Chapter 6

China's Export Responses to Exchange Rate Movement in Global Production Networks

Nobuaki Yamashita
La Trobe University, Melbourne, Australia

2011

This chapter should be cited as
Yamashita, N. (2011), 'China's Export Responses to Exchange Rate Movement in Global Production Networks', in Corbett, J. and Y. Xu (eds.), *Achieving Sustainable Growth in East Asia*. ERIA Research Project Report 2010-28, Jakarta: ERIA. pp.116-139.

Chapter 6

China's Export Responses to Exchange Rate Movement in Global Production Networks[1]

NOBUAKI YAMASHITA[2]

School of Economics and Finance
La Trobe University, Melbourne, Australia

This chapter examines how an appreciation of the Chinese renminbi (RMB) affects China's assembly exports in the context of global production networks, using a three-dimensional panel data set of China's trade for the period 1992–2008. This paper constructs two relevant exchange rate indices for the RMB: a bilateral real exchange rate of the RMB against China's importing countries and a real effective exchange rate of the RMB against East Asian component suppliers. It is robustly found that an RMB appreciation against component suppliers would increase China's exports by lowering the costs of exporting. This effect is found to be larger in relatively more capital and technology-intensive industries whereby Chinese value added is thinner. Hence, the evidence casts doubts on the efficacy of further unilateral reform of the RMB exchange rate regime for correcting trade imbalances. The policy implication is that use of the exchange rate tool is more complex and less predictable for countries that take part in supply chains than for those that export goods mainly containing a high proportion of domestic value added.

Keywords: International fragmentation of production, Chinese renminbi (RMB), Global trade imbalance

JEL Classifications: F14, F31

[1] I would like to thank Jenny Corbett, Shujiro Urata, Peter Warr, Sisira Jayasuriya, Rod Tyers, Ying Xu, and participants at the Economics Research Institute of ASEAN and East Asia (ERIA) workshops in Singapore and Canberra.
[2] Email: N.Yamashita@latrobe.edu.au.

1. Introduction

In 2010 China overtook Germany to become the world's largest exporter, having increased its share of world exports to almost 10 percent—up from about 3 percent in 1999. The rise of China as a trading powerhouse has created growing concern among the world policy circle. Industrial countries are concerned about the growing size of China's trade surplus, which has become an intense subject of debate particularly among US policymakers. It is claimed that the Chinese renminbi (RMB) has been kept at a deliberately low level in order to give a competitive edge to Chinese exports in the world market. For developing countries, concerns have mounted to a "China fear" that fierce export-market competition with China will eventually crowd out their export opportunities and growth prospects. Hence, the recent announcement of a move into a more flexible exchange rate regime for the renminbi (RMB) by the central bank of China is a crucial issue globally.

In this policy context, this chapter examines China's export elasticity to exchange rate changes from the viewpoint of China being a primal base for assembly operations of final-product exports. There has been a proliferation of studies examining the implications of China's rise as a trading powerhouse for other Asian exporters' performance. In particular, the empirical literature examining the impacts of changes in the RMB on China's trade flows typically estimates the export sensitivity (elasticity) of (nominal or real) exchange rate changes based on the imperfect substitution model between foreign and domestic goods using time-series data (Ahmed 2009; Cheung et al., 2010; Marquez and Schindler, 2007; Thorbecke, 2011; Thorbecke and Smith, 2010). Using Chinese custom trade data, most of the papers find that the sensitivity of processed exports to exchange rate changes appears to decline because of the presence of imported parts and components included in final-product exports (Thorbecke, 2011; Thorbecke and Smith, 2010. In particular, if the exchange rates of all countries in the input supply chain appreciate at the same time as the RMB, China's processed exports are reduced to an appreciable extent while an appreciation of the RMB alone has only minor effects.[3]

With the rise of cross-border production sharing and global value chains, multinational enterprises (MNEs) increasingly set up their assembly centres in locations where comparative costs are cheaper; they source intermediate inputs (or parts and components) from various countries and assemble them into final assembled goods for export. In this process, China plays a pivotal role as an assembly centre for a wide range of manufacturing products created in Asia. This has opened up new opportunities for countries that specialize in the various tasks of the production process. At the same time, Asian exporters increasingly find export opportunities in China by supplying parts and components to China (Athukorala, 2009). Hence, a standard analysis of the effects of exchange rates on exports is no longer appropriate for analysing export elasticities to exchange rate movements when imports are sourced from a set of countries and final assembled goods are exported to another set of countries. Real exchange rate appreciation makes the foreign export price of goods more expensive, while making the imported input more affordable. This eventually reduces the sensitivity of exchange rate changes on export responses, compared with the normal adjustment case. The net effect on export response is an interesting empirical question to be examined.

