] For every US$1,000 of aggregate Chinese exports in 2002, US$466 of total domestic value added and 0.242 persons-year of employment were generated in the same year. The non-processing components of the Chinese exports (i.e., ordinary exports) had a much higher impact on total DVA and employment than the aggregate exports, namely, US$633 of total DVA and 0.363 person-year of employment in 2002, respectively. In contrast, processing exports generated a far smaller amount of total DVA and employment (US$287 and 0.111 person-year in 2002, respectively). [17]

Table 1. Effects of US$1,000 of Chinese Exports to the World on Total (Direct and Indirect) Domestic Value Added and Total (Direct and Indirect) Employment

Year	Types of Exports	Total Domestic Value Added (in US$)	Total Employment (in person-year)
1995	Aggregate	545	0.375
	Processing	176	0.057
	Non-Processing	925	0.703
2002	Aggregate	466	0.242
	Processing	287	0.111
	Non-Processing	633	0.363

The fact that total DVA and employment generated by non-processing exports was higher than those by processing exports also held true for the year 1995. For both years, the aggregate total DVA and domestic employment are roughly equal to the simple averages of these two measures for non-processing and the processing exports. A decline in the effects of aggregate

[16] The direct effects on domestic value added and employment are available from the authors upon request. The 1995 results are contained in our earlier paper Chen et al (2004).

[17] The effects generated by aggregate Chinese exports are weighted sums of those of processing exports and non-processing exports.

exports on both total DVA and employment from 1995 to 2002 was driven by a substantial decline in the effects of non-processing exports. Even though the effects of processing exports on total DVA and employment actually rose from 1995 to 2002, this increase was dwarfed by the large decrease in the effects of non-processing exports.[18] Since processing exports constituted more than half of Chinese exports in these two years, it was clearly not the case that the aggregate results were driven by the proportion of non-processing exports. Rather, it was caused by non-processing exports' significant decline in the coefficients of DVA and employment. In any event, the decline in the total DVA of aggregate exports suggests that the effectiveness of the Yuan's appreciation in reducing Chinese exports declined, or equivalently a larger appreciation would be needed to correct the same trade imbalance.

Despite a decline in the total DVA and domestic employment generated by every US$1,000, the total DVA generated by China's export sector rose from US84.12 billion in 1995 to US151.75 billion in 2002, and the total domestic employment generated by China's export sector rose from 57.84 million person-year in 1995 to 78.67 million person-year in 2002, because China's total exports rose from US$148.77 billion in 1995 to US$325.60 billion in 2002. This is an important point for Chinese policy makers to keep in mind about the benefits China derives from its exports.

In the trade literature that highlights heterogeneous firms, such as Helpman et al (2004), firms with low productivity produce and sell only in the domestic market, and firms with medium and high productivity sell to both domestic and foreign markets. However, firms with medium productivity export to foreign markets, while firms with high productivity set up subsidiaries in foreign countries to produce for their host markets. The different choices between the latter two groups of U.S. firms were confirmed by their empirical tests. [19] Nevertheless, the

[18] Since our estimates are only for 1995 and 2002, it would be premature to argue that there is a clearly discernable trend.

[19] One of Helpman et al's main findings is that there was a "robust cross-sectoral relationship between the degree of dispersion in firm size and the tendency of firms to substitute FDI sales for exports." In their empirical tests, they used an indicator of the U.S. government called "sales by foreign affiliates" but did not make clear if the sales by affiliates outside of their host countries were excluded. In 1992, 85% of the sales by U.S. affiliates were to all of the host markets outside the U.S., but the percentage could be different for China.

fact that U.S. firms produce in China for exports to the U.S. and other overseas markets (including processing and non-processing exports) is a phenomenon not yet captured by the trade-theoretic models of heterogeneous firms. Since there were more foreign firms in processing exports and processing exports had higher DVAs and domestic employment coefficients in 2002 than in 1995, it means that U.S. affiliates in China were responsible for lifting China's overall productivity from 1995 to 2002, which is a major benefit to the Chinese economy.

Next, we turn our attention to the estimates by sector. The effects of US$1,000 on the FOB basis of Chinese processing exports, non-processing exports, and aggregate exports on total DVA for 2002 are given in Table 2. Note that "N.A." under "processing exports" alone means that there was no processing exports, and N.A. for the trade-related services means that their effects on DVA are included in the export sectors.

