China's Exports and Employment

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July 2007

Abstract

Dooley *et al* (2003, 2004a,b,c) argue that China seeks to raise urban employment by 10–12 million persons per year due to export growth. In fact, total employment increased by 7.5–8 million per year over 1997-2005. We estimate that export growth over 1997–2002 contributed at most 2.5 million jobs per year, with most of the employment gains coming from non-traded goods like construction. Exports grew much faster over the 2000-2005 period, which could in principal explain the entire increase in employment. However, the growth in domestic demand led to *three-times* more employment gains that did exports over 2000-2005, while productivity growth subtracted the same amount again from employment. We conclude that exports have become increasingly important in stimulating employment in China, but that the same gains could be obtained from growth in domestic demand, especially for tradable goods, which has been stagnant until at least 2002.

Prepared for the NBER conference "China's Growing Role in World Trade," August 3-4, 2007. The authors thank Caroline Freund for comments and Zhi Wang for provided the 2000 input-output table used in our calculations, as well as other data.

1. Introduction

In a series of four papers, Dooley *et al* (2003, 2004a,b,c) lay out a vision of a "revived Bretton Woods system" to explain international trade and monetary arrangements today. According to their vision, this system has the following elements:

1) Under the old Bretton Woods system, European countries adopted undervalued exchange rates and capital controls, allowing then to pursue export-led growth. They eventually graduated to flexible exchange rate and capital mobility, thereby joining forming a "capital account" region (along with Canada and Latin America);

2) Another group of countries including Asia and especially China make up the new periphery, again adopted undervalued exchange rates and capital controls to pursue export-led growth. These countries form a "trade account" region. China, in particular, needs to employ some 200 million persons from the rural area, or 10-12 million persons per year in the urban areas, which is facilitated by the inflow of foreign direct investment;

3) The United States is at the center, and its budget and current account deficits have their counterpart in the trade surpluses in Asia. The U.S. current account deficit is financed through official inflows from the "trade account" region and private inflows from the "capital account" region;

4) The system is sustainable so long as the "trade account" region continues to finance the U.S. trade deficit and protectionism does not occur. Threats of protectionism are offset by the profits earned by foreign investors in the "trade account" region, especially China. Conversely, the trade deficits run by the U.S. (or equivalently, the Treasury bills held by China) are a form of collateral that prevents the Chinese from seizing the assets of foreign firms, which would lead U.S. to default on its financial obligations.

Some of these various hypotheses are more controversial than others. For example, Wei (undated) objects to the idea that U.S. Treasury bills held by China act as collateral against the Chinese seizing foreign plants, arguing that: (i) most FDI in China does not come from the U.S., but rather from Hong Kong; (ii) there is no recent history of China seizing control of foreign firms; (iii) there is even less history of the United States defaulting on its Treasury bill obligations. But this final idea of U.S. Treasury bill acting as collateral it not really essential for the rest of the theory,[1] and controversy over it need not detract from the other hypotheses. The focus of this paper is on the least controversial of their hypotheses, and that is the idea that expanding exports from China serve to create employment in the urban areas.

Our goal is to quantitatively evaluate this employment hypothesis, i.e. to answer the question of how much employment is created by rising Chinese exports. Even this hypothesis is not as straightforward as it might seem. A recent article in the *Economist* entitled "The Jobless Boom," notes that employment growth has been lower than overall economic growth across various countries of Asia, especially in China, and that this ratio has been falling over time.[2] Citing a study by the Asian Development Bank (Felipe and Hasan, 2006a,b), the article suggests that the reasons for this weak employment growth has been the shift towards more productive, capital-intensive industries.

A logical starting point to determine the employment effect of exports is to look at the calculations from input-output (IO) tables for China, which both the direct and indirect demand for labor from ordinary and processing exports.[3] As reviewed in section 2, an increase in

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[1] In fact, Dooley et al (2004c) motivate the collateral idea by noting that the rest of their theory does not necessarily imply a *trade deficit* in the United States as center country; by adding the trade deficits as collateral, that limitation of the theory is overcome.

[2] *The Economist,* January 14, 2006, pp. 46-47.

[3] Processing exports rely on processing imports, and the value-added in this activity is much less than for domestic production. It follows the employment impacts of processing exports is less than for ordinary trade, as we discuss.

ordinary exports of $1,000 (the annual wage in manufacturing in 2000) leads to employment of 0.44 person-years in 2000, and 0.34 person-years in 2002, with much smaller effects from processing exports. But surprisingly, applying these "static employment coefficients" to compute the implied employment gains due to the growth in domestic demand and exports, over 1997–2002 and 2000–2005, leads to employment gains that *vastly exceed the actual employment increase in China*. In other words, the static employment coefficients are an unreliable guide to computing the actual employment effects of export growth.

One reason why the static employment effects are unreliable has already been suggested: changes in the industry composition of exports towards more productive industries. This source of aggregate productivity growth is sometimes called the "Denison effect" in the U.S. literature (Nordhaus, 1992, p. 215), as discussed in section 3. Shifting towards more productive industries means that the labor needed to produce any given output is reduced. We show in section 4 that accounting for the "Denison effect" reduces the employment impact of exports by about 25% from the initial calculations, but we still predict employment gains due to rising exports that are much too high.

Besides the shifting composition of industries, aggregate productivity can rise due to technological progress and capital accumulation. We do not attempt to fully account for this second source of productivity growth, but make a limited attempt by using the growth in wages over time: in our calculations with the IO tables, rising wages means reduced employment growth. We show in section 5 that this factor further reduces the employment gains that we can expect from exports, to 45% of the initial calculation for ordinary exports and 75% of the initial calculation for processing exports. These are rules of thumb that can be used to reduce the static employment coefficients for exports.

In section 6 we investigate the growth in domestic demand in China over 1997–2002, when our data is most complete. Looking first at traded goods (agriculture, mining and manufacturing), and accounting for the "Denison effect," we find that the net employment growth in those sectors due to rising domestic demand is *actually negative*. That is, the shift towards more productive industries has outstripped the increase in final demand, leading to no net job creation. The only source of employment gains during 1997–2002 was in the non-traded sectors, such as construction, and final consumer services like restaurants, health services, education, etc. Taking into account the same factors as for exports, i.e. shifting demand across industries and rising wages, we find that the impact of domestic demand on employment is 75% smaller than the initial calculation from the IO table, which gives us another rule of thumb.

Using these rules of thumb we *revise* the static employment coefficients, and in section 7 re-calculate the impact of rising exports and domestic demand on labor demand in China. We find the implied employment growth from exports is modest over the 1997–2002 period: not more than 2.5 million jobs added per year. During the 2000–2005 period exports grew much faster, so the employment impact is also higher: exports added as much as 7.5 million jobs per year. That is still less than the 10-12 million person goal suggested by Dooley *et al* (2003, 2004a,b,c), but shows that exports can play a significant if not the complete role for transferring people from the countryside. However, domestic demand led to *three-times* more employment gains that did exports, while productivity growth subtracted the same amount again from employment. We conclude in section 8 that exports have become increasingly important in stimulating employment in China, but that the same gains could be obtained from growth in domestic demand, especially for tradable goods, which has been stagnant until at least 2002 and possibly beyond.

2. Employment Gains in China

We begin by reviewing the recent growth in employment, GDP and exports in China. Throughout the paper we focus on the period 1997–2005, which gives us two overlapping five-year intervals to work with: 1997–2002 and 2000–2005. Despite the relatively short span of years and closeness of these two intervals, we will find substantial changes in the Chinese economy over this time.

In Table 1 we list total employment, broken down by urban and rural, as well as GDP and its components during these years. Total employment has grown by 7.5–8 million workers per year over this period, while urban employment has grown slighter faster: 8–8.5 million workers, as there was some migration out of the countryside. Real GDP and its components, as well as all trade data, is measured in constant 2000 US$.[4] Real GDP growth nearly doubled from 9.5% per year over 1997–2002 to 18% in 2000–2005. Notice that the growth of C+G is much less in the 2000–2005 period than is the growth in investment, indicating that an increasing share of domestic demand is for construction projects and other investments.

In Table 2 we provide the data on Chinese ordinary and processing trade, again in constant 2000 US$. Both exports and imports grew by about 33% per year over the 2000–2005 period, which greatly outstripped their prior growth: the boom in Chinese trade is really a feature of the 21st century. Note that the trade balance listed in the final column of Table 2 does not match the values for (X–M) given in the final column of Table 1, because (X–M) includes both goods and services as used in GDP accounts, whereas the trade balance in Table 2 is just for merchandise trade.

[4] We lack specific deflators for components of GDP and trade, and the overall Chinese inflation rate is erratic over this period, including some years of deflation. Since our trade data is reported in US$, we decide to use constant 2000 US$ to measure all other values, converted with the nominal yuan/dollar rate and using the U.S. CPI.

A logical starting point to determine the impacts of export growth on employment are the studies by Lau *et al* (2004), using a 1995 IO table for China, and Lau *et al* (2006a,b), using a 2002 IO table. From the 1995 table, Lau *et al* (2004) estimate that $1,000 of ordinary exports from China leads to 0.70 person-years of employment, and $1,000 of processing exports leads to 0.06 person-years, or roughly one-tenth as much as for ordinary exports. Those estimates are shown in Table 3, and have been falling over time. Using the 2002 IO table, Lau *et al* (2006a,b) estimate that $1,000 of ordinary exports from China leads to 0.36 person-years of employment (which is one-half as much as they found for 1995), and $1,000 of processing exports leads to 0.11 person-years (which is twice the estimate for 1995), so processing exports lead to about three-tenths the employment of ordinary exports.