This chapter further extends the literature in the following ways. First, we construct two components of exchange rate changes for the RMB: one is the bilateral real exchange rate of the RMB and the other is the real effective exchange rates of the RMB against East Asian component suppliers. Using these two components of RMB exchange rate indices leads to a more nuanced and richer understating of China's export

[3] These studies use trade data distinguished into processed and ordinary trade published by China Customs Statistics (CCS). The CCS data contain the Harmonized System (HS) eight-digit product level of China's trade flows administered by the Customs Office with information of the type of trade (processing exports using imported intermediate inputs, using locally sourced inputs, normal exports and imported intermediate inputs for the purpose of exports), trading partner countries, the type of trading firms (whether multinational enterprises, pure local firms or international joint ventures), the location of exporters and importers in the regions and cities, the values in US dollars and the quantity in eight different units. Based on this, we compute imported inputs weighted and export-weighted effective exchange rates. Processing trade includes imports that enter the country duty-free and will be incorporated into exported goods, and exports based on processing imports. Ordinary trade includes imports that enter China for domestic consumption, not used for exporting, or exports that do not rely on imported parts and components but using domestically sourced intermediate inputs.

elasticity to exchange rate changes. In particular, we robustly found that an RMB appreciation against component suppliers in East Asia would increase China's exports by reducing the costs of imported parts and components.

Second, most of the existing studies use highly aggregated and time-series Chinese trade data. This paper constructs a panel of bilateral Chinese exports to Organization for Economic Cooperation and Development (OECD) countries for the period 1992–2009 at the two-digit industry level. It will be shown that the degree of export elasticity to exchange rate changes would be higher in the relatively capital and technology-intensive industries in which the bulk of imported parts and components come from East Asian countries.

2. China's Export Performance

Figure 1a depicts the rise of China in world manufacturing exports. In 1992 China's exports accounted for a tiny share (about 2 percent) of world exports. The data show that China's export growth took off about the early 2000s. Since then, China has achieved formidable export expansion by overtaking Germany as the world's largest exporter, in 2007–08, accounting for 12 percent of world manufacturing exports. In Figure 1, only China's export share has been growing without any disruptions, while the world shares of Japan, the United States and Germany have not grown since 2000. At the same time, China has also been growing to become an important country in the global market (Figure 1b). While the United States still accounts for the bulk of world manufacturing imports (about 15–20 percent in world imports), its share has been declining since 2000. Meanwhile, China's share has been steadily increasing, accounting for close to 9 percent in 2009—up from 3 percent in 1992.

Figure 1. The Rise of China in World Manufacturing Exports (percent)

Figure 1a. Export (Percentage share in world manufacturing exports)

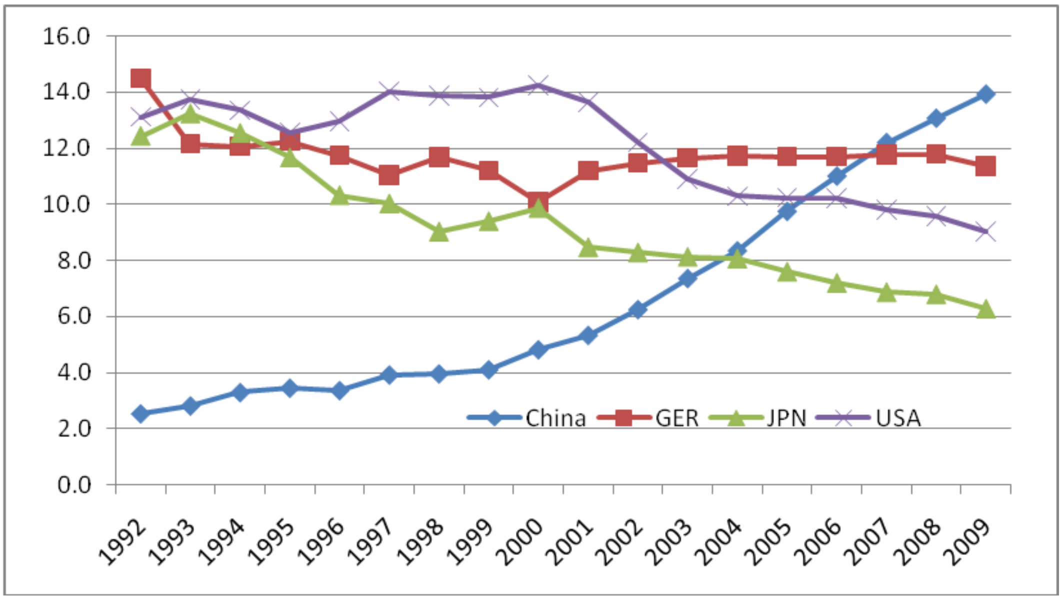
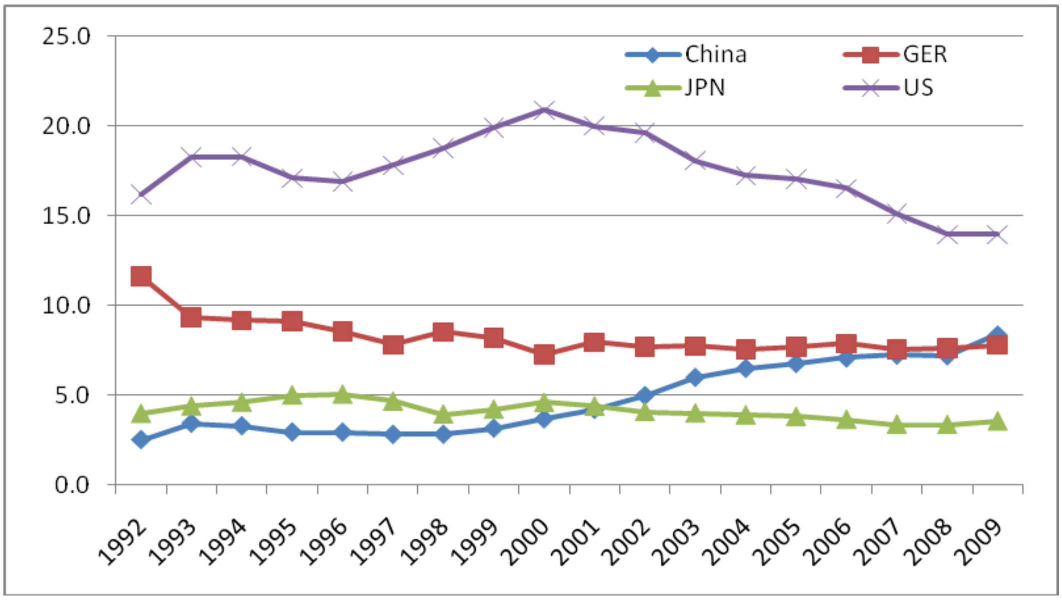


