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Abstract:

China runs surpluses of \$400 billion-\$500 billion in processing trade. In value-added terms, East Asia as a whole runs surpluses in processing trade with the West. This generates appreciation pressures on exchange rates throughout the region. Using data up to 2012, this paper reports that a concerted appreciation would rebalance trade. An appreciation in China accompanied by depreciations in other surplus economies such as Taiwan and South Korea would not reduce China's surplus in processing trade but would increase its deficit in ordinary (labor-intensive) trade. To rebalance, East Asia as a whole needs to give market forces greater play in determining exchange rates, and international organizations need to conduct surveillance on regional production networks.

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1. Introduction

Since 2005 China has run large surpluses in a customs regime called processing trade. Processed exports are final goods such as computers produced using parts and components (imports for processing) that are imported duty free. In 2012 China's surplus in processing trade was recorded at $400 billion. It was actually much larger though because many of the goods included as imports for processing were not imported. Instead they were produced in China and round-tripped to Hong Kong and back in order to exploit favorable tax provisions (see Xing, 2012).

China's surpluses in processing trade are primarily with Western countries, and it runs deficits with South Korea, Taiwan, and other East Asian economies that provide the lion's share of the imported inputs. Since much of the value added of processed exports such as smartphones and tablet PCs comes from parts and components imported from East Asian countries, the region as a whole and not just China runs surpluses with Western countries. Yoshitomi (2007) noted that these surpluses between East Asia and the West put pressure on exchange rates throughout the supply chain to appreciate. This is all the more true since economies such as Malaysia, Singapore, South Korea, and Taiwan are running global current account surpluses of between 4 and 19% of GDP.[1] Yoshitomi observed that a concerted appreciation in the region would reduce China's processed exports much more than an appreciation of the Chinese renminbi alone.

Bayoumi, Saito, and Turenen (2013) and Unteroberdoerster, Mohommad, and Vichyanond (2011) similarly emphasized the need to take account of the value added of imported inputs when calculating price competitiveness. Bayoumi *et al.* modified the traditional

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[1] Malaysia ran a current account surplus (CAS) of 7.9% of GDP in 2012 and was forecasted as of December 2013 to run a CAS of 7.7% of GDP in 2013. The comparable numbers are 18.6% and 18.4% for Singapore; 3.8% and 3.8% for South Korea; and 10.5% and 10.6% for Taiwan. These data come from www.tradingeconomics .com.

International Monetary Fund (IMF) real effective exchange rate (REER) to calculate an REER in goods. Their measure takes account of the fact that goods are not only produced using domestic factors of production but also using foreign factors. Unteroberdoerster *et al.* calculated an integrated effective exchange rate (IEER) for China by including both the renminbi exchange rate and exchange rates in supply chain countries relative to the countries importing the final assembled goods. They found that after 2008 the Chinese IEER has appreciated less than the Chinese REER because imported inputs have attenuated the link between Chinese factor prices and Chinese goods prices.

Ahmed (2009) and Thorbecke and Smith (2010) investigated the effects of exchange rates throughout the supply chain on China's processed exports. Ahmed employed an autoregressive distributed lag model and quarterly data over the 1996Q1 – 2009Q2 period. He reported that a 10% appreciation of the renminbi relative to non-East Asian countries would reduce China's processed exports by 17% and a 10% appreciation in other East Asian countries would reduce China's processed exports by 15%. This implies that a 10% appreciation throughout East Asia would reduce China's processed exports by 32%. Thorbecke and Smith (2010) constructed an integrated real exchange rate for China's processed exports. Their index measures how exchange rates affect the relative foreign currency cost not just of China's value-added in processing trade but of China's entire output of processed exports. Employing this exchange rate and DOLS estimation on a panel data set including China's bilateral trade with 31 countries over the 1994-2005 period, they reported that a 10% appreciation across the supply chain would reduce processed exports by 10%.

Although Thorbecke and Smith's data set extended to 2005, the DOLS estimation employed one lead of the variables. Thus the actual sample period for the estimation only

extended to 2004. Since China's surplus in processing trade averaged $45 billion for the eight years before 2004 and $277 billion for the 8 years after, it is desirable to extend the sample period beyond 2004.

It is also desirable to investigate how an appreciation throughout the supply chain would affect China's imports for processing. This has not been investigated before in any published work.

This paper uses data up to 2012 to examine the effect of an appreciation across the supply chain on processed exports and on imports for processing. The results indicate that a 10% appreciation throughout the supply chain would reduce processed exports by more than 10% and increase imports for processing by about 1%. Such an appreciation would thus contribute to rebalancing China's processing trade.

The next section examines China's evolving trade patterns. Section 3 presents the data and methodology for estimating export elasticities for China's two main customs regimes and Section 4 contains the corresponding results. Section 5 investigates elasticities for imports for processing. Section 6 concludes.

2. China's Evolving Trade Patterns

Table 1a presents China Customs Statistics (CCS) data for China's ordinary trade and Table 1b for China's processing trade. Ordinary trade is China's other major customs regime. Ordinary imports can either flow into the domestic market or be used to produce goods for re-export. Ordinary exports are produced using domestic factors or using ordinary imports. China's ordinary trade surplus peaked at $110 billion in 2007 and fell to a deficit of $34 billion

in 2012. China's processing trade surplus equaled $249 billion in 2007 and rose to $382 billion in 2012.

The top panel of Table 1a shows that ordinary imports from South Korea, Taiwan, and Japan have increased rapidly. The middle panel shows that ordinary exports to ASEAN have also increased rapidly. Thus China runs trade deficits with advanced East Asia and small surpluses with ASEAN in ordinary trade. The surplus with ASEAN reflects the fact, noted by Gaulier, Lemoine, and Unal (2011), that Chinese ordinary exports are less sophisticated, lower priced goods that are especially likely to penetrate markets in the South. Gaulier *et al.* and others have also noted that the large increase in ordinary imports from Europe that is evident in Table 1a reflects an increase in automobiles and sophisticated capital goods from Germany.

The bottom panel shows that China's deficit with Australia and Brazil and China's deficit in oil have increased a lot. China's deficit with Australia and Brazil is largely due to imports of iron ore, coal, and other primary inputs. It increased by $55 billion between 2007 and 2012. China's deficit in oil has increased from $76 billion to $171 billion over this period.

The top panel of Table 1b indicates that $275 billion in parts and components for processing come from East Asia. Korea has become the leading source of imports for processing, shipping almost $85 billion to China in 2012. This surge reflects the growth of the Korean electronics industry after 2009.   Taiwan is the second leading provider of imports for processing, exporting $69 billion to China in 2012. Japan is the third leading supplier, sending China $63 billion of these goods. Imports for processing from Europe and the U.S. were both under $20 billion in 2012.