Table 2: Effects of US$1,000 of Chinese Exports to the World, FOB, on Total Chinese Domestic Value-Added by Sector, 2002 (US$)

Sector	Processing Exports	Non-Processing Exports	Aggregate Exports
1. Agriculture	504	815	799
2. Coal mining, washing and processing	N.A.	717	717
3. Crude petroleum and natural gas products	500	748	740
4. Metal ore mining	402	605	584
5. Non-ferrous mineral mining	445	648	589
6. Manufacture of food products and tobacco processing	441	796	700
7. Textile goods	320	727	608
8. Wearing apparel, leather, furs, down and related products	364	717	557
9. Sawmills and furniture	368	687	556

10. Paper and products, printing and record medium reproduction	406	671	495
11. Petroleum processing, coking and nuclear fuel processing	253	315	299
12. Chemicals	309	511	431
13. Nonmetal mineral products	395	625	577
14. Metals smelting and pressing	281	543	445
15. Metal products	241	552	410
16. Common and special equipment	277	496	413
17. Transport equipment	266	485	379
18. Electric equipment and machinery	256	507	349
19. Telecommunication equipment, computer and other electronic equipment	197	419	242
20. Instruments, meters, cultural and office machinery	375	517	403
21. Other manufacturing products	365	684	520
22. Scrap and waste	N.A.	N.A.	N.A.
23. Electricity and heating power production and supply	545	739	555
24. Gas production and supply	514	633	625
25. Water production and supply	N.A.	N.A.	N.A.
Weighted Average	**287**	**633**	**466**

Table 2 shows that in 2002 the total values of DVA generated by US$1,000 of non-processing exports were uniformly higher (i.e., across all sectors) than those generated by the same amount of processing exports, thus not only confirming the widely held belief of the differential contributions of the two kinds of exports to DVA but also providing estimates of their differences. Recently there are some debates in China about the benefits of processing exports to the country's economic development and its trade frictions with its trading partners. If processing exports contribute less to China's DVA and employment but equally to its trade surplus with certain trading partners such as the U.S., then there seems to be a rational basis to promote non-processing exports and to discourage processing exports.

Recent research on production sharing and the global supply chain has highlighted in particular four production networks, namely, (1) textile and garments, (2) furniture goods, (3) automobile parts and equipment, and (4) electrical and telecom equipment and electronics goods, including computers.[20] It would be interesting to have a measure of the DVA generated in China by of these networks because China is widely regarded as a major world factory. In addition, there is also a policy question about which sectors to promote and which sectors to discourage, also from the perspective of total DVA and employment.

The table shows that sectors such as "textile goods" (sector 7), "wearing apparel, etc." (sector 8), "sawmills and furniture" (sector 9) all have higher DVAs for both the processing and non-processing exports than the corresponding weighted averages for all sectors. In contrast, again for both processing and non-processing exports, the sectors such as "common and special equipment" (sector 16), "transport equipment" (sector 17), "electric equipment and machinery" (sector 18), and "telecommunication equipment, computer and other electronic equipment" (sector 19) all have lower DVAs. The overall pattern seems to imply that in 2002, the manufacturing sectors that are often perceived to be "high-technology" (e.g. machinery, electronic goods, computers, etc.) tended to pull down the overall DVA averages, while the traditional export manufacturing sectors (e.g. textile, garment products and furniture) tended to lift up the averages.[21] Thus, promoting the high-technology industries at the expense of the traditional labor-intensive industries may not necessarily lead to greater growth in DVA and employment, unless there is much greater room for export growth in the former than in the latter. That is to say, the policy makers will need to consider both the export elasticities of demand for

[20] For some related papers, see Ng and Yeats (2001) and Ng (2003).

[21] However, for "instruments, meters, cultural and office machinery" (sector 29), total DVA is higher than its average for the processing case, but lower than its average in the ordinary export case.

Chinese products by different sectors and the elasticities of input supply, including Chinese labor.

A related question is the widely discussed damages done to China's environment by the production of Chinese exports. Again, due to inter-industry flow, the total environment damage of a sector's exports may be substantially greater than its direct environmental damage. The input-output table approach generates total damages for different sectors which can be used by policy makers as an input along side total DVA and employment in deciding which sectors are to be promoted and which sectors are to be discouraged.