Figure 1b. Imports (Percentage share of world manufacturing imports)



Source: UN Comtrade.

With the rise of China in world trade, Table 1 also highlights product compositional change in China's trade (product composition of trade structure at one and two-digit levels of SITC product categories). China clearly changed its specialization of trade from relatively labor-intensive products towards more capital and technology-intensive products. In 1992–93, miscellaneous manufacturing (including clothing, footwear, and toys and games) accounted for about 60 percent of China's manufacturing exports. Its share continuously declined, however, and dropped to 34 percent in 2004–05. On the other hand, the export share of machinery and transport equipment jumped from 21 percent in 1992–93 to 49 percent in 2004–05. In particular, the export composition is highly concentrated in information communication technology (ICT) product categories under SITC 75, 76 and 77. The share of office machines under SITC 75 increased from 2.3 percent of China's manufacturing exports in 1992–93 to 16 percent in 2004–05. Telecommunication sound equipment (including mobile phones) increased from 8 percent to 14 percent in 2004–05 and electrical machinery appliances (SITC 77) were up from 5.8 percent to 12.5 percent. While the dominant products in China's exports are electronic related, transport-related products such as automobiles still account for a small share. The share of road vehicles (SITC 78) accounted for 1 percent in 1992–93, and this share virtually remained the same until 2004–05.

Table 1. Product Composition of China's Manufactured Exports and Imports, 1992–2005

SITC	Product description	China, export			China, import		
		1992–93	2000–01	2004–05	1992–93	2000–01	2004–05
5	Chemicals	3.9	3.5	3.6	13.8	17.3	15.5
6	Manufactured goods	16.2	14.1	14.1	31.5	23.3	16.8
68	Non-ferrous metals	0.7	0.9	1.1	2.6	3.6	3.4
7	Transport equipment	20.8	36.7	49.2	49.6	55.3	59.0
71	Power—general machines	0.9	1.2	1.0	3.2	2.9	2.4
72	Special industrial machinery	0.6	0.6	0.9	14.1	6.5	5.2
73	Metal-working machinery	0.2	0.2	0.2	2.7	1.8	2.1
74	General industrial machinery	1.7	2.2	3.1	5.1	4.9	5.1
75	Office machines	2.3	9.9	16.0	1.9	6.5	7.1
76	Telecommunication sound equipment	8.0	10.2	14.0	5.8	7.1	5.9
77	Electrical machinery appliances	5.8	11.0	12.5	7.2	21.0	27.0
78	Road vehicles	1.0	1.2	1.3	5.8	2.3	2.7
79	Other transport equipment	0.2	0.2	0.2	3.8	2.3	1.5
8	Miscellaneous manufactured articles	59.8	46.6	34.1	7.7	7.7	12.0
84	Clothing	23.1	14.9	10.6	0.7	0.7	0.3
85	Footwear	9.0	5.8	3.6	0.5	0.2	0.1
894	Baby carriages, toys, games	10.4	8.8	5.7	0.4	0.1	0.1
5–8	Manufactured goods	100.0	100.0	100.0	100.0	100.0	100.0

Source: UN Comtrade

On the import side, the share of miscellaneous manufactured products (including toys, footwear and clothing) has stayed at a relatively low level compared with the export side. Instead, the electrical and transport equipment (SITC 7) category accounts for close to half of China's manufacturing imports: in 1992–93 its share was 49.6, and grew to be close to 60 percent in 2004–05. Among them, the share of electrical machinery appliances of SITC 77 increased from 7 percent in 1992–93 to 21 percent in 2000–01 and 27 percent in 2004–05.

Table 2 summarizes the percentage share of parts and components in total manufacturing trade for China and other East Asian countries for 1992–2009. The percentage share of components in manufacturing trade indicates a quite distinctive specialization of vertical trade for China. While the component share in total manufacturing exports remains relatively low compared with other East Asian countries, there has been an increase of the component share in total manufacturing imports in China. In 2005–06 the share of components in China's manufacturing exports stood at about 20 percent, while that of Association of South-East Asian Nations (ASEAN) countries accounted for 40 percent, 33 percent for South Korea and 46 percent for Taiwan. On the other hand, the share of components in China's total manufacturing imports dramatically increased—from 19 percent in 1992–93 to 44 percent in 2005–06. This share is quite comparable with average ASEAN countries and other key East Asian importers. Perhaps, these figures suggest that China predominantly imports components within manufacturing and exports final products after undertaking assembly using imported parts and components in Chinese domestic factories.