The middle panel of Table 1b indicates that the largest recipients of processed exports in 2012 were Hong Kong ($208 billion), the U.S. ($185 billion), and Europe ($124 billion). South Korea and Taiwan together only received $62 billion of processed exports.

Because of these trading patterns, South Korea and Taiwan together ran surpluses with China of more than $90 billion in processing trade. Hong Kong, the U.S., and Europe then each ran deficits of between $100 billion and $200 billion in processing trade. Because of entrepôt trade, Hong Kong's deficits largely reflect deficits with Western nations.

It is notable in Table 1b that, while China's processed exports increased by more than $250 billion between 2007 and 2012, China's imports for processing only increased by $110 billion. Imports for processing from Taiwan, ASEAN, Japan, the U.S. and Europe did not increase over this period. Thus more of the value added of processed exports is now produced in China.

This increase in value added reflects several factors. First, the Chinese government has sought to direct Chinese industries into higher value-added activities (Republic of China, 2012). Second, China's high levels of capital formation in recent years have allowed more intermediate goods to be produced domestically (Knight and Wang, 2011). Third, China has developed industrial clusters and deeper supply chains in the processing sector (Kuijs, 2011).

Xing (2012) reported that many of China's imports for processing are actually produced in China. They are then round-tripped out of China and back in in order to take advantage of favorable tax provisions. Xing reported that more than 15% of China's imports for processing in 2008 came from China. In an economic sense, goods produced in China are not imports into China.

The CEPII-CHELEM (CECH) database can be used to correct imports for processing into China that come from China itself. The database harmonizes export and import data across countries, and corrects for discrepancies such as including imports into China of goods produced in China.

Figure 1a-c shows data on China's exports, imports, and trade balance according to CCS and CECH data. Figure 1a shows that exports in the two databases track each other closely. Figure 1b shows that imports are much higher according to the CCS data than according to the CECH data. Part of this reflects the fact that the CHELEM database corrects for "imports" into China of goods produced in China. Figure 1c then shows that China's trade surplus is much higher using the CHELEM data than using the Customs Statistics data.

In the CCS data, the global surplus was measured at $170 billion in 2006, $285 billion in 2008, and $155 billion in 2011. According to the CHELEM data, China's global surplus rose from $370 billion in 2006 to $550 billion in 2008 and equaled $440 billion in 2011. Since this difference reflects imports into China that were produced in China itself, it implies that China's trade surplus in processing trade is much larger than the $382 billion recorded in Table 1. Understanding trade elasticities for China thus remains of particular moment.

3. Data and Methodology for Estimating Export Elasticities

The imperfect substitutes model of Goldstein and Khan (1985) is often used to estimate export elasticities. In this framework export functions can be written as:

$$ex_t = \alpha_{10} + \alpha_{11}\ rer_t + \alpha_{12}\ rgdp_t + \varepsilon_t, \qquad\qquad (1)$$

where ex_t represents the log of real exports, rer_t represents the log of the exporting country's real exchange rate, and $rgdp$ represents the log of foreign real income.

For exports, data on ordinary and processed exports from China to leading importing countries over the 1992-2012 period are used. Countries that imported small amounts over part of the sample period are excluded because they can have very large percentage changes from year to year due to idiosyncratic factors rather than the macroeconomic variables in equation (1). In all, China's exports to 24 countries are used.[2] The data are obtained from China Customs Statistics. They are deflated using 1) the Hong Kong re-export unit value index for exports to the U.S., 2) an export price index for Chinese exports obtained from the World Bank, and 3) the U.S. producer price index for finished goods.[3] All of these have been used in previous work to deflate Chinese exports.

The framework in equation (1) is appropriate for China's ordinary exports, since most of the value added of these goods comes from Chinese factors of production (see Gaulier, Lemoine and Unal-Kesenci, 2005). To explain China's bilateral ordinary exports to major trading partner j, the bilateral real exchange rates between China and importing country j ($rer_{Chin,j,t}$) is thus employed.

Two measures of bilateral real exchange rate are used. One is the CEPII-CHELEM measure. As Bénassy-Quéré, Fontagné, and Lahrèche-Révil (2001) discussed, this real exchange rate variable measures the units of consumer goods in the exporting country needed to buy a unit

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[2] These countries are Australia, Austria, Belgium & Luxembourg, Brazil, Canada, Denmark, Finland, France, Germany, Italy, Japan, South Korea, Malaysia, Netherlands, New Zealand, Philippines, Russian Federation, Singapore, Spain, Sweden, Taiwan, Thailand, United Kingdom, United States.

[3] The World Bank data are available from 1993 to 2011. China Customs Statistics provides an export price deflator for recent years. The growth rate of this series was used to extrapolate the World Bank series to 2012. The growth rate of the Hong Kong re-export price index from 1992-1993 was used to infer a value of the World Bank series for 1992.

of consumer goods in country j. An increase in the exchange rate represents an appreciation of the exporter's currency. The second is the bilateral nominal exchange rate between China and country j, deflated using IMF consumer price indices. The nominal exchange rate data come from the CEPII-CHELEM database and the consumer price data come from the IMF World Economic Outlook database.[4]

For processed exports, the bilateral exchange rate between China and the importing country measures how exchange rates affect the relative foreign currency cost of China's value-added in processing trade. However, much of the value added of processing trade comes from parts and components produced in supply chain countries. An integrated exchange rate across the supply chain would make it possible to measure how exchange rates affect the relative foreign currency cost not just of China's value-added in processing trade but of China's entire output of processed exports.

To compute an integrated exchange rate, China's value-added in processed exports is calculated using the method of Tong and Zheng (2008). They measure this as the difference between the value of China's processed exports (VPE_t) and the value of imports for processing from all supply chain countries ($\sum_i VIP_{i,t}$):

$$VA_{Chin,t} = (VPE_t - \sum_i VIP_{i,t})/VPE_t = 1 - \sum_i VIP_{i,t}/VPE_t, \qquad (2)$$

where $VA_{Chin,t}$ equals China's value-added in processing trade. Each year data from China Customs Statistics on the total value of processed exports and the total value of imports for processing are used to calculate China's value-added.

To calculate the share of total costs from other supply chain countries this paper focuses on the nine major providers of imports for processing (Germany, Japan, Malaysia, the

Philippines, Singapore, South Korea, Taiwan, Thailand, and the United States). According to data reported in Xing (2012) and the data in Table 1, more than 80% of imports for processing other than those produced in China and round-tripped out of China and back in come from these nine economies.