The next table presents estimates of total DVA generated by processing and non-processing exports for the year1995.

Table 3. Effects of US$1,000 of Chinese Exports to the World, FOB, on Total Domestic Value Added by Sector, 1995 (US$)

Sector	Processing Exports	Non-Processing Exports	Aggregate Exports
01 Agriculture	249	1014	943
02 Coal mining	426	1260	1138
03 Crude petroleum & natural gas production	417	1154	1045
04 Metal ore mining	213	843	781
05 Other mining	269	856	753
06 Food manufacturing	137	710	579
07 Manufacture of textiles	185	935	657
08 Manufacture of wearing apparel, leather & products of leather and fur	180	916	446
09 Sawmills & manufacture of furniture	134	674	451
10 Manufacture of paper, cultural & educational articles	169	867	404

11 Electricity, steam & hot water production and supply	275	821	765
12 Petroleum refineries	426	1755	1643
13 Coking, manufacture of gas & coal products	255	801	738
14 Chemical industries	151	749	508
15 Manufacture of building materials & non-metallic mineral products	209	816	604
16 Primary metal manufacturing	137	730	386
17 Manufacture of metal products	151	794	518
18 Manufacture of machinery	170	926	387
19 Manufacture of transport equipment	148	729	298
20 Manufacture of electric machinery & instrument	136	744	241
21 Manufacture of electronic & communication equipment	160	902	281
22 Manufacture of instruments and meters, etc.	126	606	219
23 Maintenance & repair of machinery and equipment	24	936	922
24 Industries not elsewhere classified	211	1188	775
Weighted Average	**176**	**925**	**545**

We previously mentioned that the average total DVA for aggregate exports declined from 1995 to 2002. This decline was driven by the decline of the weighted average of the non-processing exports' DVA aggregated over all sectors because the DVA generated by US$1,000 of aggregate processing exports actually went up. However, because the number of sectors in the 1995 input-output table was different from that for 2002, it would not be possible to attribute the decline of the non-processing exports' overall DVA further to that of a subset of sectors.

In the next set of tables, we present our estimates of the employment generated by processing and non-processing exports. Remarks similar to those about DVA can be made about employment. In 2002, employment generated by non-processing exports in all sectors was uniformly higher than that generated by processing exports.[22] No single sector or a subset of sectors could account adequately for the average employment generated by either processing or non-processing exports. In the case of processing exports, traditional manufacturing export sectors such as textile and garment (sectors 7 and 8) generated more employment than "high-technology" sectors such as "electric equipment and machinery" (sector 18) or "telecommunication equipment, computer and other electronic equipment" (sector 19). As in the case of the DVA, the decline in employment associated with aggregate exports from 1995 to 2002 was due to the significant decline of employment generated by non-processing exports because the employment generated per US$1,000 of aggregate processing exports actually went up. However, an examination of Tables 4 and 5 shows that no single sector or subset of sectors drives the decline of employment associated with non-processing exports from 1995 to 2002.

Table 4: The Effects of US$1,000 of Chinese Exports to the World, FOB, on Total Employment by Sector, 2002 (person-year)

Sector	Processing Exports	Non-Processing Exports	Aggregate Exports
1. Agriculture	0.267	0.658	0.640
2. Coal mining, washing and processing	N.A.	0.363	0.348
3. Crude petroleum and natural gas products	0.104	0.202	0.194
4. Metal ore mining	0.144	0.264	0.250
5. Non-ferrous mineral mining	0.185	0.345	0.297

[22] The only exception is the sector "scrap and waste" (sector 22), whose processing and non-processing numbers are identical.

6. Manufacture of food products and tobacco processing	0.259	0.666	0.555
7. Textile goods	0.169	0.486	0.393
8. Wearing apparel, leather, furs, down and related products	0.185	0.426	0.318
9. Sawmills and furniture	0.171	0.419	0.318
10. Paper and products, printing and record medium reproduction	0.166	0.335	0.228
11. Petroleum processing, coking and nuclear fuel processing	0.099	0.130	0.120
12. Chemicals	0.117	0.246	0.195
13. Nonmetal mineral products	0.176	0.332	0.297
14. Metals smelting and pressing	0.090	0.188	0.151
15. Metal products	0.085	0.220	0.159
16. Common and special equipment	0.098	0.211	0.169
17. Transport equipment	0.091	0.199	0.148
18. Electric equipment and machinery	0.093	0.213	0.141
19. Telecommunication equipment, computer and other electronic equipment	0.063	0.159	0.089
20. Instruments, meters, cultural and office machinery	0.094	0.276	0.124
21. Other manufacturing products	0.179	0.432	0.303
22. Scrap and waste	N.A.	N.A.	N.A.
23. Electricity and heating power production and supply	0.160	0.223	0.171
24. Gas production and supply	0.218	0.269	0.263