Table 2. Percentage Share of Parts and Components (P&Cs) in Total Manufacturing Trade, 1992–2009

	Export (%)				Import (%)			
	1992–93	2000–01	2005–06	2008–09	1992–93	2000–01	2005–06	2008–09
China	5.2	14.2	20.2	15.5	19.3	34.5	43.8	24.1
Hong Kong (China)	18.8	27.5	26.5	14.9	16.8	30	36	21
ASEAN6	27.4	38.6	40.2	18.1	34.6	48.8	43.4	24.9
Malaysia	33.4	46.1	48	20.5	42	57.4	53.1	25.4
Philippines	34.4	58.2	66.6	21.6	33.9	55.1	51.1	23.8
Singapore	33.8	43.2	43.5	18.2	38.6	50.4	46.5	25.7
Vietnam	1.4	9.9	10.2	9.2	8.9	18.5	17.2	15.7
Thailand	21.2	27.2	27.4	18	29.1	43.6	38.2	27.5
Indonesia	3.2	12.4	19.7	15.4	24	31	32.9	26.4
Japan	26.9	34.1	32.4	24.4	18.5	26.7	25.2	19.2
Rep. of Korea	19.1	27.4	33.1	18.5	29.2	36.7	31.9	19.4
Taiwan	21.1	36.9	45.9	19.2	30.5	39.1	37.7	17.6
USA	30.3	35.6	31.2	23.8	24.5	24.1	21.5	17.7
NAFTA	29.6	32.2	29	22.8	27.4	27	23.7	19.4
EU15	18.6	20.7	19.6	18	19.1	21.7	19.7	16.6
Low income	2.9	5.4	6.5	7.3	15.3	17.1	16.1	14.9
Low–middle income	8.1	17.5	21.7	15.3	21.6	31.3	34.3	22.1
High income	22.7	26	24	19.4	21.3	24.2	22.1	17.5
World	20.8	25.1	24.1	18.2	21.7	25.6	23.9	18.2

Source: UN Comtrade.

The share of components in total manufacturing trade dropped sharply during the Global Financial Crisis (GFC) in 2008 and 2009 (for fuller exposition, see Athukorala, 2011). As became apparent, a substantial drop in the volume of trade in 2008–09 was caused largely by a sharp decline in demand for consumer durable goods (ITC products and motor vehicles) in industrial countries. This sharp drop of demand had a consequence for components trade in supply chains because of direct linkages with demand for final products. For China, the component share in total manufacturing imports dropped from 44 percent in 2005–06 to 24 percent in 2008–09. ASEAN countries' average share of components in manufacturing also dropped sharply—to 25 percent in imports and 18 percent in exports in 2008–09.

Table 3 summarizes China's export destinations and import sourcing countries from 1992 to 2009. Major trading countries are broken down into ASEAN countries, South Korea and Taiwan, Japan, the United States and EU15 countries. Table 3 also separates China's trade patterns into parts and components and final goods. In machinery and transport equipment (SITC 7), China's component sourcing from ASEAN countries accounted for only 2.2 percent in 1992–93 but ASEAN's share grew to be about 13 percent in 2000–01 and 17 percent in 2005–06 (panel A of Table 3). The lion's share of China's component imports comes from other East Asian countries, South Korea, Taiwan and Japan (excluding Hong Kong, China). In 2005–06, South Korea and Taiwan accounted for 30 percent and Japan for 18 percent of China's component imports. On the other hand, the share of the United States has declined from 11 percent in 1992–93 to less than 6 percent in 2005–06, and the share of the EU15 dropped from 19 percent in 1992–93 to 9.4 percent in 2005–06. During the recent crisis period in 2008–09, the share of ASEAN in China's component imports declined substantially—down to 8 percent in 2008–09. Similarly, the shares of South Korea and Taiwan dropped.

Table 3. Directions and Sources of China's Trade in Components and Final Products, 1992–2009 (percent)

(A) —Imports

	Parts and components in machinery and electrical (SITC 7)					Final products in machinery and electrical (SITC 7)				
Year	ASEAN	Korea+Taiwan	Japan	US	EU15	ASEAN	Korea+Taiwan	Japan	US	EU15
1992–93	2.2	15.0	33.4	10.7	19.1	1.1	15.5	28.5	14.1	25.6
2000–01	13.3	20.3	24.1	9.4	17.2	5.2	15.9	20.6	17.3	26.0
2005–06	17.2	30.1	18.2	5.7	9.4	12.1	14.1	21.5	10.2	24.3
2008–09	8.0	19.7	23.4	6.3	19.0	17.5	23.5	16.2	8.0	15.4

	Part and components in toys and clothing (SITC 8)					Final products in toys and clothing (SITC 8)				
Year	ASEAN	Korea+Taiwan	Japan	US	EU 15	ASEAN	Korea+Taiwan	Japan	US	EU 15
1992–93	1.0	22.1	30.5	7.2	5.2	1.4	20.5	25.0	14.9	8.6
2000–01	5.5	16.6	36.1	9.0	13.6	3.1	16.4	20.8	19.4	18.0
2005–06	4.6	31.3	30.0	7.9	8.0	4.0	44.0	16.5	7.4	8.7
2008–09	5.6	25.1	28.0	7.4	13.6	4.2	41.8	15.4	8.0	11.2