For each of these nine countries a weight ($w_{i,t}$) can be determined by dividing the value of imports for processing coming into China from the country by the value of imports for processing coming into China from all nine countries together. The weights can then be used to find a weighted exchange rate ($wrer_{j,t}$) for a country j that purchases China's processed exports by calculating the inner product of the weights and the bilateral real exchange rates between the countries supplying imports for processing and country j:

$$wrer_{j,t} = \sum_i w_{i,t} * rer_{i,j,t} \, , \tag{3}$$

where $rer_{i,j,t}$ is the bilateral real exchange rate between supply chain country i and country j purchasing the final processed exports. $wrer_{j,t}$ can then be combined with the bilateral exchange rate between China and country j weighted by China's value-added in processing trade. This makes it possible to calculate a single integrated exchange rate ($irer_{j,t}$) measuring how exchange rate changes affect the entire cost of China's exports of processed goods to country j:

$$irer_{j,t} = VA_{Chin,t} * rer_{Chin,j,t} + (1 - VA_{Chin,t}) * wrer_{j,t} \, . \tag{4}$$

To calculate *irer* in this way it is necessary to use exchange rates that are comparable cross-sectionally. The CEPII-CHELEM exchange rates are thus used. The value-added ($VA_{Chin,t}$), the weights ($w_{i,t}$), and the exchange rates ($wrer_{j,t}$, $irer_{j,t}$) in equations (2) through (4)

are recalculated for each year. Data on real GDP in the importing countries are also obtained from the CEPII-CHELEM database.

The stock of foreign direct investment (FDI), a WTO dummy variable that takes on a value of 1 after China joined the WTO in 2001, and a dummy variable for the great trade collapse of 2009 are also included as independent variables. Including FDI may be important since 84% of processed exports are produced by foreign-invested enterprises (Feenstra and Wei, 2010). In addition, FDI into emerging Asia has been closely related with firms' ability to obtain technology transfer and become more competitive (Kimura and Lim, 2010). Data on the stock of FDI are obtained from the United Nations Conference on Trade and Development (UNCTAD) website.[5] Including the dummy variables may be important because many have observed that China's WTO accession stimulated China's exports and because there was a large and transitory fall in China's exports in 2009 (see Table 1).

Results from a battery of panel unit root tests indicate that in most cases the series are integrated of order one. Results from Kao residual cointegration tests indicate that there exist cointegrating relationships between Chinese exports, the exchange rate variable, income in the rest of the world, and the stock of Chinese FDI.

Panel DOLS, a technique for estimating cointegrating relationships, is thus employed. The estimated models take the form:

$$ex_{i,j,t} = \beta_0 + \beta_1 rer_{j,t} + \beta_2 y_{j,t}^* + \beta_3 FDI_t + \sum_{k=-p}^{p} \alpha_{1,k} \Delta rer_{j,t-k} + \sum_{k=-p}^{p} \alpha_{2,k} \Delta y_{j,t-k}^* \tag{5}$$

$$+ \sum_{k=-p}^{p} \alpha_{3,k} \Delta FDI_{t-k} + u_{i,j,t},$$

$$t = 1, \cdots, T; \qquad j = 1, \cdots, N.$$

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[5] The website is www.unctad.org. The data are measured in U.S. dollars. Following Eichengreen and Tong (2007), they were deflated using the U.S. consumer price index.

Here $ex_{i,j,t}$ represents real exports of customs regime i (either processed or ordinary) from China to country j, $rer_{j,t}$ represents either the integrated exchange rate between supply chain countries and importing country j (for processed exports) or the bilateral real exchange rate between China and importing country j (for ordinary exports), and $y_{j,t}^{*}$ represents real income in country j. Country j fixed effects are always included and linear trends are sometimes included. The panel DOLS model is estimated using heteroskedasticity-consistent standard errors.

Santos Silva and Tenreyro (2006) have shown that log-linear models can lead to biased estimates when there is heteroskedasticity in the data-generating process. They presented simulation evidence indicating that in a variety of cases Poisson pseudo-maximum-likelihood (PPML) estimators perform better both in terms of bias and efficiency. Thus the DOLS results from estimating equation (5) are compared with findings obtained from PPML estimation.

4. Results for Export Elasticities

Table 2 presents the results using processed exports as the dependent variable and the integrated real exchange rate as the right-hand side variable, Table 3 presents the results using ordinary imports as the dependent variable and the CPI-deflated real exchange rate as a right-hand side variable, and Table 4 presents results using ordinary exports as the dependent variable and the CEPII real exchange rate as a right-hand side variable. In Tables 2-4, the top panel reports results using the Poisson pseudo maximum likelihood estimator and the bottom panel reports panel DOLS results. Columns (1) and (2) report findings with exports deflated using the Hong Kong re-export unit value index, Columns (3) and (4) with exports deflated using the World Bank export price deflator, and columns (5) and (6) with exports deflated using the U.S.

producer price index for finished goods. Columns (1), (3), and (5) report results without a trend term, and columns (2), (4) and (6) report results with a linear trend included.

In both panels of Table 2 the first row reports the elasticities for the integrated exchange rate. These are always correctly signed and statistically significant at the 1% level. They range in value from -0.99 to -1.46. When a trend term is included the elasticities vary from -0.99 to -1.09 and when no trend term is included they vary from -1.32 to -1.46. In either case the results indicate that an appreciation across the supply chain would cause a large decrease in processed exports.

The second row reports income elasticities. Again these are always correctly signed and statistically significant at the 1% level. The values are more dispersed than the exchange rate elasticities. They vary from 0.33 to 0.98 when a trend is included and from 0.81 to 1.75 when no trend is included. These differing values occur because rest of the world GDP resembles a time trend. The results thus indicate that Chinese processed exports are sensitive to rest of the world GDP, although the size of the estimated response varies across specifications.

The third row reports coefficients on FDI and the fourth row coefficients on the time trend. When a trend term is not included an increase in FDI is associated with a large increase in exports. When a linear trend is included, the coefficient on FDI takes on the wrong sign. The coefficient on the time trend varies from 0.19 to 0.26 in column (6). Thus controlling for other factors, Chinese processed exports have increased on average by 20% per year or more over the 1994-2011 period.

Tables 3 and 4 report results for ordinary exports. The exchange rate elasticities are always correctly signed and statistically significant at the 1% level. The elasticities for CPI-

deflated exchange rates in Table 3 average -1.17 and the elasticities for the CEPII exchange rate in Table 4 average -1.01.

The income elasticities are also always statistically significant. They average 1.05 in Table 3 and 1.14 in Table 4. The results, however, are dispersed and sensitive to the inclusion of a time trend.

As in Table 2, an increase in FDI is associated with a large increase in exports when a time trend is not included. When a trend is included, however, the coefficients on FDI again take on the wrong sign. As with processed exports, the coefficient on the time trend in Tables 3 and 4 indicate that Chinese ordinary exports have increased on average by 20% per year or more over the 1994-2011 period.