We will refer to these employment estimates computed from the IO tables as "static employment coefficients," because they each refer to a single year. The change in these static employment coefficients can be due to either of the factors we identified in the introduction: shifting composition of exports across industries and technological progress. We will attempt to measure the importance of each of these, but first need to replicate the results of Lau and his co-authors for one year. Using the IO table for 2000, as we find that $1,000 of ordinary exports from China leads to 0.44 person-years of employment, and $1,000 of processing exports leads to 0.13 person-years, so again, processing exports leads to about three-tenths the employment of ordinary exports. Our estimates for 2000 are also shown in Table 3, and fall neatly in-between the estimates of Lau *et al* (2004, 2006a,b), giving us some confidence that our employment estimates are consistent with theirs.

The methodology we have used to obtain the static employment coefficients from the 2000 IO table is discussed in the Appendix, and is briefly summarized as follows. Denote the sources of demand by j = D, O, P for domestic demand, ordinary exports and processing exports, respectively. Then the portion of value-added going to labor from $1 demand of type j in sector i is B_{Lit}^{j}, which is computed from the IO table as the sum of direct plus indirect payments to labor. Our calculations are only for 2000, which we denote t = 0, but the same calculations are made by Lau *et al* (2004, 2206a,b) for 1995 and 2002. Having obtained these coefficients B_{Lit}^{j} for each sector, these are averaged across sectors:

$$\overline{B}_{Lt}^{D} \equiv \frac{\sum_i D_{it} B_{Lit}^{D}}{\sum_i D_{it}}, \text{ and } \quad \overline{B}_{Lt}^{j} \equiv \frac{\sum_i X_{it}^{j} B_{Lit}^{j}}{\sum_i X_{it}^{j}}, \quad \text{for } j = O,P \qquad (1)$$

where D_{it} denotes domestic demand in sector j, while X_{it}^{O} denotes ordinary exports and X_{it}^{P} denotes processing exports.

Notice the averaged terms $\overline{B}_{Lt}^{j}$ refer to the portion of value-added going to labor. To convert this into employment we need to divide by a wage. For the 2000 IO table, we have used the average 2000 wage, which was $842 per year. So the static employment coefficients shown in Table 3 for 2000 are obtained as:

$$\overline{C}_{L0}^{j} \equiv \overline{B}_{L0}^{j} / \$842, \quad \text{for } j = D,O,P \qquad (2)$$

We are unsure what wages were used by Lau *et al* (2004, 2006a,b) for 1995 and 2002, but the calculation is presumably analogous to that in (2), which we will write in other years as:

$$\overline{C}_{Lt}^{j} \equiv \overline{B}_{Lt}^{j} / W_t. \qquad (2')$$

In Table 3 we also show the static employment coefficient for *domestic demand,* which equals C+I+G. For 2000, we have computed the domestic coefficients as in (1) and (2), for j=D.

For 2002, we choose $\overline{C}_{Lt}^{j}$ so that the implied employment from domestic demand plus exports just equals the *actual* employment in each year. That is, we have chosen $\overline{C}_{Lt}^{D}$ so that:

$$\overline{C}_{Lt}^{D}D_t + \overline{C}_{Lt}^{O}X_t^{O} + \overline{C}_{Lt}^{P}X_t^{P} = L_t \ , \tag{3}$$

where L_t is employment in year t. Notice that this full-employment condition also holds in 2000 by construction of the static employment coefficients from the IO table.

Despite the fact that the static employment coefficients are obtained for a single year, there is a strong temptation to apply them over time, i.e. to use these coefficients to predict the future course of employment due to export growth. There are potentially large errors associated with that procedure, however. To see this point theoretically, take the difference of (3) over a 5-year period. After some simplification, we obtain the equation:

$$\begin{aligned} \Delta L_t = {} & \Delta D_t \tfrac{1}{2}(\overline{C}_{Lt}^{D} + \overline{C}_{Lt-5}^{D}) + \Delta X_t^{O} \tfrac{1}{2}(\overline{C}_{Lt}^{O} + \overline{C}_{Lt-5}^{O}) + \Delta X_t^{P} \tfrac{1}{2}(\overline{C}_{Lt}^{P} + \overline{C}_{Lt-5}^{P}) \\ & + \Delta\overline{C}_{Lt}^{D} \tfrac{1}{2}(D_t + D_{t-5}) + \Delta\overline{C}_{Lt}^{O} \tfrac{1}{2}(X_t^{O} + X_{t-5}^{O}) + \Delta\overline{C}_{Lt}^{P} \tfrac{1}{2}(X_t^{P} + X_{t-5}^{P}), \end{aligned} \tag{4}$$

where $\Delta D_t = D_t - D_{t-5}$ is the change over a 5-year interval, and likewise for every other variable. On the first line of (4) we have the change in domestic demand and exports times the average employment coefficients, and on the second line we have the change in the employment coefficients times the average demand. Generally, the employment coefficients are *falling* over time, as can be seen by comparing the rows of Table 3. It follows that the second line of (4) is negative, and potentially quite large: the fall in each employment coefficient is multiplied by the average level of demand, and not just its growth. Since the second line is negative and potentially large, it follows that the first line on the right is potentially much larger than the actual increase in employment.

This theoretical result is confirmed in Table 4, where we take the static employment coefficients and apply them to the change in exports over the two 5-years periods, 1997-2002 and 2000-2005. In the first row of Table 4, for example, we use our estimates of the C_{i0}^{j} employment coefficient from the 2000 IO table, as shown in Table 3, and multiply each of the employment coefficients by the real change in domestic demand, ordinary exports and processing exports over 1997–2002. That is we compute:

$$\text{Prediction } 1 = \Delta D_t \overline{C}_{L0}^{D} + \Delta X_t^{O} \overline{C}_{L0}^{O} + \Delta X_t^{P} \overline{C}_{L0}^{P} \ , \qquad (5)$$

which is similar to the first line of (4). From domestic demand we predict an employment increase of 216 million persons,[5] and for ordinary processing exports we predict an employment increase of 31 million persons. Summing over these we obtain nearly 250 million workers, as compared to an *actual* employment increase of only 39 million! We see that simply multiplying the real changes in demand and exports by the employment coefficients, as in (5), massively overstates the true change in employment.

The situation is even worse over the 2000–2005 period, where now we use the static employment coefficients of Lau *et al* (2006a) from the 2002 IO table. Again we multiply the employment coefficients by the real change in domestic demand and exports, as in (5), and predict an increase in employment in China of 550 million workers, as compared to the actual increase of only 37 million! Thus, the predicted employment impact *vastly exceeds* the actual employment increase. The difference between the predicted and actual employment increases is due to fall in the employment coefficients, as shown on the second line of (4).

[5] The rise in domestic demand of $411.5 billion in Table 4 is taken from the IO tables for 1997 and 2002, and is less than the rise in domestic demand of $506.6, taken from C+I+G in the national accounts, Table 1. We use domestic demand from the IO tables for consistency with later calculations. If instead we use the national accounts figure to predict employment gains in Table 4, then we obtain 266 million workers over 1997–2002, which is ever larger that what we report in Table 4,so using the national accounts data would add further to the error in prediction 1!

We conclude from these calculations that the static employment coefficients, times the changes in demand, do not provide reliable estimates of the actual employment gains in China. Reasons for this have already been suggested: the static employment coefficients do not take into account the changing industry composition of domestic demand and exports, and the coefficients can also fall due to technological progress and capital accumulation. We now examine each of these explanations in turn.

3. Shifting Composition of Exports and Domestic Demand

The static employment coefficients computed from the IO table refer to the employment impact of an additional $1,000 in *average* exports or domestic demand, i.e. using the same composition of output that occurred in the year of the IO table, as shown by taking the averages in (1). But that is not a good guide for the effects of an actual change in demand, because with shifting comparative advantage, export growth may be in industries different from in the past. In addition, for domestic demand the growth in China in recent years has been especially strong in investment (as shown in Table 1), especially construction, which differs in its labor requirements from other industries.

The growth in exports is shown in Figures 1 and 2, where we graph the percentage increase over 2000-2005 in total and ordinary exports, respectively, and industry wages in 2000. Regardless of whether we use total or ordinary exports, the industry with the greatest percentage increase in exports was electronic and telecommunications equipment, and that industry also had the highest wage in 2000.[6] Overall, there is a positive correlation between the percentage growth in exports, and the real wage in 2000, with food products and tobacco appearing as an outlier (and a relatively small export industry). The fact that the percentage increase in exports differs

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[6] This industry also had by far the greatest increase in real exports over 2000-2005, exceeding $160 billion, though the majority of those sales were for processing exports.

substantially across industries, meaning that the use of "average" exports as in Lau *et al* (2004, 2006a,b) will lead to inaccurate results. Instead, we want to use the "marginal" exports, i.e. the *actual increase* in exports that occurred in each industry over the five-year period.