25. Water production and supply	N.A.	N.A.	N.A.
Weighted Average	**0.111**	**0.363**	**0.242**

Table 5: Effects of US$1,000 of Chinese Exports to the World on Total Employment by Sectors, 1995 (person-year)

Sector	Processing Exports	Non-Processing Exports	Aggregate Exports
01 Agriculture	0.189	1.831	1.692
02 Coal mining	0.227	0.924	0.825
03 Crude petroleum & natural gas production	0.102	0.391	0.334
04 Metal ore mining	0.103	0.521	0.477
05 Other mining	0.120	0.533	0.460
06 Food manufacturing	0.045	0.690	0.544
07 Manufacture of textiles	0.061	0.814	0.537
08 Manufacture of wearing apparel, leather & products of leather and fur	0.057	0.711	0.292
09 Sawmills & manufacture of furniture	0.060	0.448	0.287
10 Manufacture of paper, cultural & educational articles	0.059	0.635	0.253
11 Electricity, steam & hot water production and supply	0.063	0.293	0.267
12 Petroleum refineries	0.090	0.615	0.561
13 Coking, manufacture of gas & coal products	0.099	0.521	0.473
14 Chemical industries	0.046	0.428	0.273

15 Manufacture of building materials & non-metallic mineral products	0.083	0.456	0.325
16 Primary metal manufacturing	0.045	0.361	0.178
17 Manufacture of metal products	0.056	0.429	0.269
18 Manufacture of machinery	0.062	0.477	0.184
19 Manufacture of transport equipment	0.047	0.361	0.131
20 Manufacture of electric machinery & instrument	0.041	0.362	0.099
21 Manufacture of electronic & communication equipment	0.035	0.357	0.091
22 Manufacture of instruments and meters, etc.	0.066	0.378	0.128
23 Maintenance & repair of machinery and equipment	0.009	0.529	0.518
24 Industries not elsewhere classified	0.084	0.830	0.516
Weighted Average	**0.057**	**0.703**	**0.375**

Since the number and definition of input-output sectors for 2002 are different from those for 1995, a comparison of changes from 1995 to 2002 by sector could not be done. One way is to do a comparison is to map the results obtained for the input-output sectors into a common set of merchandise export classifications. These results are reported in Tables A-D in Appendix 2.

Table A shows that export products such as “textile materials and products” , “footwear,.., etc.” “wood and wood products, .., etc.” and “raw hides, leather, …, etc” all have higher DVAs for both the processing and non-processing exports than, whereas export products such as “machinery, electric equipment and accessories, .. etc.” and “locomotives, vehicles, … etc.” all have lower DVAs, than the corresponding weighted averages for all export products. This seems to confirm the earlier identified pattern that the manufacturing sectors often perceived to be “high-technology” tended to pull down the overall DVA averages, while the traditional export manufacturing sectors tended to lift up the averages. However, the same cannot be said about the pattern observed in Table B for 1995. Similar comparative results hold for the employment effects of exports.

A comparison of Tables A and B reveals that the DVAs for processing exports in 2002 was uniformly higher than those for 1995, but generally lower for non-processing exports. A comparison of Tables C and D reveals that the employment effects in 2002 was uniformly higher than those for 1995 for processing exports, but the opposite was true for non-processing exports.

4. Concluding Remarks

In this paper we study two important effects of Chinese exports on the Chinese economy. Specifically we estimate the extent of total domestic value added (DVA) and domestic employment generated by Chinese exports to the world in 1995 and 2002. The total DVA and employment for 2002 (1995) were estimated to be US$466 (US$545) and 0.242 (0.375) person-year for every US$1,000 of Chinese exports. From 1995 to 2002, there was a decline in both total DVA and employment generated by the same amount of Chinese aggregate exports. These declines were due to a drop in the DVA and employment of non-processing exports. In contrast, the processing exports' DVA and employment actually increased from 1995 to 2002.