The income elasticities in the top panels of Tables 2-4 (obtained using the Poisson pseudo-maximum-likelihood approach of Santos Silva and Tenreyro, 2006) seem to be less sensitive to the inclusion of time trends. Santos Silva and Tenreyro argued that, because of Jensen's inequality, estimating models in logarithms can produce biased estimates. This bias can be eliminated by using the PPML approach. Focusing on the estimates in Tables 2-4 obtained using their approach, for processed exports the income elasticity averages 1.32. For ordinary exports the income elasticity averages 1.0. Thus the PPML results provide unbiased estimates and imply that rest of the world income exerts important effects on China's exports.

The results reported in this section help explain the evolution of China's trade. Section 2 indicates that China's surplus in processing trade has exploded since 2002 while China's surplus in ordinary trade has disappeared. Figure 2 presents real effective exchange rates for China's processed exports. These exchange rates are weighted averages of the bilateral exchange rates for the 24 countries employed, with weights determined by the share of processed exports going

to each of the 24 countries. By this measure, China's real effective exchange rate has appreciated 39% between 2002 and 2012. However, the real effective exchange rate in supply chain countries has depreciated 10% over the same period. As a result, the integrated real effective exchange rate essentially has the same value in 2012 that it had in 2002. The appreciation of China's REER reduced the growth of China's ordinary exports. The offsetting depreciation in supply chain countries, however, implied that China's processed exports were not affected by the renminbi appreciation.

An implication of the results presented here is that if countries in the supply chain allowed their exchange rates to appreciate in response to their huge surpluses in processing trade and their global current account surpluses, China's processed exports would decline. The next section investigates how such an appreciation would affect China's imports for processing.

5. How an Appreciation of the Integrated Exchange Rate Would Affect Processed Imports

The IMF (2005) observed that imports for processing into assembly economies tend to vary directly with processed exports. A recursive system is thus posited, where processed exports depend on demand in the rest of the world and imports for processing depend on processed exports.   Imports for processing are also modeled as a function of Chinese GDP and the integrated exchange rate. Import functions can be written as:

$$im_t = \alpha_{10} + \alpha_{12}\, ex_t + \alpha_{11}\ irer_t + \alpha_{12}\, rgdp_t + \varepsilon_t, \qquad\qquad (6)$$

where im_t represents the log of real imports for processing, ex_t represents the log of real processed exports, $irer_t$ represents the log of the integrated exchange rate, and $rgdp$ represents the log of Chinese real income. Since imports for processing are intended to produce processed exports and not for the domestic market, Chinese GDP is not expected to exert a large effect on imports for processing.

Data on imports for processing into China over the 1992-2012 period from the same 24 countries listed in footnote 2 are employed. These data are obtained from China Customs Statistics. They are deflated using 1) the Hong Kong re-export unit value index for exports to China, 2) an import price index for Chinese imports obtained from the World Bank, and 3) the U.S. producer price index for finished goods. All of these have been used in previous work to deflate Chinese imports. Data on processed exports are obtained from the China Customs Statistics and data on Chinese real GDP are obtained from the CEPII-CHELEM database.

Results from a battery of panel unit root tests indicate that over the sample period in most cases the series are integrated of order one. Results from Kao residual cointegration tests indicate that there exist cointegrating relationships between Chinese imports for processing, the integrated exchange rate, processed exports, and Chinese real GDP.

Panel DOLS is thus employed, along with Poisson pseudo-maximum-likelihood estimators. Dummies variables for China's WTO accession and the trade collapse of 2009 are again included.

Table 5 presents the results. The top panel reports the PPML results and the bottom panel the DOLS results. Columns (1) and (2) report findings with exports deflated using the Hong Kong re-export unit value index, Columns (3) and (4) with exports deflated using the World Bank export price deflator, and columns (5) and (6) with exports deflated using the U.S.

producer price index for finished goods. Columns (1), (3), and (5) report results without a trend term, and columns (2), (4) and (6) report results with a linear trend included.

In both panels the first row reports the elasticities for the integrated exchange rate. These are always correctly signed and statistically significant at the 1% level. They range in value from 1.02 to 1.27. These results indicate that an appreciation across the supply chain would increase imports for processing.

The second row reports results for processed exports. Again these are always correctly signed and statistically significant at the 1% level. For the PPML estimation the coefficients range in value from 1.15 to 1.26. For the DOLS estimation they range in value from 0.44 to 0.54. The results indicate that Chinese imports for processing are sensitive to Chinese processed exports, although the size of the estimated response varies across specifications.

The third row reports coefficients on Chinese GDP and the fourth row coefficients on the time trend. Chinese GDP is sometimes positive and sometimes negative, indicating as expected that there is not a tight link between imports for processing and Chinese GDP. The coefficient on the time trend is positive and statistically significant in three of the six cases.

The implication of these results is that a concerted appreciation in East Asia would help rebalance China's processing trade. Table 2 indicates that on average a 10% appreciation would reduce processed exports by 12.2%. Table 5 indicates that such an appreciation will have two effects on imports for processing. A 12.2% drop in processed exports will reduce imports for processing on average by 10.2%. A 10% appreciation will also increase imports for processing directly by 11.3%. The net effect is a 12.2% decrease in processed exports and a 1.1% increase in imports for processing. Since processed exports in 2012 and 2013 are almost twice as large as imports for processing, the key parameter for determining how the balance in processing trade

will respond is the coefficient on *irer* for processed exports in Table 2. This equals -1 or less in every specification, implying that an appreciation of the integrated exchange rate would help to rebalance processing trade.

6. Conclusion

After 2004, China's surplus in processing trade has exploded while its surplus in ordinary trade has disappeared. This paper investigates why. Since much of the value added of processed exports comes from imported parts and components, it models processed exports as a function of exchange rates throughout the supply chain. Since the lion's share of the value added of ordinary exports comes from China, it models ordinary exports as a function of the renminbi exchange rate.

Results presented here indicate that processed exports are sensitive to exchange rates throughout the supply chain and that ordinary exports are sensitive to the RMB exchange rate. Figure 2 shows that China's real effective exchange rate for processed exports appreciated 39% between 2002 and 2012. However, real effective exchange rates in supply chain countries depreciated over this period. As a result the integrated real effective exchange rate had the same value in 2012 as it had in 2002. Thus the appreciation of the renminbi did little to slow processed exports. On the other hand, it caused ordinary exports to be much lower than they would otherwise be.

The large surpluses that supply chain countries run in processing trade and in their global current account surpluses generate appreciation pressure. However, many countries in the region manage their exchange rates and resist appreciation pressures. If central banks in Asia gave

greater play to market forces, the enormous surpluses against the U.S. and Europe would produce a concerted appreciation of currencies against the U.S. dollar and the euro.

This paper investigated in Section 5 how such an appreciation would affect China's imports for processing. The results indicate that it would lead to a small increase in imports. Putting together the effects on processed exports and on imports for processing, these results indicate that a concerted appreciation would help to rebalance China's processing trade.