(B) —Exports

	Parts and components in machinery and electrical (SITC 7)					Final products in machinery and electrical (SITC 7)				
Year	ASEAN	Korea+Taiwan	Japan	US	EU15	ASEAN	Korea+Taiwan	Japan	US	EU15
1992–93	7.8	6.2	15.8	17.5	13.0	6.2	3.0	8.6	22.3	15.2
2000–01	12.8	7.8	14.9	15.4	12.8	7.0	5.2	11.1	24.4	21.3
2005–06	11.6	9.5	10.1	15.6	13.4	5.2	4.0	8.2	26.4	23.2
2008–09	8.6	7.1	8.8	14.5	16.7	8.6	5.9	5.8	19.9	17.8

	Parts and components in toys and clothing (SITC 8)					Final products in toys and clothing (SITC 8)				
Year	ASEAN	Korea+Taiwan	Japan	US	EU15	ASEAN	Korea+Taiwan	Japan	US	EU15
1992–93	3.9	5.5	13.0	16.8	9.6	1.5	2.3	16.0	27.1	14.5
2000–01	4.6	5.3	19.7	27.4	9.5	2.1	3.5	20.5	27.4	14.2
2005–06	5.9	7.7	25.3	19.4	9.1	2.9	3.5	12.9	26.6	18.2
2008–09	9.1	6.7	13.4	18.4	12.1	4.8	3.2	10.6	24.0	21.4

Source: UN Comtrade.

The recent crisis had little impact on China's final goods imports from ASEAN countries, in contrast with component imports. The share of ASEAN actually went up—from 12 percent in 2005–06 to 17.5 percent in 2008–09, while the shares of Japan, the United States and the EU15 all went down in the same period. The share of Japan in China's final-product imports declined from 20 percent in 2000–01 to 16 percent in 2008–09. Similarly, the share of the United States dropped from 17 percent in 2000–01 to 8 percent in 2008–09, and the share for EU15 countries went down from 26 percent to 15 percent.

Table 3b looks at the export directions of China's exports in parts and components and final products. Similarly to the import pattern, here, the share of ASEAN countries has substantially increased since the early 1990s. ASEAN's share went up from 7.8 percent in 1992–93 to 12.8 percent in 2000–01 and 11.6 percent in 2005–06, while the shares of other country groups have not changed dramatically in the same period. The United States and EU15 countries account for about 40 percent of China's final-product exports, the importance of which has not changed in the past 20 years. This indicates that China still finds export markets for its manufacturing exports in rich Western countries. In 1992–93, 22 percent of China's final-goods exports went to the United States and 15 percent to the EU15. In 2008–09, the United States' share stood at 20 percent, while it was 18 percent for EU15 countries.

China's trade in miscellaneous manufactured articles (SITC 8)—mainly toys and clothing—shows a quite different pattern. ASEAN countries continue to make up a small portion of China's imports and exports in this product category, while imports from South Korea and Taiwan dominate. About 40 percent of China's final-goods imports in this product category comes from these two East Asian countries. On the export side, the majority of Chinese products are directed towards Japan, the United States and EU15 countries. All in all, Table 3 clearly suggests the role of China as a major final-assembly country. The majority of China's component imports are sourced from East Asian countries, including Japan, while China's final-product exports are directed towards the United States and EU15 countries.

3. Empirical Analysis

This section undertakes gravity modelling to estimate China's export elasticity of exchange rate changes. As theoretically and empirically demonstrated in Baldwin and Taglioni (2011), a standard formation of the gravity equation might not be appropriate for explaining trade flows where trade in parts and components is prevalent. They point out the potential problem of regressing trade in parts and components on the typical gravity variables. A typical form of the gravity equation postulates demand and supply in a bilateral trade relationship—simply represented by GDP and GDP per capita of importing and exporting countries. The GDP of importing countries might, however, not strictly represent demands for imports because of demand coming from the third countries.

As shown in Section 3, China primarily imports parts and components from other East Asian countries, and then exports final-assembly products to the United States and EU15 countries. Hence, our dependent variable is China's final-product exports to developed countries in the West, rather than the reported volume of China's exports, as in Baldwin and Taglioni (2011) (refer to our data approach of identifying final products in China's exports separated from parts and components in the Data Appendix). Of course, this is not a perfect solution. As is well known, the trade data collected are gross flows, not value added. The input–output (I/O) table is required to measure value-added contents of China's exports, netting out imported and domestically sourced parts and components. The I/O table is, however, published only in discrete time (for example, every five years), hence it is difficult to associate value-added exports from the I/O table to a more dynamic analysis of exchange rate fluctuations. Hence, even if our approach is able to separate final products from parts and components in China's trade statistics, they are not value-added measures. Our measure of the volume of final-good exports contains imported as well as domestically sourced parts and components.