In theoretical terms, we want to compare the results of using *aggregate* employment coefficients, as shown in Table 3, with using *disaggregate* sector-level coefficients. To obtain the disaggregate results, write the full-employment condition (1) alternatively as:

$$\sum_i C^D_{Lit} D_{it} + C^O_{Lit} X^O_{it} + C^P_{Lit} X^P_{it} = \sum_i L_{it} \ , \tag{6}$$

where C^D_{Lit}, C^O_{Lit}, and C^P_{Lit} are the disaggregate employment coefficients by IO sectors, and likewise for domestic demand D_{it}, ordinary exports X^O_{it} and processing exports X^P_{it}. Taking the difference of (6) over a 5-year interval we obtain:

$$\begin{aligned} \Delta L_t = & \sum_i \left\{ \Delta D_{it} \tfrac{1}{2}(C^D_{Lit} + C^D_{Lit-5}) + \Delta X^O_{it} \tfrac{1}{2}(C^O_{Lit} + C^O_{Lit-5}) + \Delta X^P_{it} \tfrac{1}{2}(C^P_{Lit} + C^P_{Lit-5}) \right\} \\ & + \sum_i \left\{ \Delta C^D_{Lit} \tfrac{1}{2}(D_{it} + D_{it-5}) + \Delta C^O_{Lit} \tfrac{1}{2}(X^O_{it} + X^O_{it-5}) + \Delta C^P_{Lit} \tfrac{1}{2}(X^P_{it} + X^P_{it-5}) \right\}. \end{aligned} \tag{7}$$

By using the sectoral data in the 2000 IO table, we can make an alternative prediction of the employment gains from the first line of (7):

$$\text{Prediction } 2 = \sum_i \left\{ \Delta D_{it} C^D_{Li0} + \Delta X^O_{it} C^O_{Li0} + \Delta X^P_{it} C^P_{Li0} \right\}, \tag{8}$$

where we are using employment coefficients from the year 2000 table in place of the average employment coefficients that appear in (5). Note that these are obtained from the 2000 IO table by dividing B^j_{Li0} by the wage in each sector:

$$\text{Prediction 2 uses:} \quad C^j_{Li0} \equiv B^j_{Li0} / W_{i0}, \quad \text{for } j = D,O,P. \tag{9}$$

Comparing the new prediction obtained from the disaggregate coefficients in (8) with that from the aggregate coefficients in (5), since $\Delta D_t = \sum_i \Delta D_{it}$ and $\Delta X^j_t = \sum_i \Delta X^j_{it}$ we obtain:

$$\text{Prediction 2} - \text{Prediction 1} = \sum_i \left\{ \Delta D_{it}(C^D_{Li0} - \overline{C}^D_{L0}) + \Delta X^O_{it}(C^O_{Li0} - \overline{C}^O_{L0}) + \Delta X^P_{it}(C^P_{Li0} - \overline{C}^P_{L0}) \right\}. \quad (10)$$

If there is a negative correlation between the growth in demand and the employment coefficients in each sector, as we would expect if growth in output occurs in the more efficient sectors, then (10) is negative and our second prediction of employment growth is less than the first. This reduction in employment gains come from shifts towards more productive industries, and is an example of what Nordhaus (1992, p. 215) calls the "Denison effect." Nordhaus refers to the work of Edward Denison (1967, 1980), who demonstrated that if resources shift from low-productivity to high-productivity industries, like from agriculture to manufacturing, then the economy would show aggregate productivity growth even if sectoral productivity growth was zero in both sectors. The aggregate productivity growth is due to a "reallocation effect" across industries. The flip-side of this aggregate productivity growth is that the labor needed to produce any given output is reduced, as we are showing in (10).

Another interpretation of the calculation in (8) can be obtained by taking the averages:

$$\tilde{C}^D_{L0} \equiv \frac{\sum_i \Delta D_{it} C^D_{Li0}}{\sum_i \Delta D_{it}}, \text{ and } \quad \tilde{C}^j_{L0} \equiv \frac{\sum_i \Delta X^j_{it} C^j_{Li0}}{\sum_i \Delta X^j_{it}}, \quad \text{for } j = O,P. \quad (11)$$

Notice that (11) is an average of the sectoral employment coefficients C^j_{Li0} in 2000, but using with the change in domestic demand and exports as weights, rather than their average levels as in (1)-(2). Again, since $\Delta D_t = \sum_i \Delta D_{it}$ and $\Delta X^j_t = \sum_i \Delta X^j_{it}$, it is immediate that prediction 2 in (8) can be alternatively written as:

$$\text{Prediction } 2 = \Delta D_t \tilde{C}_{L0}^{D} + \Delta X_t^{O} \tilde{C}_{L0}^{O} + \Delta X_t^{P} \tilde{C}_{L0}^{P}, \tag{12}$$

which is the change in demand times the revised employment coefficients. From (11) and (12), we can see our second prediction of the rise in employment uses *actual* or "marginal" increase in exports and domestic demand, rather than the "averages" used in (1)-(2) and (5).

In the following sections, we implement this second prediction, as well as a third variant, using the 2000 IO table. In sections 4 and 5 we focus on the growth of exports, over 1997–2002 and 200–2005, and in section 6 discuss the growth in domestic demand, in which case we do not have disaggregate data for 2005 so we are restricted to investigating 1997–2002.

4. Growth of Exports, 1997–2002 and 200–2005

In Table 5, we report the employment gains over 1997-2002 and 2000-2005 using the disaggregate increase in exports over these two periods (prediction 2a). In the former period, 1997-2002, the employment growth is 23 million persons, rather than 31 million from Table 1. So the shift towards more productive industries reduces the employment growth by 25% (or 17% for ordinary exports and 52% for processing exports). A similar decline is seen over 2000-2005, when using the actual rather than the average increase in exports reduces employment growth from 115 million (prediction 1) to 86 million (prediction 2a), again a decline of 25%.[7] We conclude that the employment gain from increased exports is reduced once we account for the industry composition of exports, as suggested by Felipe and Hasan (2006a,b).

The adjustments we have made for prediction 2 can be extended in two directions: we have the data to take into account the provincial compositions of exports, along with provincial

[7] If instead of using the industry wages in prediction 2, as in (9), we instead continued to use the overall average wage of $842 in 2000, then the predicted employment impact of exports is reduced by 15% as compared with the first prediction. That reduction comes from using the disaggregate calculation as in (8), but with the average wage of $842 in (9). The additional 10% reduction for prediction 2 is obtained by using the industry wages, as in (9).

wages by industry; or to account for the differing wages paid by types of firm-ownership (state-owned, collective, or private) and the exports by firm-ownership and industry as well as wages by firm-ownership and industry. To the extent that exports are shifting to more productive provinces (e.g. coastal) or firms (e.g. private), the estimated employment gains are reduced.

It should be noted that the maintained assumption in these calculations is that the national IO table for 2000 applies equally well across provinces and across types of firm-ownership. We have only very limited data that could be used to test this assumption. To the extent possible, we applied the methods of Bernstein and Weinstein (2002), and found that the 2000 IO table appears to hold reasonably well across provinces except for Guangdong (where labor compensation was higher than predicted from the national IO table). Because Guangdong was the only outlier, and because our ability to construct an alternative IO table for Guangdong is extremely limited, we continued to apply the national table across all provinces, and types of firm-ownership.

Focusing first on the provincial effects (prediction 2b), accounting for the shift in exports by industry and province further reduces the employment impact of increased exports, to 20.6 million persons over 1997-2002, or one-third less than the initial calculation. For 2000-2005, the implied increase in employment is 77.5 million persons, which is also one-third less than the initial calculation. The employment effects that are obtained when we instead take into account the shift in exports by industry and firm-ownership (prediction 2c) are similar to those that take into account provincial effects: the predicted employment gains are reduced by about one-third from the initial calculations. The data we have available do not allow us to take into account both of these effects at the same time. In any case, for 2000-2005 the implied increase in employment is still much larger than the actual increase of 37 million, which calls for an explanation.

5. Increase in Wages due to Productivity Gains

A final limitation of the static employment coefficients computed from the IO table, and also a limitation of our results reported in Table 5, is that we have assumed that wages are constant over time. That is, we are using wages in 2000: either at the overall wage in (2), or the industry wage in (9). But of course, real wages will rise over time due to both productivity gains and capital accumulation. With rising wages, any implied increase in value-added and payments to labor will correspond to a smaller increase in employment.

For our next calculation, we divide the direct plus indirect payments to labor from the 2000 IO table by the real 1997 and 2002 wages, respectively, when estimate labor demand in each year. That is, we obtain the employment coefficients in each year as:

$$\hat{C}^{j}_{Lit} \equiv B^{j}_{Li0} / W_{it} \text{ and } \hat{C}^{j}_{Lit-5} \equiv B^{j}_{Li0} / W_{it-5}, \text{ for } j = D,O,P. \tag{13}$$

Then our third prediction of the employment gains for rising demand is:

$$\text{Prediction } 3 = \sum_i \left\{ D_{it}\hat{C}^{D}_{Lit} - D_{it-5}\hat{C}^{D}_{Lit-5} + X^{O}_{it}\hat{C}^{O}_{Lit} - X^{O}_{it-5}\hat{C}^{O}_{Lit-5} + \Delta X^{P}_{it}\hat{C}^{P}_{Lit} - \Delta X^{P}_{it-5}\hat{C}^{P}_{Lit-5} \right\}. \tag{14}$$

Note that if instead of the estimates in (13), we had used the true employment coefficients C^{j}_{Lit} obtained from the IO table in each year, then (14) would be an exact prediction of the change in employment: there would be no error involved. So the difference between the third prediction, which uses the industry wages in each year, and the actual changes in employment occurs because: (i) we are using wages in (13) that do not differ between domestic and export production, and (ii) we are still using coefficients B^{j}_{Li0} from 2000, rather than allowing these coefficients to change over time. In brief, we still not accurately predict employment changes with (14) because we are not allowing the IO table to change over time, and our wage data is not detailed enough. Still, we find that this third prediction is a further improvement over our earlier calculations.

In Table 6 we show how the implied employment effects are further reduced when we allow for the actual increase in wages over 1997–2002 or 2000–2005. For 1997–2002, we find that the employment gains due to ordinary exports range from 5 to 10 million (predictions 3a, 3b and 3c), which are reduced by 55% or more as compared to the initial calculation. For processing exports, the implied employment effects ranges from -1.4 to 1.7 million, a reduction of at least 80% from the initial calculation. Over this period, most of the increase in exports over these years can be explained by the shift in workers towards more efficient industries, firms and provinces, so the employment gain is very modest. Over 2000–2005, we also find that the employment gains due to increased exports are reduced by 55% from our initial calculation, while the employment gains due to processing exports are reduced by about 75%.