We have found that for both 1995 and 2002, non-processing exports had higher total DVA and domestic employment effects in all sectors than processing exports. For both processing and non-processing exports, traditional manufacturing exports such as textile and garment products generated higher total DVA and employment than "high-technology" manufacturing exports such as electric equipment and machinery or telecommunication equipment, computer and other electronic products Thus, promoting the high-technology industries at the expense of the traditional labor-intensive industries may not necessarily lead to greater growth in DVA and employment, unless there is much greater room for export growth in the former than in the latter.

In this paper, we have focused on the estimation of the DVA and domestic employment generated by China's exports to the world. By incorporating data on China's export composition to a particular country, say, the U.S., estimates can be obtained for the DVA and domestic employment generated by China's exports to the U.S. A similar exercise can be carried out to estimate the DVA and domestic employment generated by the U.S.' exports to China. By combining both sets of estimates, it is possible to estimate their bilateral trade balance in terms of DVA (Lau et al, 2006), as opposed to the traditional trade balance that is measured in terms of the gross value of exports.

Multinational firms have helped to raise China's productivity. However, the fact that their affiliates in China not only produce for the Chinese market but also for exports to their home markets is a phenomenon yet to be captured by the trade-theoretic models of heterogeneous firms. Perhaps that would be a worthwhile direction of future theoretical research.

As one of the first papers to quantitatively estimate the direct and total DVA and domestic employment generated by Chinese exports, [23] we have developed an input-output methodology that can be applied to other countries for which processing export accounts for some non-trivial percentages, for example, Mexico, Indonesia and Vietnam, to estimate the effects of their exports. Furthermore, we believe that the input-output approach will also be useful in obtaining information on the total rather than direct environmental damages caused by different kinds of exports, thus contributing to rational economic development.

[23] The working paper Chen et al (2004) is the first paper to make such contributions.

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Appendix 1: Proof of the equivalence of the direct and indirect methods of estimating total DVA

We want to prove that $A_V(I-A^D)^{-1}=i-B^M$, where the variables are as defined under equations (1)-(4) in Section 2 of the text.

Since $A_o^M=iA^M$ and $A_V=i-iA=i-iA^D-iA^M$ **,** we have

$$
\begin{aligned}
i-B^M &= i-A_o^M(I-A^D)^{-1} \\
&= i-iA^M(I-A^D)^{-1} \\
&= i(I-A^D-A^M)(I-A^D)^{-1} \\
&= (i-iA^D-iA^M)(I-A^D)^{-1} \\
&= A_V(I-A^D)^{-1}
\end{aligned}
$$

Q.E.D.

Appendix 2: Results based on 22 Trade Classifications

Table A: Effects of US$1,000 of Chinese Exports to the World, FOB, on Total Chinese Domestic Value-Added by Merchandise Exports Classification, 2002 (US$)

CODE	DESCRIPTION	Processing Exports	Non-Processing Exports	Aggregate Exports
01	Live Animals & Animal Products	451	795	709
02	Vegetables; Fruits and Cereals	484	798	779
03	Animal and Vegetable Oils; Fats and Wax; Refined Edible Oils and Fats	437	787	691
04	Food; Beverages; Liquor and Vinegar;	442	796	700

	Tobacco and Tobacco Substitutes			
05	Minerals	405	598	532
06	Chemicals and Related Products	311	513	436
07	Plastics and Related Products; Rubber and Related Products	309	511	431
08	Raw Hides; Leather; Furs and Related Products; Saddle; Travel Articles; Handbags and Similar Containers	364	717	557
09	Wood and Wooden Products; Charcoal; Cork and Related Products; Straws; Plaited Products; Baskets and Wickerwork	368	687	554
10	Paper Pulp and Cellulose Pulp; Paper and Waste Paper; Paperboard and Related Products	406	671	495
11	Textile Materials and Products	336	721	588
12	Footwear; Headgear; Umbrellas; Canes; Whips; Processed Feather; Artificial Flowers; Wigs	350	679	515
13	Gypsum; Cement; Asbestos; Mica; Ceramic Glass	394	626	575
14	Natural or Cultivated Pearls; Precious or Semi-Precious Stones; Jewelry of Precious Metal or Rolled Precious Metal; Artificial Jewelry; Coins	378	656	532
15	Base Metals and Related Products	267	551	422
16	Machinery; Electric Equipment and Accessories; Recorders; Video Recorder and Accessories	244	460	305
17	Locomotives; Vehicles; Aircraft; Ship and Related Transportation Equipment	260	501	386