Our estimation strategy incorporates two relevant exchange rates for the RMB. The first refers to the real bilateral exchange rates between China and its importing countries. The second one is the effective exchange rates of the RMB against currencies of component-sourcing countries (the variable definition given below). The regression specification takes the following form:

$$\ln CHE_{ijt} = \alpha + Z'_{it}\beta + \phi_1 \ln BER_{it} + \phi_2 \ln RER_{jt} + \varepsilon_{ijt}, \qquad (1)$$

in which subscript *i* denotes importing countries, *j* denotes industry and *t* year. The dependent variable (*CHE*) is the volume of China's exports of final products to a set of trading-partner countries (US and euro countries). *Z* is a vector of variables (other than exchange rate variables) that determines the volume of China's final-goods exports. *BER* denotes real bilateral exchange rates for the RMB against currencies used in importing countries (defined as a foreign currency per RMB). Hence, an increase in BER means appreciation of the RMB. The expected sign for BER is negative. *RER* is an industry-level RMB real effective exchange rate (RER) computed at SITC two-digit level (see below for a formula). The computation closely follows the industry-level computed RER in Goldberg (2004). The symbol *ln* before a variable denotes the natural logarithm. ε is a random variable that is *i.i.d.* normal with mean zero and variance u_u.

As shown in Section 3, the majority of China's component imports come from East Asian countries, and China's final product exports are mainly destined for industrial countries in North America and Europe. Hence, in construction of relevant exchange rates, we use the RMB's RER against the currencies of nine East Asian countries (Japan, Hong Kong—China, Taiwan, South Korea, Singapore, Malaysia, Indonesia, Thailand, and the Philippines) for component suppliers' RER. Each industry is indexed in *j* in SITC two-digit level and East Asian exporters to China are indexed as *c*. The weight is determined by the share of that country *c* in China's component imports in each industry.

$$RER_t^j = \sum_c w_t^{jc} er_t^c, \quad \text{where } w_t^{jc} = \frac{M_t^{jc}}{\sum_c M_t^{jc}}, \qquad (2)$$

where *M* stands for China's component imports for those East Asian countries and *er* represents the bilateral exchange rates of each of China's component sourcing countries—*c* against the RMB. The bilateral real exchange rates are constructed by multiplying a country's nominal exchange rate (defined as a local currency per RMB) by the ratio of the consumer price indices of China against East Asian suppliers. The subscript *t* means that the weight varies through time. A real appreciation of the RMB's RER against currencies of component providers would essentially lower the marginal costs of importing, exerting upward pressure on China's final-good exports.

For a vector of explanatory variables contained in *Z*, a gravity specification is formed by including a constant, the GDP of importing countries (to measure market size), the distance between China and trading countries, and a dummy variable for country pairs that share a common language. All variables except the dummies and the constant are in logarithm.

The data on the bilateral trade at five-digit commodity level are drawn from the UN Comtrade database. We use annual data series for the period 1992–2008. The initial year is set to 1992 because from this year more countries started reporting under SITC Revision 3, and the end year is 2008 for which the latest data are available. This time span also covers the period when China's exchange rate to the US dollar became flexible to some extent: 2005–08. GDP and GDP per capita of China and her trading-partner countries are drawn from the World Bank's *Development Indicators*.

4. Results

We employ the fixed-effect model of the panel data estimation methods because it will address the multilateral resistance terms accounting for cross-country price variations in the gravity modeling (Anderson and van Wincoop, 2004; Feenstra, 2004).[4] Regression results of fixed-effect models are presented in Table 4 and results for the fixed effect with time dummies are presented in Table 5. Columns 1–3 report the regression results including all two-digit industries of both SITC 7 (machinery and transport equipment) and SITC 8 (miscellaneous manufacturing). As shown in Table 1, SITC 8 includes relatively more labour-intensive goods such as clothing and footwear. The results only for industries within SITC 7 are presented in columns 4–6, and columns 7–9 show results for products under SITC 8. We run separate regressions for

[4] Of course, one limitation of the fixed-effect estimator for the gravity modeling is that it will automatically drop a time-invariant variable (a geographical distance).

two industries because the degree of imported parts and components contained in China's final product exports might differ between two industries. We expect higher elasticity of exchange rate changes for the machinery and transport equipment industry (SITC 7) than for SITC 8 because of a higher content of imported parts and components. We also introduce the RMB's BER and supplier-weighted RER in separate regressions because of high correlation between two exchange rate indices.

Results in Table 4 show that an appreciation of the RMB's bilateral real exchange rates (BER) on average would decrease China's final-product exports as expected (column 1). A 1 percent appreciation of BER would decrease China's final-product exports by 0.96 percent. Considering the fact that the RMB has been pegged to the US dollar for most of the estimation period, this effect is quite large. An appreciation of the RMB's real effective exchange rate (RER), as expected, would increase China's exports: a 1 percent appreciation of RER would increase them by 0.66 percent. These effects are found to be statistically significant at the 1 percent level. These findings show that the RMB's appreciation against both importing countries and component suppliers would have offsetting effects on China's exports. Once BER and RER are estimated separately, however, in columns 2 and 3 in Table 4a, the statistical significance of BER is lost, although the estimated sign remains negative. Perhaps this is driven by a high correlation between BER and RER (a correlation coefficient is about 0.84), while the estimated coefficient for RER in column (3) remains similar to the one found in column (1) and retains a 1 percent statistical significance. This makes sense since most of the value added in China's final exports comes from those East Asian countries.

We also found that export elasticity is greater in machinery and transport equipment (SITC 7) than more relatively labour-intensive industries in SITC 8, as expected. A 1 percent appreciation of RER leads to an increase of China's exports by 1.15 percent (column 4), whereas the same effect shows only 0.3 percent in SITC 8 (column 7). Again, this difference in the estimated magnitude comes from greater contents of imported parts and components in the electronics and transport equipment industries.