To sum up, our calculations have reduced the employment impact of increased exports by *more than one-half* of the initial calculation for ordinary exports, and at least *three-quarters* for processing exports. Are these results in Table 6 believable? The smaller employment gains indicate an efficient reallocation of resources, which is plausible. We note that these efficiency gains come from reallocations across many industries (as well as province and firm-ownership), and do not simply reflect a rural-urban migration. Indeed, agriculture and manufacturing industries tend to rise or fall together in our calculations: allowing for rising wages over time, we find that the increase in exports is associated with rising employment in both agriculture and the sum of all manufacturing industries. So the net changes in implied employment reported in Tables 5 and 6 would be similar if we omitted agriculture and reported instead the changes in manufacturing employment due to exports.

6. Shifting Composition of Domestic Demand, 1997–2002

To measure domestic demand we rely on the sum of C+I+G by industry from the IO tables, which we have for the years 1997, 2000 and 2002, but not for 2005.[8] So to evaluate the change in employment due to domestic demand, we are restricted to the five-year period 1997-2002, and will not be able to report any results for 2000-2005. Furthermore, domestic demand is not broken down by province nor by the type of firm-ownership. So the calculations for domestic demand will *only* by broken down by industry over 1997-2002.

The implied employment increase due to the growth in domestic demand are reported in Table 7, where we distinguish domestic demand for tradable goods (all manufacturing plus mining and agriculture) and non-traded goods (all utilities and services, including construction).[9] That is, we have re-computed the employment coefficients shown in (1)-(2) and (10)-(11) for domestic demand by separating trade from non-traded goods. Traded goods are shown in part A of Table 7. We find that domestic demand for tradable goods has risen by a very modest amount in real terms over 1997-2002, $24 billion, shown in the first column. Multiplying that fall in demand by the static employment coefficient of 0.525, we obtain a modest rise in employment of 12.7 million persons, as shown in the third column (prediction 1).

However, if instead we use the actual change in demand rather than its "average" change, then fall in demand would actually lead to *reduced* employment of 10 million workers when holding wages fixed at their 2000 levels (prediction 2). Allowing for the growth of wages between 1997 and 2002, the implied fall in employment is even higher, 50 million workers, due to the fall in domestic demand (prediction 3). Only a very small amount, 3.3 million workers, is made up by the increase in demand due to rising exports, so the net change in employment due to

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[8] Imports are treated entirely as intermediate inputs in the IO table, so need not be deducted from C+I+G.
[9] Tradable goods are defined as sectors 1-22 of the 2000 IO table, and nontradable goods as sectors 23-40.

domestic demand plus exports is a fall of some 47 million jobs.

Since employment actually increased by 39 million jobs over 1997-2002, the gap must be made up by the non-traded sector, which is confirmed in the next row of Table 7. An initial calculation using a static employment coefficient gives a rise in employment of 203 million (prediction 1, part B). Use the actual change in demand rather than its "average" change, then the employment increase becomes 166 million workers when holding wages fixed at their 2000 levels (prediction 2). Allowing wages to rise over 1997-2002, the employment gain in non-tradable goods is 111 million workers (prediction 3). That is an enormous rise in employment due to domestic demand, that far exceeds any of our calculations for exports. The sector with the largest increase in domestic demand in construction, which accounts for at least half of the overall rise in employment. Employment gains are also shown in final consumer services like real estate, restaurants, health services, education, etc.

The changes in domestic demand for tradable and non-tradable goods are graphed in Figure 3, along with the industry wages in 2000.[10] Sectors with the greatest increase in demand include a few tradable industries, like instruments and office machinery, and electronic and telecommunication equipment, but many more non-traded goods: real estate, restaurants, scientific research, education, public administration, health and social services, etc. At the far right of the figure, sectors like textile, wearing apparel, food products, furniture and agriculture all have *negative* growth in real demand over 1997–2002. We find it quite remarkable that the rapidly growing Chinese economy did not generate more domestic demand for its own tradable goods over this period! Domestic demand should be treated as a viable alternative to exports as a source of employment growth, but did not function in that way, presumably because the income gains in China did not led to a commensurate rise in consumption.

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[10] For convenience we omit the petroleum and mining sectors in Figure 3, as well as several other smaller sectors.

That estimate for rising employment due to non-traded goods can be combined with the fall in employment in tradable goods, to obtain a total implied change in employment of 111–50 = 61 million workers (prediction 3, part C). That is our final estimate for 1997-2002. In principle, this estimate of 61 million jobs added over 1997-2002, from both domestic demand and exports, should equal the actual gain in employment of 39 million jobs. The discrepancy between these numbers (25 million) can be due to multiple causes: we have not been able to distinguish domestic demand by firm-ownership or province; we have used a fixed 2000 IO table; and the wage data we use is not as detailed as we would like. But we feel that even if these improvement were made to our calculations, the overall message of Table 7 would not change: the vast majority of job growth over 1997-2002 is due to the increase in demand for non-traded goods, especially the construction sector. The main reason that employment has grown as much as it has in China over 1997-2002 is due to the increase in domestic demand for non-tradable goods!

Furthermore, it is important to recognize that our final estimate of 61 million job gained over 1997–2002, from prediction 3, is vastly better than our initial calculation of 216 million jobs (prediction 1, part C). Comparing these two numbers, we see that the initial calculation is reduced by 72% due to the adjustments we have made. That is nearly the same adjustment (75%) that we found in the previous section for processing trade, but larger than the adjustment (45%) that we found for ordinary exports. It is noteworthy that a downwards adjustment of 45% is shown in Table 7 for the nontradable sector, where the employment gains were reduced from 203 million in our initial calculation to 61 million (prediction 3). The fact that *total* employment generated from domestic demand is revised downwards by nearly 75% reflects the very weak growth in demand for tradable goods, leading to negative employment gains once we account for the industry composition of demand and wage increases over time. In other words, the “Denison effect" operates very strongly in the pattern of domestic demand for tradable goods, as we have already seen for exports.[11]

7. Implied Growth in Employment Once Again

Let us now summarize what we have learned from the last three sections, and return to the calculations of employment growth. In Table 8 we show again the static employment coefficients for 2000 (our calculations) and 2002 (from Lau *et al,* 2006a,b). We found in section 2 that those coefficients vastly overstate the actual change in employment over 1997–2002 or 2000–2005. But by using improved calculations, we were able to reduce the predicted employment growth. Our final calculations showed that the employment growth for ordinary exports was 55% lower than obtained from the static employment coefficients, while that employment growth from processing exports and domestic demand were 75% lower (and possibly more). We apply those rules of thumb to the initial static employment coefficients to obtain *revised* employment coefficients, as shown in Table 8.

For example, instead of the initial calculations for the 2000 IO table, we now predict that \$1000 in ordinary exports generates $0.44 \times 0.45 = 0.20$ person-years of employment, while \$1000 in processing exports or domestic demand generates $0.13 \times 0.25 = 0.03$ and $0.53 \times 0.25 = 0.13$ person-years, respectively. For 2002, we now predict that \$1000 in ordinary exports generates $0.36 \times 0.45 = 0.16$ person-years of employment, while \$1000 processing exports of domestic demand generates $0.11 \times 0.25 = 0.03$ and $0.44 \times 0.25 = 0.11$ person-years, respectively. These estimates are upper-bounds, since we obtained lower employment impacts in some calculations, but we shall use these adjustments as conservative.

[11] Note that in Figure 3, the industry with tradable-good industry with the highest percentage increase in domestic demand is instruments and office machinery, followed by electronic and telecommunication equipment. The latter industry has among the highest wage of any tradable industry, and also shows the highest percentage increase in exports (both for ordinary and processing exports).

We use the revised employment coefficients in Table 8 to re-calculate the employment gains for both periods, as shown in Table 9. For 1997–2002, we find that the growth in domestic demand (for nontradable goods, in particular), leads to an increase in employment of 67 million workers. In addition, the growth in exports (for ordinary exports, especially), leads to an increase in employment of 12 million workers, or about 2.5 million workers per year. Summing over domestic demand and exports, we predict employment gains of 79 million from 1997–2002, as compared to the *actual* employment increase of 39 million.[12] So our prediction is still twice as big as the actual gain, but that is a great improvement over our initial calculation (Table 4) where the predicted employment gain was 216 million–more than five times greater than the actual increase! The gap between our revised employment gain over 1997–2002 and the actual is due to the fall in the labor coefficients B^{j}_{Lit} from the IO table, reflecting technological progress and capital accumulation.

In later period, 2000–2005, the growth in domestic demand and exports are both stronger. We again use the revised employment coefficient from Table 8 for 2002, and multiply those by the real changes in domestic demand and exports. We find that the growth in domestic demand (especially investment), leads to an increase in employment of 114 million workers. In addition, the growth in exports adds employment of another 38 million workers. By coincidence, the predicted employment impact of exports is nearly exactly equal to the *actual* rise in employment of 37 million workers, or 7.5 million per year. That is less than the 10-12 million person goal suggested by Dooley *et al* (2003, 2004a,b,c), but shows that exports can play a significant if not the complete role for transferring people from the countryside.

[12] Note that the predicted employment gains in Table 9 are not exactly the same as the final row of Table 7, because in Table 9 we are using the rules of thumb shown in Table 8 to reduce the static employment coefficients, i.e. the coefficient for ordinary exports is reduced by 55%, and the coefficients for processing exports and domestic demand are reduced by 75%. Those rules of thumb are broadly consistent but not identical to the calculations in the final row of Table 7.