One difficulty is that domestic policymakers and international organizations such as the IMF and the ASEAN+3 Macroeconomic Research Office (AMRO) conduct surveillance at the country level. If China has a large current account surplus, they might recommend an appreciation of the renminbi. However, if the appreciation of the renminbi is offset by depreciations in other supply chain countries, the source of China's surplus (processing trade) will not be affected but low margin labor-intensive trade (ordinary trade) will fall further into deficit. When making recommendations for China's trade surplus and its exchange rate, it is thus necessary to take account of exchange rates throughout the region.

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Table 1a. China's Ordinary Trade, 2002-2012

	S. Korea & Taiwan	ASEAN5	Japan	Hong Kong, China	US	Europe	Australia & Brazil	Rest of the World (oil)	Rest of the World (non-oil)	Total
Ordinary Imports (billions of U.S. dollars)										
2002	19.4	11.5	18.7	1.9	14.7	24.1	6.4	11.2	21.2	129.1
2003	27.6	16.6	27.8	2.7	18.9	34.7	10.3	17.5	31.8	187.9
2004	34.0	20.5	34.7	3.2	24.4	41.5	16.0	31.0	42.4	247.7
2005	56.8	20.5	35.9	3.6	25.9	42.1	21.1	44.6	29.2	279.7
2006	41.9	25.1	42.2	3.1	28.3	52.6	27.6	63.7	48.7	333.2
2007	48.5	32.9	50.5	4.5	36.1	67.7	39.1	76.0	73.4	428.7
2008	55.3	38.9	62.3	5.7	47.0	79.9	61.8	123.7	98.1	572.7
2009	54.5	39.7	62.8	3.7	50.2	85.2	62.1	83.5	92.6	534.3
2010	74.6	58.5	89.4	5.6	63.8	114.6	91.0	126.4	144.4	768.3
2011	90.1	78.2	100.5	9.2	81.4	144.3	122.4	183.1	198.4	1007.6
2012	92.9	78.7	88.7	11.7	90.0	142.7	122.6	171.6	222.9	1021.8
Ordinary Exports (billions of U.S. dollars)										
2002	10.8	9.8	19.8	13.8	21.5	21.3	3.5	0.1	35.6	136.2
2003	13.9	13.0	23.6	18.1	27.9	29.8	4.8	0.1	50.9	182.1
2004	19.3	17.6	29.1	23.1	38.1	40.9	6.9	0.1	68.6	243.7
2005	24.5	22.4	33.4	25.2	52.8	56.9	8.8	0.2	91.0	315.2
2006	31.6	28.1	37.4	32.1	69.1	74.5	11.6	0.2	131.8	416.4
2007	39.7	38.6	41.8	34.5	80.3	100.7	16..1	0.3	186.6	538.6
2008	51.1	49.5	50.2	34.3	93.6	126.9	23.8	0.4	232.8	662.6
2009	30.7	41.5	41.3	32.0	78.6	99.4	19.1	0.5	186.6	529.7
2010	42.6	55.5	51.1	40.4	107.5	137.5	29.9	0.5	255.7	720.7
2011	53.8	73.2	66.5	48.5	135.6	166.8	39.6	0.5	332.5	917.0
2012	51.4	94.7	66.4	57.7	151.3	157.3	43.3	0.7	365.2	988.0
Balance in Ordinary Trade (billions of U.S. dollars)										
2002	-8.6	-1.7	1.1	11.9	6.8	-2.8	-2.9	-11.1	14.4	7.1
2003	-13.7	-3.6	-4.2	15.4	9.0	-4.9	-5.5	-17.4	19.1	-5.8
2004	-14.7	-2.9	-5.6	19.9	13.7	-0.6	-9.1	-30.9	26.2	-4.0
2005	-32.3	1.9	-2.5	21.6	26.9	14.8	-12.3	-44.4	61.8	35.5
2006	-10.3	3.0	-4.8	29.0	40.8	21.9	-16.0	-63.5	83.1	83.2
2007	-8.8	5.7	-8.7	30.0	44.2	33.0	-23.0	-75.7	113.2	109.9
2008	-4.2	10.6	-12.1	28.6	46.6	47.0	-38.0	-123.3	134.7	89.9
2009	-23.8	1.8	-21.5	28.3	28.4	14.2	-43.0	-83.0	94.0	-4.6
2010	-32.0	-3.0	-38.3	34.8	43.7	22.9	-61.1	-125.9	111.3	-47.6
2011	-36.3	-5.0	-34.0	39.3	54.2	22.5	-82.8	-182.6	134.1	-90.6
2012	-41.5	16.0	-22.3	46.0	61.3	14.6	-79.3	-170.9	142.3	-33.8

Table 1b. China's Processing Trade, 2002-2012

	S. Korea	Taiwan	ASEAN4	Japan	Hong Kong, China	Singapore	US	Europe	Rest of the World	Total
Imports for Processing (billions of U.S. dollars)										
2002	14.4	24.6	11.8	25.0	8.0	3.1	6.9	6.3	22.2	122.3
2003	20.7	32.5	17.9	32.8	7.7	4.7	8.1	6.9	31.7	163.0
2004	32.0	43.9	23.8	40.2	7.8	6.2	11.0	9.8	47.1	221.8
2005	42.8	52.1	29.6	45.2	7.7	7.8	12.8	12.2	63.9	274.1
2006	48.5	61.2	33.8	51.1	6.8	8.5	16.8	16.1	78.4	321.2
2007	56.2	69.1	39.2	59.4	7.3	8.9	18.2	18.5	91.6	368.4
2008	59.2	68.4	38.8	61.3	6.1	8.6	19.7	21.7	94.6	378.4
2009	54.7	54.7	31.4	50.0	7.0	7.0	15.5	17.8	84.2	322.3
2010	71.1	70.0	42.1	61.6	9.9	9.9	21.7	21.0	110.1	417.4
2011	79.6	71.9	44.7	64.9	10.1	10.1	21.9	22.9	143.7	469.8
2012	83.9	68.5	38.2	62.8	10.6	10.0	19.8	19.9	167.5	481.2
Processed Exports (billions of U.S. dollars)										
2002	7.0	4.0	5.9	28.1	42.3	4.4	46.8	26.1	15.4	180.0
2003	9.3	5.3	7.3	35.1	54.6	5.5	62.4	41.1	21.3	241.9
2004	13.7	7.2	10.1	43.5	72.2	8.3	83.7	57.2	32.4	328.3
2005	16.5	9.2	13.4	49.7	92.7	10.7	105.7	75.2	43.6	416.7
2006	20.2	11.2	16.4	52.9	114.0	15.1	128.8	91.1	60.9	510.6
2007	24.6	11.9	20.1	57.7	138.5	17.6	145.4	114.8	87.0	617.6
2008	32.1	12.7	22.1	62.3	141.9	18.8	149.9	126.3	109.1	675.2
2009	29.1	10.9	19.9	53.6	120.7	19.7	133.1	102.7	97.2	586.9
2010	34.9	15.0	25.2	65.5	160.6	20.9	162.6	127.3	128.3	740.3
2011	39.6	17.7	28.6	75.2	193.8	20.6	175.6	135.6	148.6	835.3
2012	46.1	16.2	32.0	78.6	207.9	21.7	184.6	123.5	152.2	862.8
Balance in Processing Trade (billions of U.S. dollars)										
2002	- 7.4	-20.6	-5.9	3.1	34.3	1.3	39.9	19.8	-6.8	57.7
2003	-11.4	-27.2	-10.6	2.3	46.9	0.8	54.3	34.2	-10.4	78.9
2004	-18.3	-36.7	-13.7	3.3	64.4	2.1	72.7	47.4	-14.7	106.5
2005	-26.3	-42.9	-16.2	4.5	85.0	2.9	92.9	63.0	-20.3	142.6
2006	-28.3	-50.0	-17.4	1.8	107.2	6.6	112.0	75.0	-17.5	189.4
2007	-31.6	-57.2	-19.1	-1.7	131.2	8.7	127.2	96.3	-4.6	249.2
2008	-27.1	-55.7	-16.7	1.0	135.8	10.2	130.2	104.6	14.5	296.8
2009	-25.6	-43.8	-11.5	3.6	113.7	12.7	117.6	84.9	13.0	264.6
2010	-36.2	-55.0	-16.9	3.9	150.7	11.0	140.9	106.3	18.2	322.9
2011	-40.0	-54.2	-16.1	10.3	183.7	10.5	153.7	112.7	4.9	365.5
2012	-37.8	-52.3	-6.2	15.8	197.3	11.7	164.8	103.6	-15.3	381.6