Table 5 presents results of the fixed-effect model with the year fixed effects. The results change somewhat, although it is understandable that the year effects drive time-series components of growing China's exports under the estimation period. Now it is found that the estimated sign for the RMB's RER turns to negative, while that of BER remains an expected negative sign. This implies that a 1 percent appreciation of BER would decrease China's exports by 0.6 percent, and also a 1 percent appreciation of RER would decrease them by 0.1 percent (column 1). In columns (2) and (3) of Table 5, the estimated coefficients for both BER and RER virtually remain the same with statistical significance. Column (4), however, shows the expected signs for RER: a 1 percent appreciation of RER would increase China's exports by 0.3 percent, which is lower than the one shown in Table 4. Moving into column (7), the estimated coefficient for RER for more labour-intensive products changes again. These findings show that the exchange rate effect on China's exports, especially RER, is quite sensitive to the specifications.

We briefly summarize other variables. As found in other studies, an income elasticity of China's exports is found to be about unity and the income effects are larger in the machinery and transport equipment industry (SITC 7). This is consistent with a view that income elasticity for technology-intensive products (such as digital cameras and laptop computers) is more elastic than for relatively labour-intensive products such as clothing and footwear. The income elasticity is also, however, not robustly estimated. In Table 5, income elasticity shows an unexpected negative sign and is hardly statistically significant for all regressions. As found in Thorbecke (2011), the WTO effect is positive and statistically significant in all regressions.

Table 4. Export Elasticity of Exchange Rate Changes to China's Final Products (Fixed Effect)

	SITC 7 and 8			Electronics and transport equipment (SITC 7)			Miscellaneous Manufactured (SITC 8)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Importer GDP	0.84	0.98	1.12*	1.05**	1.16	1.39**	0.58	0.69	0.81
	[0.511]	[0.675]	[0.569]	[0.474]	[0.737]	[0.577]	[0.522]	[0.593]	[0.545]
BER	**–0.96*** **	**–0.76**		**–1.24*** **	**–0.82**		**–0.74** **	**–0.68**	
	[0.319]	**[0.481]**		**[0.327]**	**[0.545]**		**[0.330]**	**[0.409]**	
RMB RER	**0.66*** **		**0.61*** **	**1.15*** **		**1.06*** **	**0.30*** **		**0.28*** **
	[0.074]		**[0.084]**	**[0.093]**		**[0.106]**	**[0.057]**		**[0.066]**
WTO	1.11***	1.62***	1.11***	0.89***	1.80***	0.91***	1.13***	1.36***	1.12***
	[0.133]	[0.223]	[0.160]	[0.131]	[0.248]	[0.161]	[0.139]	[0.196]	[0.158]
Constant	–8.85	–10.33	–15.03	–16.82	–15.99	–24.09	0.26	–1.74	–4.94
	[13.062]	[17.388]	[14.926]	[12.087]	[18.984]	[15.085]	[13.355]	[15.308]	[14.341]
Obs	4,976	4,976	5,101	2,985	2,985	3,062	1,991	1,991	2,039
R-squared	0.643	0.587	0.635	0.689	0.589	0.677	0.658	0.632	0.648

Note: SITC 7 = electronics and transport equipment and SITC 8 = miscellaneous manufactured articles. Standard errors based on White's heteroscedasticity correction cluster by importing countries for SITC two-digit industry level are given in parentheses with statistical significance (two-tailed test) denoted as: *** 1%; ** 5%; and * 10%.

Table 5. Export Elasticity of Exchange Rate Changes to China's Final Products with the Year Effect (Fixed Effect with the Year Effects)

	SITC 7 and 8			Electronic and transport equipment (SITC 7)			Miscellaneous Manufactured (SITC 8)		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Importer GDP	–0.29	–0.28	–0.35	–0.3	–0.31	–0.35	–0.26	–0.25	–0.34
	[0.352]	[0.351]	[0.416]	[0.405]	[0.408]	[0.469]	[0.333]	[0.334]	[0.396]
BER	**–0.60***	**–0.60***		**–0.48**	**–0.49**		**–0.76****	**–0.75****	
	[0.339]	**[0.335]**		**[0.402]**	**[0.408]**		**[0.278]**	**[0.266]**	
RMB RER	**–0.10*****		**–0.10*****	**0.33*****		**0.35*****	**–0.25*****		**–0.24*****
	[0.024]		**[0.025]**	**[0.069]**		**[0.068]**	**[0.018]**		**[0.018]**
WTO	3.92***	2.53***	3.86***	2.17***	2.29***	1.30***	2.07***	2.74***	1.75***
	[0.218]	[0.241]	[0.244]	[0.315]	[0.269]	[0.145]	[0.224]	[0.112]	[0.137]
Constant	22.84**	22.55**	25.27**	21.92**	22.69**	23.78*	23.27**	22.45**	26.37**
	[9.306]	[9.302]	[11.056]	[10.412]	[10.519]	[12.408]	[9.195]	[9.242]	[10.557]
Obs	4,976	4,976	5,101	2,985	2,985	3,062	1,991	1,991	2,039
R-squared	0.760	0.759	0.761	0.761	0.758	0.764	0.842	0.831	0.835

Note: SITC 7 = electronic and transport equipment and SITC 8 = miscellaneous manufactured articles). Standard errors based on White's heteroscedasticity correction cluster by importing countries for SITC two-digit industry level are given in parentheses with statistical significance (two-tailed test) denoted as: *** 1%; ** 5%; and * 10%.