However, the role of domestic demand over 2000–2005, which added 114 million to employment is actually *three-times* large than the role of exports. Based on that evidence, we could not refute the claim that *domestic demand* is responsible for the employment increase. Whether we want to claim that it is domestic demand or exports that are responsible is really just an exercise in semantics, however: the fact is that both have played an important role in stimulating employment growth, and the sum of them (152 million) is still considerably large than the actual employment gains (37.4 million) over this period. Again, we would attribute the gap between the predicted and actual employment gains as due to technological progress and capital accumulation, as well as illustrating the limits of how far we can push our calculations from the IO table. We have made a substantial improvement over the initial calculations, whose predictions were off by an order of magnitude, but still have not obtained a precise accounting of the causes of employment growth.

8. Conclusions

Dooley *et al* (2003, 2004a,b,c) argue that the current systems of current account imbalances is sustainable so long as China is willing to absorb the Treasury bills used to finance the U.S. deficits. And that willingness is tied to its desire to move workers from unproductive rural employment into urban, manufacturing jobs. These authors suggests that China needs to re-employ some 200 million persons from the countryside, or 10-12 million persons per year in the urban areas, and that this is achievable by continued growth in exports.

We have evaluated this hypothesis by using calculations on the employment impact of exports, and domestic demand, from Chinese IO tables. We have started with the calculations of Lau *et al* (2004, 2006a,b) for 1995 and 2002, and added our own calculation for the 2000 IO table. The "static employment coefficients" obtained from these tables summarize the amount of employment generated by $1000 in exports or domestic demand for one years. By construction, these static employment coefficients are consistent with the full-employment condition for the economy. But the static employment coefficients do a very poor job at predicting the *future* growth in employment from the future growth in exports or domestic demand. We have shown that the errors involved in this forward-looking forecast are enormous, which mean that the static employment coefficients are highly unreliable for that purpose.

To improve on that situation, we have proposed adjustments to the static employment coefficients. These adjustments take into account the future growth in export and domestic industries, which may be quite different from their former growth, as well as rising wages over time. The adjustments partially close the gap between predicted and actual employment growth, even when using an IO table for a single year. Using the *revised* employment coefficients, we find that export growth over 1997-2002 explains at most one-third of the total employment growth in the economy (2.5 out of 7.5–8 million workers per year). For 2000–2005, however, export growth was faster, and in principle can explain the entire employment growth of 7.5 million workers per year. However, the rise in domestic demand – especially for investment – generated employment gains that are *three-time*s larger than those for exports. The same amount of employment is reduced by productivity growth in the economy.

The other key finding is that over 1997–2002, the rise in domestic demand was *nearly entirely* in the nontradable sector: predicted employment for tradable goods actually fell. This is very surprising, but reflects the shift in expenditure in China towards construction projects as well as nontradable consumer goods. We do not have the detailed data to evaluate whether the same shift occurred during 2000–2005, but from the aggregate GDP data, there has been substantially faster growth in investment I instead of private and public consumption C+G. So we speculated that domestic demand for tradable goods continues to lag, despite the newspaper reports of rising consumer expenditures.

The importance of this finding is that China could certainly turn towards domestic demand instead of export (and consumer expenditures, in particular) as an engine to stimulate employment. The transition from export-led growth to domestic demand would undoubtedly rely on many economic and policy actions that are now only beginning: a real appreciation as the prices of non-tradable goods begin to rise, shifting domestic demand towards both imports and exportable goods; accompanied by some nominal appreciation of the yuan; fiscal policies that allow for greater security of income in old age, allowing higher expenditures today; reform of the banking sector; etc. We believe that it is these features – and not the reliance on export-led growth – that should determine the future path of the government and trade accounts in China and ultimately restore greater balance to these accounts.

Appendix: Chinese Input-Output Table

Figure A1: Input-Output Table

	Domestic Product	Ordinary Export	Process Export	Sub-total	C+I+G	Export	Total Output
Domestic Intermediate Input	X^{DD}	X^{DO}	X^{DP}		F^{D}		X^{D}
Ordinary Import Input	X^{MD}	X^{OO}	X^{OP} (=0)		F^{O}	$(E^{O})^{T}$	
Process Import Input	X^{PD} (=0)		X^{PP}			$(E^{P})^{T}$	
Value-Added	V^{D}	V^{O}	V^{P}				
Labor Payment	L^{D}	L^{O}	L^{P}				
Total Input	X^{D}	E^{O}	E^{P}				

The structure of extended IO table we are constructing is presented in Figure A1, where:

- X^{DD} is an $n \times n$ matrix of domestic intermediate input needed for domestic production;
- X^{DO} is an $n \times n$ matrix of Domestic Intermediate Input to Ordinary Export;
- X^{DP} is an $n \times n$ matrix of Domestic Intermediate Input to Processing Export;
- X^{MD} is an $n \times n$ matrix of Ordinary Imported Input to Domestic Production;
- X^{OO} is an $n \times n$ matrix of Ordinary Imported Input to Ordinary Export;
- X^{OP} is an $n \times n$ matrix of Ordinary Imported Input to Processing Export, which is assumed to be 0 in our paper, meaning Ordinary Import will not be used on Processing Export Production;
- X^{PD} is an $n \times n$ matrix of Processing Imports used as intermediate Inputs to Domestic Production, which is assumed to be 0, meaning Processing Imports are solely used for Processing Exports and can not be used to produce domestic production or Ordinary Export;
- X^{PP} is an $n \times n$ matrix of Processing Imports used as Intermediate Input to Processing Export;
- F^{D} and F^{O} are each an $n \times n$ matrix of Final demand on domestic products and on Ordinary Imports respectively;
- V^{D}, V^{O}, and V^{P} are each an $1 \times n$ matrix of Direct value-added (VA) because of Domestic Production, Ordinary Export, and Processing Export respectively;
- L^{D}, L^{O}, L^{P} are each $1 \times n$ vector of labor input demanded for domestic production, ordinary export, and processing export;
- E^{O} and E^{P} are each an $n \times 1$ vector of ordinary export and processing export respectively.

<u>Direct Input Coefficient Matrix</u>

From the above IO table, we can obtain the direct input requirement matrix as shown in Figure 2:

$$A^{DD} = X^{DD} / X^{D} = [x_{ij}^{DD} / x_{j}^{D}],\ A^{DO} = X^{DO} / E^{O} = [x_{ij}^{DO} / e_{j}^{O}] \quad (1)$$
$$A^{DP} = X^{DP} / E^{P} = [x_{ij}^{DP} / e_{j}^{P}],\ A^{MD} = X^{MD} / X^{D} = [x_{ij}^{MD} / x_{j}^{D}]$$

$$A^{OO} = X^{OO}/E^{O} = [x_{ij}^{OO}/e_j^{O}],\ A^{PP} = X^{PP}/E^{P} = [x_{ij}^{PP}/e_j^{P}]$$
$$A_V^{D} = V^{D}/X^{D} = [v_j^{D}/x_j^{D}],\ A_V^{O} = V^{O}/E^{O} = [v_j^{O}/e_j^{O}]$$
$$A_V^{P} = V^{P}/E^{P} = [v_j^{P}/e_j^{P}],\ A_L^{D} = L^{D}/X^{D} = [l_j^{D}/x_j^{D}]$$
$$A_L^{O} = L^{O}/E^{O} = [l_j^{O}/e_j^{O}],\ A_L^{P} = L^{P}/E^{P} = [l_j^{P}/e_j^{P}]$$

where i is row, and j is column

Figure A2: Direct Input Requirement Coefficient Matrix

	Domestic Product	**Ordinary Export**	**Process Export**	**Sub-total**	**C+I+G**	**Export**	**Total Output**
Domestic Intermediate Input	A^{DD}	A^{DO}	A^{DP}				X^{D}
Ordinary Import Input	A^{MD}	A^{OO}	A^{OP} (=0)				
Process Import Input	A^{PD} (=0)		A^{PP}				
Value-Added	A_V^{D}	A_V^{O}	A_V^{P}				
Labor	A_L^{D}	A_L^{O}	A_L^{P}				
Total Input	X^{D}	E^{O}	E^{P}				

where:

- A^{DD}, A^{DO}, A^{DP} are the matrixes of direct input requirement of domestic products for one unit of domestic product, ordinary export, and processing export, respectively.
- A^{MD} and A^{OO} are the direct input requirement coefficient of ordinary import for one unit domestic production and ordinary exports;
- A^{PP} is the direct processing import requirement coefficient of producing one unit processing export;
- A_V^{D}, A_V^{O}, and A_V^{P} are each an $1 \times n$ vector of direct value added caused by one dollar of sector j's production in domestic products, ordinary export, or processing exports;
- A_L^{D}, A_L^{O}, A_L^{P} are correspondingly the direct labor demand generated by one dollar production of domestic products, ordinary export, or processing exports.