Notes: ASEAN 4 includes Indonesia, Malaysia, the Philippines, and Thailand. ASEAN 5 includes ASEAN 4 plus Singapore.   Europe includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Luxembourg, Netherlands, Italy, Portugal, Spain, Sweden and United Kingdom.
Source: China Customs Statistics.

Table 2. Elasticity Estimates for China's Processing Exports to 24 countries over the 1994-2011 period

	(1)	(2)	(3)	(4)	(5)	(6)
	Santos Silva and Tenreyro Poisson Pseudo Maximum Likelihood Estimates					
Integrated RER	-1.46***	-1.09***	-1.41***	-1.08***	-1.38***	-1.08***
	(0.12)	(0.08)	(0.11)	(0.08)	(0.10)	(0.08)
RoW Real GDP	1.75***	0.98***	1.66***	0.97***	1.56***	0.98***
	(0.21)	(0.14)	(0.19)	(0.13)	(0.17)	(0.13)
FDI	0.64***	-1.31***	0.73***	-1.05***	0.63***	-0.95***
	(0.08)	(0.13)	(0.07)	(0.12)	(0.07)	(0.12)
Time		0.23***		0.21***		0.19***
		(0.02)		(0.01)		(0.02)
	DOLS (1,1) Estimates with Heteroskedasticity Consistent Standard Errors					
Integrated RER	-1.40***	-1.00***	-1.35***	-0.98***	-1.32***	-0.99***
	(0.15)	(0.07)	(0.14)	(0.07)	(0.13)	(0.07)
RoW Real GDP	0.91***	0.34***	0.86***	0.33***	0.81***	0.33***
	(0.28)	(0.09)	(0.26)	(0.09)	(0.24)	(0.09)
FDI	0.92***	-1.26***	0.98***	-1.04***	0.88***	-0.94***
	(0.14)	(0.14)	(0.13)	(0.10)	(0.11)	(0.10)
Time		0.26***		0.24***		0.21***
		(0.02)		(0.01)		(0.01)

Notes: The data extend from 1992 to 2012. Because of lags and leads in the estimation the actual sample period extends from 1994-2011. There are 432 observations. Columns (1) and (2) report results with exports deflated using the Hong Kong re-export unit value index for exports to the U.S. Columns (3) and (4) report results with exports deflated using an export price index for China's exports obtained from the World Bank. Columns (5) and (6) report results with exports deflated using the US producer price index for finished goods. Country fixed effects and dummy variables to control for the period after China joined the WTO in 2001 and for the great trade collapse in 2009 are also included.
*** (**) denotes significance at the 1% (5%) level.

Table 3. Elasticity Estimates for China's Ordinary Exports to 24 countries over the 1994-2011 period

	(1)	(2)	(3)	(4)	(5)	(6)
	Santos Silva and Tenreyro Poisson Pseudo Maximum Likelihood Estimates					
Bilateral RER (CPI-deflated)	-1.32***	-1.12***	-1.27***	-1.09***	-1.28***	-1.12***
	(0.19)	(0.13)	(0.18)	(0.13)	(0.17)	(0.13)
RoW Real GDP	1.33***	0.77***	1.28***	0.77**	1.23***	0.81**
	(0.27)	(0.26)	(0.27)	(0.26)	(0.26)	(0.26)
FDI	1.27***	-0.80***	1.34***	-0.53***	1.23***	-0.43***
	(0.10)	(0.21)	(0.10)	(0.21)	(0.10)	(0.20)
Time		0.24***		0.21***		0.19***
		(0.02)		(0.02)		(0.02)
	DOLS (1,1) Estimates with Heteroskedasticity Consistent SEs					
Bilateral RER (CPI-deflated)	-1.37***	-0.95***	-1.30***	-0.91***	-1.40***	-0.94***
	(0.17)	(0.07)	(0.16)	(0.08)	(0.06)	(0.07)
RoW Real GDP	0.89***	0.26***	0.84***	0.26***	1.29***	0.25***
	(0.30)	(0.09)	(0.29)	(0.09)	(0.27)	(0.09)
FDI	1.59***	-0.95***	1.64***	-0.71***	1.34***	-0.61***
	(0.12)	(0.09)	(0.11)	(0.09)	(0.11)	(0.09)
Time		0.28***		0.26***		0.23***
		(0.01)		(0.01)		(0.01)

Notes: The data extend from 1992 to 2012. Because of lags and leads in the estimation the actual sample period extends from 1994-2011. There are 432 observations. Columns (1) and (2) report results with exports deflated using the Hong Kong re-export unit value index for exports to the U.S. Columns (3) and (4) report results with exports deflated using an export price index for China's exports obtained from the World Bank. Columns (5) and (6) report results with exports deflated using the US producer price index for finished goods. Country fixed effects and dummy variables to control for the period after China joined the WTO in 2001 and for the great trade collapse in 2009 are also included.
*** (**) denotes significance at the 1% (5%) level.