18	Optical; Photographic; Film; Measuring and Checking and Medical Instruments and Equipment; Precision Instruments and Equipment; Clocks; Musical Instruments; Related Parts and Accessories	381	567	408
19	Arms and Ammunition; Related Parts and Accessories	277	496	413
20	Miscellaneous Manufactured Articles	372	659	494
21	Works of Art, Collectors' Pieces and Antiques	382	683	530
22	Commodities and Transactions Not Included in Merchandise Trade	368	680	521
	Weight Average	**287**	**633**	**466**

Table B: Effects of US$1,000 of Chinese Exports to the World, FOB, on Total Chinese Domestic Value-Added by Merchandise Exports Classification, 1995 (US$)

CODE	DESCRIPTION	Processing Exports	Non-Processing Exports	Aggregate Exports
01	Live Animals & Animal Products	158	767	647
02	Vegetables; Fruits and Cereals	208	902	806
03	Animal and Vegetable Oils; Fats and Wax; Refined Edible Oils and Fats	137	710	579
04	Food; Beverages; Liquor and Vinegar; Tobacco and Tobacco Substitutes	140	716	586
05	Minerals	384	**1,204**	**1,100**
06	Chemicals and Related Products	151	750	511
07	Plastics and Related Products; Rubber and Related Products	151	749	508

08	Raw Hides; Leather; Furs and Related Products; Saddle; Travel Articles; Handbags and Similar Containers	171	864	465
09	Wood and Wooden Products; Charcoal; Cork and Related Products; Straws; Plaited Products; Baskets and Wickerwork	155	702	497
10	Paper Pulp and Cellulose Pulp; Paper and Waste Paper; Paperboard and Related Products	169	867	404
11	Textile Materials and Products	183	925	545
12	Footwear; Headgear; Umbrellas; Canes; Whips; Processed Feather; Artificial Flowers; Wigs	175	892	451
13	Gypsum; Cement; Asbestos; Mica; Ceramic Glass	209	816	604
14	Natural or Cultivated Pearls; Precious or Semi-Precious Stones; Jewelry of Precious Metal or Rolled Precious Metal; Artificial Jewelry; Coins	180	873	459
15	Base Metals and Related Products	142	751	428
16	Machinery; Electric Equipment and Accessories; Recorders; Video Recorder and Accessories	155	859	296
17	Locomotives; Vehicles; Aircraft; Ship and Related Transportation Equipment	152	766	314
18	Optical; Photographic; Film; Measuring and Checking and Medical Instruments and Equipment; Precision Instruments and Equipment; Clocks; Musical Instruments; Related Parts and Accessories	173	856	414
19	Arms and Ammunition; Related Parts and	170	926	387

	Accessories			
20	Miscellaneous Manufactured Articles	161	826	422
21	Works of Art, Collectors' Pieces and Antiques	169	867	404
22	Commodities and Transactions Not Included in Merchandise Trade	211	1,188	775
	Weight Average	**176**	**925**	**545**

Table C: Effects of US$1,000 of Chinese Exports to the World, FOB, on Total Chinese Domestic Employment by Merchandise Exports Classification, 1995 (person-year)

CODE	DESCRIPTION	Processing Exports	Non-Processing Exports	Aggregate Exports
01	Live Animals & Animal Products	0.255	0.645	0.557
02	Vegetables; Fruits and Cereals	0.259	0.641	0.622
03	Animal and Vegetable Oils; Fats and Wax; Refined Edible Oils and Fats	0.254	0.653	0.544
04	Food; Beverages; Liquor and Vinegar; Tobacco and Tobacco Substitutes	0.259	0.666	0.556
05	Minerals	0.151	0.274	0.220
06	Chemicals and Related Products	0.118	0.247	0.198
07	Plastics and Related Products; Rubber and Related Products	0.117	0.246	0.195
08	Raw Hides; Leather; Furs and Related Products; Saddle; Travel Articles; Handbags and Similar Containers	0.185	0.426	0.318
09	Wood and Wooden Products; Charcoal; Cork and Related Products; Straws; Plaited	0.171	0.420	0.317