Structure of IO Table

Horizontally, we can have:

$$\begin{aligned} X^{D} &= X^{DD}\cdot i + X^{DO}\cdot i + X^{DP}\cdot i + F^{D} \\ &= A^{DD}X^{D} + A^{DO}E^{O} + A^{DP}E^{P} + F^{D} \end{aligned} \quad (2)$$

$$\begin{aligned} M^{O} &= X^{OD}\cdot i + X^{OO}\cdot i + F^{O} \\ &= A^{OD}X^{D} + A^{OO}E^{O} + F^{O} \end{aligned} \quad (3)$$

$$M^{P} = X^{PP} \cdot i = A^{PP} \cdot E^{P} \tag{4}$$

and vertically we have:

$$X^{D} = i \cdot X^{DD} + i \cdot X^{MD} + V^{D} = i \cdot A^{DD} X^{D} + i \cdot A^{MD} X^{D} + A_V^D X^{D} \tag{5}$$

$$E^{O} = i \cdot X^{DO} + i \cdot X^{OO} + V^{O} = i \cdot A^{DO} E^{O} + i \cdot A^{OO} E^{O} + A_V^O E^{O} \tag{6}$$

$$E^{P} = i \cdot X^{DP} + i \cdot X^{PP} + V^{P} = i \cdot A^{DP} E^{P} + i \cdot A^{PP} E^{P} + A_V^P E^{P} \tag{7}$$

Total Value Added (VA) Coefficient Matrix

To calculate the total economy value added, we must consider the linkages between sectors. When one unit domestic product is produced, it generates a first round of value added, which is the direct value added A_V^D. However, in order to produce this unit of domestic product, intermediate inputs must be used. The production of these intermediate inputs hence create the second round of value added, which is named indirect value added ($A_V^D \cdot A^{DD}$). This process of creating indirect value added can continue on and on, as intermediate inputs are needed to produce other intermediate inputs. Therefore, the total domestic VA induced by a unit domestic production is the sum of first round direct domestic VA and all the indirect domestic VA. Hence, we derive the total domestic VA coefficient (B_V^D) aroused by domestic production as:

$$\begin{aligned} B_V^D &= A_V^D + A_V^D \cdot A^{DD} + A_V^D \cdot A^{DD} \cdot A^{DD} + A_V^D \cdot \left(A^{DD}\right)^3 + \cdots \\ &= A_V^D \cdot \left(I - A^{DD}\right)^{-1} \end{aligned} \tag{8}$$

Similarly, producing one unit of ordinary or processing export products also requires domestic made intermediate goods, which in turn generates many rounds of VA from these domestic intermediate inputs. Therefore total domestic VA caused by $1 of export equals the direct VA of $1 export plus the total domestic VA of all the extra domestic intermediate inputs required for this $1 export production. We thus have:

$$\begin{aligned} B_V^P &= A_V^P + A_V^D \cdot A^{DP} + A_V^D \cdot A^{DD} \cdot A^{DP} + A_V^D \cdot A^{DD} \cdot A^{DD} \cdot A^{DP} + A_V^D \cdot \left(A^{DD}\right)^3 \cdot A^{DP} + \cdots \\ &= A_V^P + A_V^D \cdot \left(I - A^{DD}\right)^{-1} \cdot A^{DP} \\ &= A_V^P + B_V^D \cdot A^{DP} \end{aligned} \tag{9}$$

$$\begin{aligned} B_V^O &= A_V^O + A_V^D \cdot A^{DO} + A_V^D \cdot A^{DD} \cdot A^{DO} + A_V^D \cdot A^{DD} \cdot A^{DD} \cdot A^{DO} + A_V^D \cdot \left(A^{DD}\right)^3 \cdot A^{DO} + \cdots \\ &= A_V^O + A_V^D \cdot \left(I - A^{DD}\right)^{-1} \cdot A^{DO} \\ &= A_V^O + B_V^D \cdot A^{DO} \end{aligned} \tag{10}$$

where B_V^i represents the total VA coefficient vector for production i, for i= D (domestic), O (ordinary), and P(processing) respectively.

If we further consider the total employment effect caused by one unit production of domestic product, ordinary export, or processing export, we can easily get:

$$B_L^D = A_L^D \cdot \left(I - A^{DD}\right)^{-1} \tag{11}$$
$$B_L^O = A_L^O + B_L^D \cdot A^{DO} \tag{12}$$
$$B_L^P = A_L^P + B_L^D \cdot A^{DP} \tag{13}$$

Total Foreign Content Coefficient Matrix

Total import caused by Domestic Production equals direct import by it, plus the total import caused by the domestic intermediate inputs required by this Domestic Production, i.e:

$$\begin{aligned} B_M^D &= i \cdot A^{MD} + i \cdot A^{MD} \cdot A^{DO} + i \cdot A^{MD} \cdot A^{DD} + i \cdot A^{MD} \cdot A^{DD} \cdot A^{DD} + i \cdot A^{MD} \cdot \left(A^{DD}\right)^3 + \cdots \\ &= i \cdot A^{MD} \cdot \left(I - A^{DD}\right)^{-1} \end{aligned} \tag{14}$$

Similarly, we can also get the foreign content of exports:

$$\begin{aligned} B_M^O &= i \cdot A^{OO} + i \cdot A^{MD} \cdot A^{DO} + i \cdot A^{MD} \cdot A^{DD} \cdot A^{DO} + i \cdot A^{MD} \cdot A^{DD} \cdot A^{DD} \cdot A^{DO} \\ &\quad + i \cdot A^{MD} \cdot \left(A^{DD}\right)^3 \cdot A^{DO} + \cdots \\ &= i \cdot A^{OO} + i \cdot A^{MD} \cdot \left(I - A^{DD}\right)^{-1} \cdot A^{DO} \end{aligned} \tag{15}$$

$$\begin{aligned} B_M^P &= i \cdot A^{PP} + i \cdot A^{MD} \cdot A^{DP} + i \cdot A^{MD} \cdot A^{DD} \cdot A^{DP} + i \cdot A^{MD} \cdot A^{DD} \cdot A^{DD} \cdot A^{DP} \\ &\quad + i \cdot A^{MD} \cdot \left(A^{DD}\right)^3 \cdot A^{DP} + \cdots = i \cdot A^{PP} + i \cdot A^{MD} \cdot \left(I - A^{DD}\right)^{-1} \cdot A^{DP} \end{aligned} \tag{16}$$

This is conceptually similar to the vertical specialization (VS) as in Hummels, Ishii and Yi (2001) and Dean, Fung and Wang (2007).

And we can prove that

$$B_V^O + B_M^O = i \tag{17}$$
$$B_V^P + B_M^P = i \tag{18}$$
$$B_V^D + B_M^D = i \tag{19}$$

Total outputs can be decomposed into domestic value-added embodied in production and all the imports embodied in the production.

Proof:

$$X^D = i \cdot X^{DD} + i \cdot X^{MD} + V^D = i \cdot A^{DD} X^D + i \cdot A^{MD} X^D + A_V^D X^D$$

$$\Rightarrow \; i = i \cdot A^{DD} + i \cdot A^{MD} + A_V^D$$

Similarly:

$$i = i \cdot A^{DO} + i \cdot A^{OO} + A_V^O$$

$$i = i \cdot A^{DP} + i \cdot A^{PP} + A_V^P$$

$$\begin{aligned} B_V^O + B_M^O &= A_V^O + A_V^D \left(I - A^{DD}\right)^{-1} A^{DO} + i \cdot A^{OO} + i \cdot A^{MD} \left(I - A^{DD}\right)^{-1} A^{DO} \\ &= i \cdot \left(I - A^{DO}\right) + (A_V^D + i \cdot A^{MD})\left(I - A^{DD}\right)^{-1} A^{DO} \\ &= i \cdot (I - A^{DO}) + i \cdot (I - A^{DD})(I - A^{DD})^{-1} A^{DO} \\ &= i \end{aligned}$$

Total Value Added obtained from Chen et. al 2002 Trade Extended IO Table

Using an extended IO table from Chen *et al* (2004), we estimate the total value-added B matrixes using equations (8), (9), and (10). The results are reported in Table A1.

Table A1: Total Value-Added

IO Industries	BVD	BVO	BVP	BMD	BMO	BMP
1.Agriculture	0.969	0.896	0.625	0.031	0.104	0.375
2.Coal mining and processing	0.945	0.811	0	0.055	0.189	0
3.Crude petroleum and natural gas products	0.957	0.814	0.762	0.043	0.186	0.238
4.Metal ore mining	0.908	0.623	0.370	0.092	0.377	0.630
5.Non-ferrous mineral mining	0.944	0.772	0.443	0.056	0.228	0.557
6.Manufacture of food products and tobacco processing	0.965	0.909	0.474	0.035	0.091	0.526
7.Textile goods	0.956	0.899	0.256	0.044	0.101	0.744
8.Wearing apparel, leather, furs, down and related products	0.958	0.909	0.171	0.042	0.091	0.829
9.Sawmills and furniture	0.915	0.674	0.225	0.085	0.326	0.775
10.Paper and products, printing and record medium reproduction	0.928	0.760	0.335	0.072	0.240	0.665
11.Petroleum processing and coking	0.865	0.268	0.343	0.135	0.732	0.657
12.Chemicals	0.923	0.664	0.345	0.077	0.336	0.655
13.Nonmetal mineral products	0.926	0.737	0.352	0.074	0.263	0.648
14.Metals smelting and pressing	0.901	0.635	0.404	0.099	0.365	0.596
15.Metal products	0.901	0.655	0.404	0.099	0.345	0.596
16.Machinery and equipment	0.890	0.591	0.347	0.110	0.409	0.653
17.Transport equipment	0.895	0.647	0.311	0.105	0.353	0.689
18.Electric equipment and machinery	0.899	0.680	0.174	0.101	0.320	0.826
19.Electronic and telecommunication equipment	0.855	0.702	0.184	0.145	0.298	0.816
20.Instruments, meters, cultural and office machinery	0.857	0.550	0.191	0.143	0.450	0.809
21.Maintenance and repair of machinery and equipment	0.907	0	0	0.093	0	0