Table 4. Elasticity Estimates for China's Ordinary Exports to 24 countries over the 1994-2011 period

	(1)	(2)	(3)	(4)	(5)	(6)
	Santos Silva and Tenreyro Poisson Pseudo Maximum Likelihood Estimates					
Bilateral RER (CEPII)	-0.95***	-1.09***	-0.95***	-1.07***	-0.99***	-1.09***
	(0.15)	(0.10)	(0.14)	(0.10)	(0.13)	(0.10)
RoW Real GDP	1.39***	0.62***	1.31***	0.62**	1.26***	0.66**
	(0.26)	(0.22)	(0.25)	(0.23)	(0.24)	(0.23)
FDI	1.37***	-0.91***	1.45***	-0.63***	1.36***	-0.54***
	(0.10)	(0.19)	(0.10)	(0.19)	(0.09)	(0.19)
Time		0.27***		0.25***		0.22***
		(0.02)		(0.02)		(0.02)
	DOLS (1,1) Estimates with Heteroskedasticity Consistent SEs					
Bilateral RER (CEPII)	-1.09***	-0.95***	-1.05***	-0.92***	-1.06***	-0.94***
	(0.10)	(0.08)	(0.10)	(0.08)	(0.09)	(0.08)
RoW Real GDP	1.04***	0.21**	0.98***	0.21**	0.91**	0.21**
	(0.37)	(0.09)	(0.35)	(0.09)	(0.33)	(0.10)
FDI	1.64***	-1.04***	1.70***	-0.81***	1.58***	-0.71***
	(0.13)	(0.08)	(0.12)	(0.09)	(0.11)	(0.08)
Time		0.30***		0.29***		0.26***
		(0.01)		(0.01)		(0.01)

Notes: The data extend from 1992 to 2012. Because of lags and leads in the estimation the actual sample period extends from 1994-2011. There are 432 observations. Columns (1) and (2) report results with exports deflated using the Hong Kong re-export unit value index for exports to the U.S. Columns (3) and (4) report results with exports deflated using an export price index for China's exports obtained from the World Bank. Columns (5) and (6) report results with exports deflated using the US producer price index for finished goods. Country fixed effects and dummy variables to control for the period after China joined the WTO in 2001 and for the great trade collapse in 2009 are also included.
*** (**) denotes significance at the 1% (5%) level.

Table 5. Elasticity Estimates for China's Imports for Processing from 24 countries over the 1994-2011 period

	(1)	(2)	(3)	(4)	(5)	(6)
	Santos Silva and Tenreyro Poisson Pseudo Maximum Likelihood Estimates					
Integrated RER	1.27***	1.25***	1.17***	1.15***	1.21***	1.20***
	(0.42)	(0.43)	(0.39)	(0.39)	(0.40)	(0.40)
Processed Exports	1.26***	1.22***	1.19***	1.15***	1.19***	1.16***
	(0.25)	(0.27)	(0.23)	(0.25)	(0.24)	(0.25)
Chinese Real GDP	-0.41	-3.24	-0.65**	-3.00	-0.44	-1.85***
	(0.35)	(3.12)	(0.32)	(2.93)	(0.23)	(2.99)
Time		0.29		0.24		0.14
		(0.32)		(0.30)		(0.31)
	DOLS (1,1) Estimates with Heteroskedasticity Consistent Standard Errors					
Integrated RER	1.11***	1.03***	1.09***	1.02***	1.08***	1.02***
	(0.27)	(0.26)	(0.27)	(0.26)	(0.27)	(0.26)
Processed Exports	0.54***	0.47***	0.52***	0.46***	0.49***	0.44***
	(0.10)	(0.08)	(0.09)	(0.08)	(0.09)	(0.07)
Chinese Real GDP	0.78***	-4.30***	0.45***	-3.78***	0.69***	-2.81***
	(0.18)	(1.44)	(0.16)	(1.38)	(0.15)	(1.35)
Time		0.51***		0.42***		0.35***
		(0.13)		(0.13)		(0.13)

Notes: The data extend from 1992 to 2012. Because of lags and leads in the estimation the actual sample period extends from 1994-2011. There are 432 observations. Columns (1) and (2) report results with imports deflated using the Hong Kong re-export unit value index for exports to China. Columns (3) and (4) report results with imports deflated using an import price index for China's imports obtained from the World Bank. Columns (5) and (6) report results with imports deflated using the US producer price index for finished goods. Country fixed effects and dummy variables to control for the period after China joined the WTO in 2001 and for the great trade collapse in 2009 are also included.
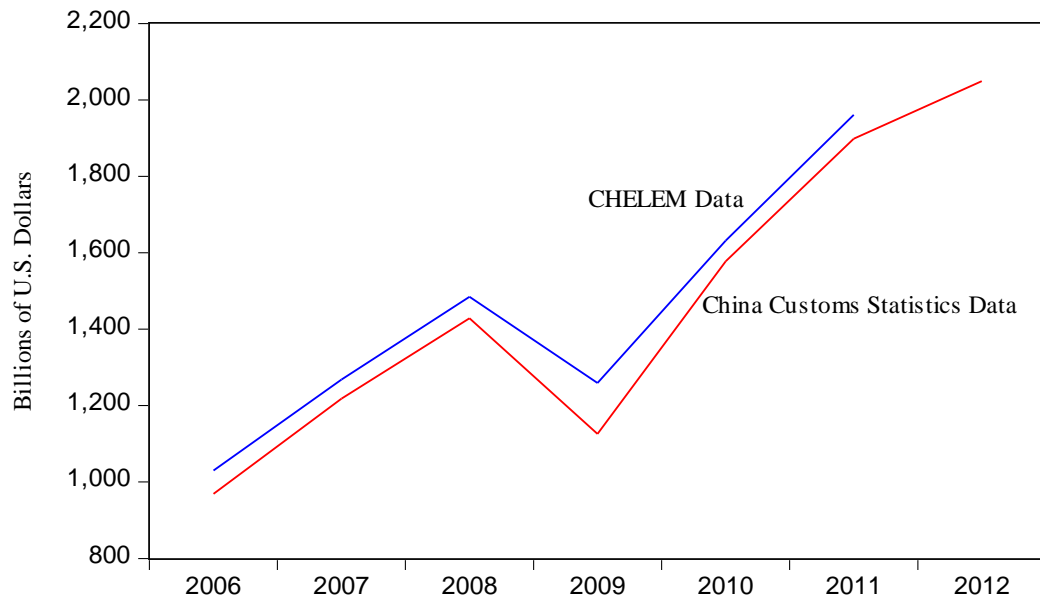*** (**) denotes significance at the 1% (5%) level.