	Products; Baskets and Wickerwork			
10	Paper Pulp and Cellulose Pulp; Paper and Waste Paper; Paperboard and Related Products	0.166	0.335	0.228
11	Textile Materials and Products	0.174	0.474	0.364
12	Footwear; Headgear; Umbrellas; Canes; Whips; Processed Feather; Artificial Flowers; Wigs	0.171	0.420	0.281
13	Gypsum; Cement; Asbestos; Mica; Ceramic Glass	0.176	0.334	0.297
14	Natural or Cultivated Pearls; Precious or Semi-Precious Stones; Jewelry of Precious Metal or Rolled Precious Metal; Artificial Jewelry; Coins	0.170	0.378	0.286
15	Base Metals and Related Products	0.090	0.203	0.160
16	Machinery; Electric Equipment and Accessories; Recorders; Video Recorder and Accessories	0.078	0.192	0.115
17	Locomotives; Vehicles; Aircraft; Ship and Related Transportation Equipment	0.089	0.204	0.150
18	Optical; Photographic; Film; Measuring and Checking and Medical Instruments and Equipment; Precision Instruments and Equipment; Clocks; Musical Instruments; Related Parts and Accessories	0.118	0.293	0.134
19	Arms and Ammunition; Related Parts and Accessories	0.098	0.211	0.168
20	Miscellaneous Manufactured Articles	0.162	0.360	0.246
21	Works of Art, Collectors' Pieces and Antiques	0.197	0.451	0.324

22	Commodities and Transactions Not Included in Merchandise Trade	0.171	0.412	0.290
	Weight Average	**0.111**	**0.363**	**0.242**

Table D: Effects of US$1,000 of Chinese Exports to the World, FOB, on Total Chinese Domestic Employment by Merchandise Exports Classification, 1995 (person-year)

CODE	DESCRIPTION	Processing Exports	Non-Processing Exports	Aggregate Exports
01	Live Animals & Animal Products	0.072	0.901	0.757
02	Vegetables; Fruits and Cereals	0.137	1.407	1.264
03	Animal and Vegetable Oils; Fats and Wax; Refined Edible Oils and Fats	0.045	0.690	0.544
04	Food; Beverages; Liquor and Vinegar; Tobacco and Tobacco Substitutes	0.048	0.712	0.567
05	Minerals	0.119	0.542	0.480
06	Chemicals and Related Products	0.046	0.429	0.276
07	Plastics and Related Products; Rubber and Related Products	0.046	0.429	0.275
08	Raw Hides; Leather; Furs and Related Products; Saddle; Travel Articles; Handbags and Similar Containers	0.053	0.623	0.286
09	Wood and Wooden Products; Charcoal; Cork and Related Products; Straws; Plaited Products; Baskets and Wickerwork	0.069	0.461	0.314
10	Paper Pulp and Cellulose Pulp; Paper and Waste Paper; Paperboard and Related Products	0.059	0.635	0.253
11	Textile Materials and Products	0.059	0.762	0.409

12	Footwear; Headgear; Umbrellas; Canes; Whips; Processed Feather; Artificial Flowers; Wigs	0.057	0.675	0.290
13	Gypsum; Cement; Asbestos; Mica; Ceramic Glass	0.083	0.456	0.325
14	Natural or Cultivated Pearls; Precious or Semi-Precious Stones; Jewelry of Precious Metal or Rolled Precious Metal; Artificial Jewelry; Coins	0.071	0.692	0.348
15	Base Metals and Related Products	0.048	0.384	0.207
16	Machinery; Electric Equipment and Accessories; Recorders; Video Recorder and Accessories	0.044	0.390	0.118
17	Locomotives; Vehicles; Aircraft; Ship and Related Transportation Equipment	0.050	0.382	0.141
18	Optical; Photographic; Film; Measuring and Checking and Medical Instruments and Equipment; Precision Instruments and Equipment; Clocks; Musical Instruments; Related Parts and Accessories	0.067	0.465	0.211
19	Arms and Ammunition; Related Parts and Accessories	0.062	0.477	0.184
20	Miscellaneous Manufactured Articles	0.060	0.593	0.266
21	Works of Art, Collectors' Pieces and Antiques	0.059	0.635	0.253
22	Commodities and Transactions Not Included in Merchandise Trade	0.084	0.830	0.516
	Weight Average	**0.057**	**0.703**	**0.375**