22.Other manufacturing products	0.929	0.767	0.385	0.071	0.233	0.615
23.Scrap and waste	1	0	0	0	0	0
24.Electricity, steam and hot water production and supply	0.930	0	0	0.070	0	0
25.Gas production and supply	0.921	0	0	0.079	0	0
26.Water production and supply	0.954	0	0	0.046	0	0
27.Construction	0.916	0.723	0	0.084	0.277	0
28.Transport and warehousing	0.944	0.806	0.717	0.056	0.194	0.283
29.Post and telecommunication	0.941	0.850	0.388	0.059	0.150	0.612
30.Wholesale and retail trade	0.949	0.835	0.672	0.051	0.165	0.328
31.Eating and drinking places	0.967	0.921	0.274	0.033	0.079	0.726
32.Passenger transport	0.928	0.766	0.633	0.072	0.234	0.367
33.Finance and insurance	0.974	0.907	0.875	0.026	0.093	0.125
34.Real estate	0.968	0	0	0.032	0	0
35.Social services	0.929	0.769	0.579	0.071	0.231	0.421
36.Health services, sports and social welfare	0.927	0.741	0	0.073	0.259	0
37.Education, culture and arts, radio, film and television	0.957	0.871	0.755	0.043	0.129	0.245
38.Scientific research	0.893	0	0	0.107	0	0
39.General technical services	0.951	0.824	0.622	0.049	0.176	0.378
40.Public administration and other sectors	0.944	0.807	0	0.056	0.193	0

Other Data

In Table A2 we show the allocation of value-added to labor and capital, along with the share of value-added within the sum of value-added plus imports used for each type of production: domestic production, ordinary exports, and processing exports. For each type of production, about one-half of value-added goes towards compensating labor, with the remainder divided between capital income (one-third) and taxes on production (one-sixth). The amount of value-added differs a great deal across type of production, however: it is 94% of the sum of value-added plus imports used in domestic production, 62% for ordinary exports, and 20% for processing exports.

We have also confirmed that the employment levels in Table 1 are consistent with the IO table itself, as described in Table A3. In the first column we list the economy-wide compensation to labor from the various years of the IO tables, and in the next columns the real agricultural and manufacturing wages (in US$, 2000). China employs one-half of its workers in agriculture and one-half in manufacturing, so we take the simple average of these two wages to obtain the average wage, which is $842 in 2000, for example. Dividing the labor compensation from the IO table by the average wage, we obtain employment of 716.5 million persons in 2000, which is very close to the 720.5 million persons reported in Table 1.

For years before and after 2000, however, there is an inconsistency between the actual employment figures reported by the China Statistical Yearbook, in the last column of Table 4, and the implied employment obtained by dividing total compensation from the IO tables by average wages from the China Statistical Yearbook, in the second-last column. Implied employment even falls over 1997–2002, which does not seem believable. The problem appears to be an inconsistency between the wage series we use (from the China Statistical Yearbook) and the wages that are implicit in the IO tables, at least in 1997 and 2002.[13] It is essential that the implied employment from the IO table in each year equal actual employment in the economy. To achieve this, we inflate the 1997 wages from the China Statistical Yearbook by 8%, and deflate the 2002 wages by 4%, obtaining the revised wages reported in the bottom of Table 4. Those adjusted wages lead to implied employment from the IO tables that is roughly equal to that reported by the China Statistical Yearbook. We will continue to use this simple adjustment to 1997 and 2002 wages in all our calculations.

[13] For 2000, when we have the most complete IO table available, it lists both labor compensation and employment at the end of the year. So the wages being used in the Io table can be computed, and they are highly consistent with both the wages and actual employment figures used in Table 4 for 2000. For 1997 and 2002, however, the IO table is less complete, and in particular, does not list employment so that implied wages cannot be computed.

Table A2:
Division of Value-added, 2000 and 2002

	From 2000 Input-output Table				2002
	Domestic Production	**Ordinary Exports**	**Processing Exports**	**Combined Production**	**Combined Production**
Value-added/(Value-added + imports)	0.94	0.62	0.20	0.36	n.a.
Compensation of employees/VA	0.54	0.50	0.45	0.54	0.48
Net taxes on production/Value-added	0.14	0.16	0.18	0.15	0.14
Gross Capital Income/Value-added	0.31	0.34	0.37	0.31	0.37

Notes:
Figures reported here are only for the direct use of labor and imports in each type of production, and do not take into account the indirect usage through domestic intermediate inputs.

Table A3: Wages and Employment

Year	**Compensation from IO table** (Million US$, 2000)	**Agriculture Sector Wage** (US$, 2000)	**Manufacturing Sector Wage** (US$, 2000)	**Real Wage[1] (Average)** (US$, 2000)	**Implied Employment[2]** (Million persons)	**Actual Employment[3]** (Million persons)
1995	334,000	476.6	699.4	520	641.9	680.7
1997	501,101	557.9	767.8	618	811.0	698.2
2000	603,003	626.2	1057.0	842	716.5	720.9
2002	712,224	740.0	1272.4	1,006	708.0	737.4
2005	**n.a.**	894.1	1695.5	1,468		758.3
Using revised wage data:[4]						
1997	501,101	602.5	829.2	715.9	700.0	698.2
2002	712,224	710.4	1221.5	966.0	737.3	737.4

Notes:
1. Average wage is the simple average of manufacturing and agriculture sectors. Source for wage data is the China Statistical Yearbook, 2006.
2. Implied employment = real compensation from IO table / real average wage.
3. Actual employment data come from China Statistical Yearbook of each year.
4. The revised wage data multiplies 1997 wages by 1.08, and multiplies 2002 wages by 0.96 , so that the implied employment is roughly equal to actual employment.

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Table 1:
China's Employment and GDP

Year	Employment	Urban	Rural	GDP	C+G	Investment	X - M
	(Millions of persons)			(billions of US$, 2000)			
1997	698	208	490	1,057	623	388	46
2000	721	232	489	1,278	796	451	31
2002	737	248	490	1,557	928	590	40
2005	758	273	485	2,416	1,254	1030	132
	Growth Rate (million per year)			**Growth Rate (percent per year)**			
1997-2002	7.8	8.0	-0.2	9.5	9.8	10.4	-2.6
2000-2005	7.5	8.4	-0.9	17.8	11.5	25.7	65.5

Source:
China Statistical Yearbook, various years.

Table 2:
China's Ordinary and Processing Trade

Year	Ordinary Exports	Processing Exports	Total Exports	Ordinary Imports	Processing Imports	Total Imports	Trade Balance
1997	89	107	196	77	75	152	44
2000	112	138	249	133	93	225	24
2002	139	172	312	166	117	283	29
2005	305	367	672	340	242	582	90
			Growth Rate (percent per year)				
1997-2002	11.2	12.2	11.8	22.9	11.1	17.1	-6.7
2000-2005	34.6	33.4	33.9	31.4	32.2	31.7	54.4

Source:
China customs trade data.

Table 3:
Static Employment Coefficients

Source	**Implied Employment Increase per $1,000 of Exports or Domestic Demand (person-years)**		
	Ordinary Exports	Processing Exports	Domestic Demand
Lau et al from 1995 IO[1]	0.703	0.057	n.a.
Our estimates 2000 IO[2]	0.444	0.130	0.525
Lau et al from 2002 IO[3]	0.363	0.111	0.440

Sources:
1. Lau et. al (2004, Tables 7, 8).
2. Our estimates for 2000 IO table, as described in the Appendix.
3. Lau et. al (2006a, Table 4) for ordinary and processing exports, with domestic demand coefficient computed as explained in the text.

Table 4:
Implied Chinese Employment from Domestic Demand and Exports
(Using *static* employment coefficients)

Source	**Period**	**Growth in demand (billion US$, 2000)**		**Implied Employment Increase**[1] **(million persons)**			**Actual Employment Increase**[2]
		Domestic Demand	Exports	Domestic Demand	Exports	Total	(million persons)
Our estimates from 2000 IO	1997-2002	411.5	115.5	216.0	30.8	246.8	39.2
Lau *et al* from 2002 IO	2000-2005	1,037	422.7	456.2	95.6	551.7	37.4

Notes:
1. Uses the static employment coefficients from Table 3, and multiplies these by the real growth in domestic demand, ordinary exports and processing exports.
2. Actual employment increase comes from the China Statistical Yearbook of each year (see Table 1).

Table 5:
Implied Increase in Chinese Employment from Exports
(Using IO table in 2000, and industry wages in 2000)

	Period	**Implied Employment Increase (Million persons)**			**Percentage Reduction from Prediction 1**	
Our estimates using 2000 IO table		Ordinary Export	Processing Export	Total Export	Ordinary Export	Processing Export
Prediction 1, from Table 4	1997-2002	22.3	8.5	30.7		
Using average exports, and average wages in 2000	2000-2005	85.7	29.7	115.4		
Prediction 2a	1997-2002	18.6	4.1	22.7	17%	52%
Using industry exports, and industry wages in 2000	2000-2005	69.4	16.7	86.1	19%	44%
Prediction 2b,	1997-2002	17.0	3.5	20.6	24%	59%
Using industry-province exports, and industry-province wages in 2000	2000-2005	63.2	14.4	77.5	26%	52%
Prediction 2c	1997-2002	17.2	3.9	21.0	23%	54%
Using firm-ownership exports, and firm-ownership wages in 2000	2000-2005	59.1	15.1	74.1	31%	49%

Source: Authors calculations as explained in the text.