Figure 1a. The Value of Chinese Exports to the World.
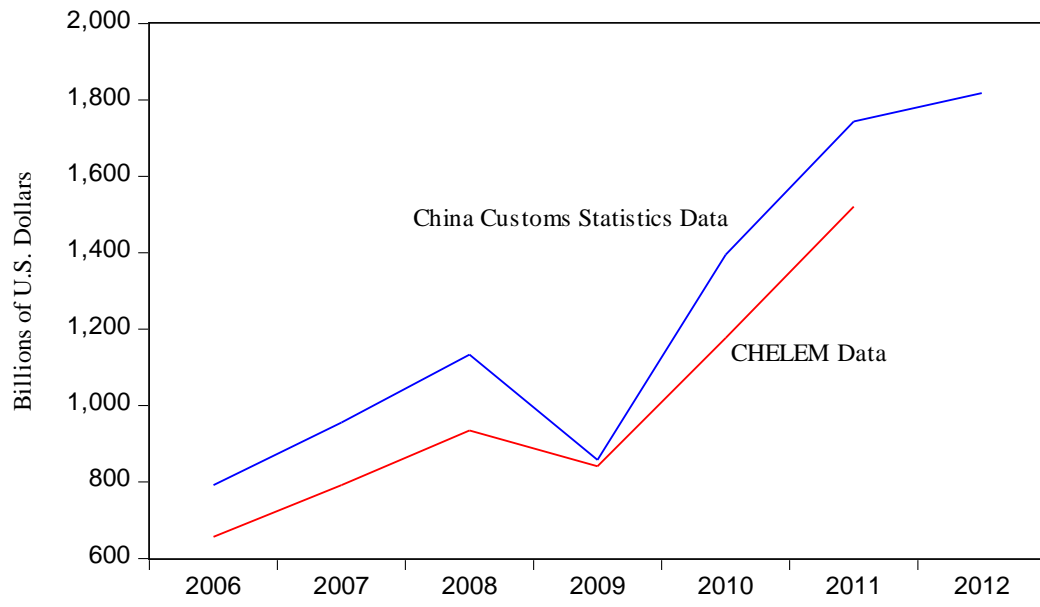*Source:* China Customs Statistics and CEPII-CHELEM Database

Figure 1b. The Value of Chinese Imports from the World.
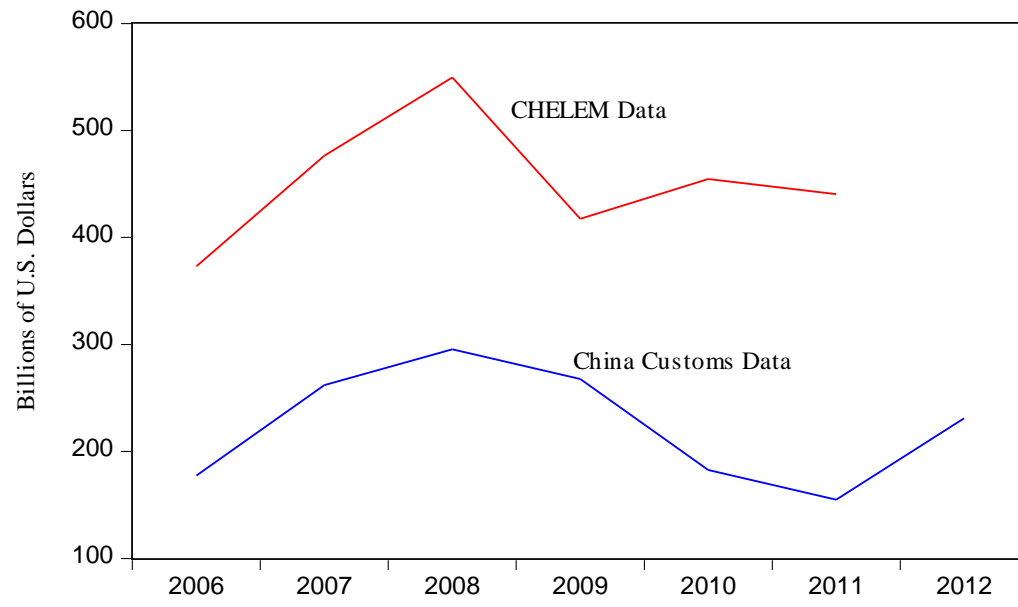*Source*: China Customs Statistics and CEPII-CHELEM Database

Figure 1c. The Value of China's Trade Surplus with the World.
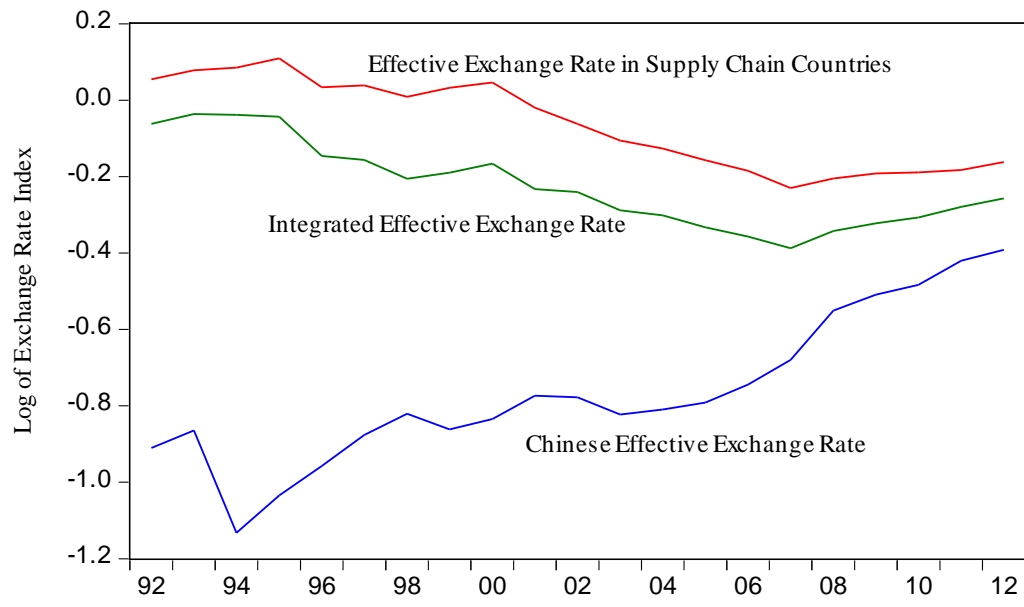*Source*: China Customs Statistics and CEPII-CHELEM Database

Figure 2. Real Effective Exchange Rate for China, Supply Chain Countries, and China and Supply Chain Countries Together Relative to Countries Importing China's Processed Exports.

Note: The effective exchange rates are weighted average exchange rates calculated based on China's processed exports to 24 leading importers.

Source: China Customs Statistics, CEPII-CHELEM Database, and author's calculations.