Table 6:
Implied Chinese Employment from Exports
(Using IO table in 2000, and industry wages by year)

	Period	**Implied Employment Increase (Million persons)**			**Percentage Reduction from Prediction 1**	
Estimates using 2000 IO table		Ordinary Export	Processing Export	Total Export	Ordinary Export	Processing Export
Prediction 2a, Table 5	1997-2002	17.2	3.9	21.0	23%	54%
Using firm-ownership exports, and firm-ownership wages in 2000	2000-2005	59.1	15.1	74.1	31%	49%
Prediction 3a	1997-2002	4.7	-1.4	3.3	79%	117%
Using industry exports, and industry wages by year	2000-2005	37.9	7.8	45.7	56%	74%
Prediction 3b,	1997-2002	5.7	0.1	5.8	74%	99%
Using industry-province exports, and ind.-province wages by year	2000-2005	36.5	7.8	44.4	57%	74%
Prediction 3c	1997-2002	10.3	1.7	12.0	54%	80%
Using firm-ownership exports, and firm-ownership wages by year	2000-2005	38.3	8.1	46.4	55%	73%

Source: Authors calculations as explained in the text.

Table 7:
Implied Chinese Employment from Domestic Demand and Exports, 1997–2002
(Using IO table in 2000 and industry wages, 2000 or by year)

	Growth in Demand (billion US$, 2000)		**Implied Employment Increase (Million persons)**		**Percentage Reduction from Prediction 1**	
Our estimates using 2000 IO table	Domestic Demand	Total Export	Domestic Demand	Total Export	Domestic Demand	Total Export
A. Traded Goods						
Prediction 1, Using average demand, average wages in 2000	24.1	115.5	12.7	30.8		
Prediction 2 Using industry demand, industry wages in 2000	24.1	115.5	-9.9	22.7	-178%	26.3%
Prediction 3 Using industry demand, industry wages by year	24.1	115.5	-49.8	3.3	-492%	89.3%
B. Non-traded Goods						
Prediction 1 Using average demand, average wages in 2000	387.4	0	203.3	0		
Prediction 2 Using industry demand, industry wages in 2000	387.4	0	165.7	0	18.5%	n.a.
Prediction 3 Using industry demand, industry wages by year	387.4	0	110.8	0	45.5%	n.a.
C. All Goods						
Prediction 1 Using average demand, average wages in 2000	411.5	115.5	216.0	30.8		
Prediction 2 Using industry demand, industry wages in 2000	411.5	115.5	155.8	22.7	27.9%	26.3%
Prediction 3 Using industry demand, industry wages by year	411.5	115.5	61.0	3.3	72%	89.3%

Source: Authors calculations as explained in the text.

Table 8:
***Revised* Employment Coefficients**

Source	Implied Employment Increase per $1,000 of Exports or Domestic Demand (person-years)		
	Ordinary Exports	Processing Exports	Domestic Demand
Our estimates from 2000 IO[1]	0.444	0.130	0.525
Revised estimates for 2000 IO[2]	0.444×0.45=0.20	0.130×0.25=0.03	0.525×0.25=0.13
Lau et al from 2002 IO[3]	0.363	0.111	0.440
Revised estimates for 2000 IO[4]	0.363×0.45=0.16	0.111×0.25=0.03	0.440×0.25=0.11

Sources:
1. From Table 3.
2. Revised as explained in the text and shown in the table.
3. Lau et. al (2006a, Table 4), from Table 3.
2. Revised as explained in the text and shown in the table.

Table 9:
Implied Chinese Employment from Domestic Demand and Exports
(Using *revised* employment coefficients)

Source	Period	Growth in demand (billion US$, 2000)		Implied Employment Increase[1] (million persons)			Actual Employment Increase[2]
		Domestic Demand	Exports	Domestic Demand	Exports	Total	(million persons)
Our estimates from 2000 IO	1997-2002	411.5	115.5	54.0	12.2	66.2	39.2
Lau *et al* from 2002 IO	2000-2005	1,037	422.7	114.0	37.9	152.0	37.4

Notes:
1. Uses the *revised* employment coefficients from Table 8, and multiplies these by the real growth in domestic demand, ordinary exports and processing exports.
2. Actual employment increase comes from the China Statistical Yearbook of each year (see Table 1).

Figure 1: Growth in Total Exports, 2000-2005, and Industry Wages, 2000

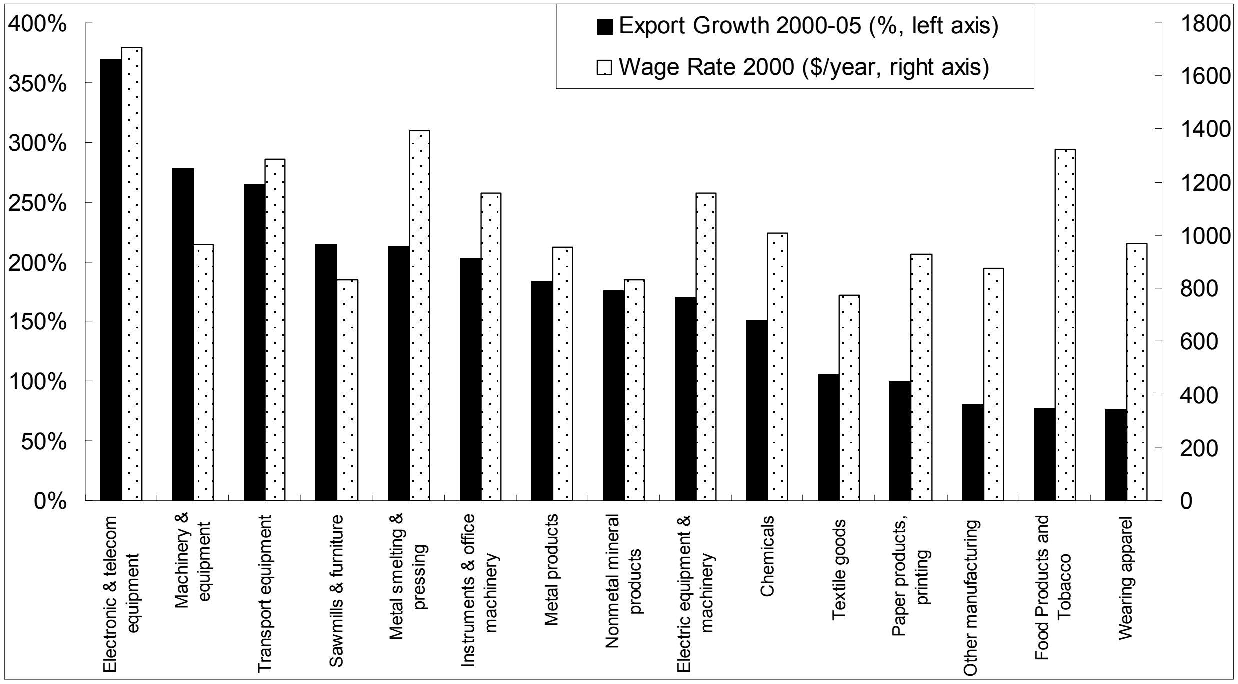

Figure 2: Growth in Ordinary Exports, 2000-2005, and Industry Wages, 2000

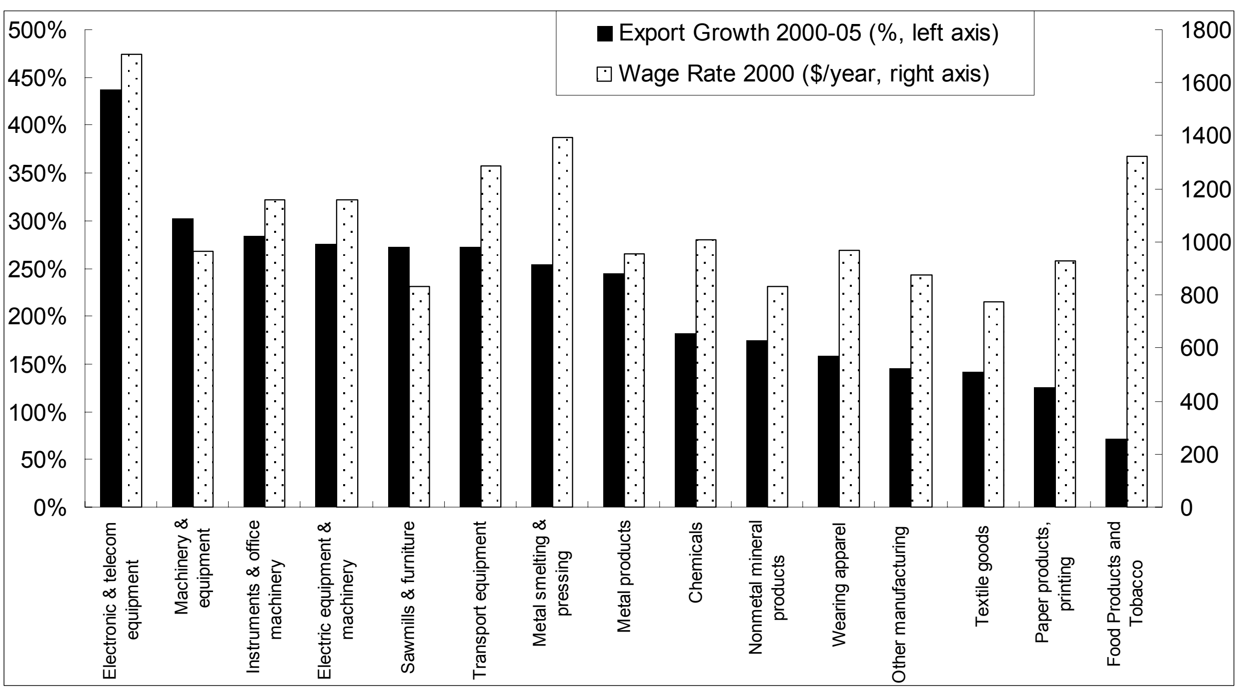

Figure 3: Growth in Domestic Demand, 1997-2002, and Industry Wages, 2000