5. Conclusion

China's emergence as an exporting powerhouse in recent years has attracted much attention from policymakers around the world. Industrial countries are concerned about the ever-growing size of trade deficits with China. Developing countries in East Asia fear export competition with China in third-country markets. Many of them accuse China of unreasonably maintaining a low value of the Chinese currency to give a competitive edge to China's exports in the world market. This chapter contributes to this debate by examining China's export elasticity to changes in the RMB from the perspective of China as a final-assembly country. China's trade specialization is based on processing whereby the assembly of final products uses imported parts and components from East Asian countries that are then exported to industrial countries in the West. We computed two relevant exchange rate indices of the RMB for China's exports: one against prices of component-supplying countries' currencies and the other against prices of Western industrial countries. We found that a 1 percent appreciation of the RMB against industrial countries in the West would decrease China's final-product exports by 0.96 percent, but a 1 percent appreciation of the RMB's component import-weighted real effective exchange rate (RER), *ceteris paribus*, would increase China's exports by 0.66 percent. This is because an appreciation of the RMB against component suppliers in East Asian countries would increase China's exports by importing parts and components more cheaply. This effect is greater in the machinery and transport equipment industry in which reliance on imported parts and components remains high and the Chinese value added remains low. This finding implies that a bilateral exchange rate change of the RMB alone will have less than the expected impact on the volume of China's exports and thus will contribute less to correcting some of the growing trade imbalance with China. The policy implication is that the use of the exchange rate tool is more complex and less predictable for countries that take part in supply chains than for those that export goods containing mainly a high proportion of domestic value added.

References

Ahmed, S. (2009). "Are Chinese Exports Sensitive to Changes in the Exchange Rates?" *Federal Reserve Board International Finance Discussion Paper* 987.

Anderson, J.E., and E. van Wincoop (2004). "Trade Costs." *Journal of Economic Literature* 42, no. 3: 691–751.

Athukorala, P. (2005). "Product Fragmentation and Trade Patterns in East Asia." *Asian Economic Papers* 4(3): 1–27.

Athukorala, P. (2009). "The Rise of China and East Asian Export Performance: Is the Crowding-Out Effect Warranted." *World Economy* 32, no. 2: 234–66.

Athukorala, P. (2011). "Production Networks and Trade Patterns in East Asia: Regionalization or Globalization?" *Asian Economic Papers* 10, no. 1: 66–95.

Athukorala, P., and N. Yamashita (2006). "Production Fragmentation and Trade Integration in a Global Context." *North American Journal of Economics and Finance* 17, no. 4: 233–56.

Baldwin, R., and D. Taglioni (2011). "Gravity Chains: Estimating Bilateral Trade Flows When Parts and Components Trade is Important." *NBER Working Paper Series* 16672.

Cheung, Y., M.D. Chinn, and E. Fujii (2010). "China's Current Account and Exchange Rate." In *China's Growing Role in World Trade*, eds R.C. Feenstra and S. Wei. Cambridge, Mass.: Cambridge University Press.

Dean, J., K.C. Fung, and Z. Wang (2007). "Measuring the Vertical Specialisation in Chinese Trade." *USITC Working Paper* 2007-01-A. Washington, DC: US International Trade Commission.

Feenstra, R.C. (2004). *Advanced International Trade: Theory and Evidence*. Princeton, NJ: Princeton University Press.

Feenstra, R.C., and G.H. Hanson (1996). "Globalization, Outsourcing, and Wage Inequality." *American Economic Review* 86(2): 240–5.

Feenstra, R., and Q. Wei (2010). *China's Growing Role in World Trade*. Cambridge, Mass.: Cambridge University Press.

Goldberg, L.S. (2004). "Industry-Specific Exchange Rates for the United States." *FRBNY Economic Policy Review* 10, no. 1: 1–16.

Hummels, D., J. Ishii, and K.-M. Yi (2001). "The Nature and Growth of Vertical Specialization in World Trade." *Journal of International Economics* 54, no. 1: 75–96.

Krugman, P. (2008). "Trade and Wages, Reconsidered." *Brookings Papers on Economic Activity 1: Macroeconomics*: 103–38.

Marquez, J., and J. Schindler (2007). "Exchange Rate Effects on China's Trade." *Review of International Economics* 15: 837–53.

Thorbecke, W. (2011). "Investigating the Effect of Exchange Rate Changes on China's Processed Exports." *Journal of the Japanese and International Economies* 25, no. 2: 33–46.

Thorbecke, W., and G. Smith (2010). "How Would an Appreciation of the Renminbi and Other East Asian Currencies Affect China's Exports?" *Review of International Economics* 18, no. 1: 95–108.

Wang, Z., and S. Wei (2010). "What Accounts for the Rising Sophistication of China's Exports?" In *China's Growing Role in World Trade*, eds R.C. Feenstra and S. Wei. Cambridge, Mass.: Cambridge University Press: 63–104.

Yamashita, N. (2010). *International Fragmentation of Production: The Impact of Outsourcing on the Japanese Economy*. Cheltenham, UK: Edward Elgar.

Yeats, A.J. (2001). "Just How Big is Global Production Sharing?" In *Fragmentation: New Production Patterns in the World Economy*, eds S.W. Arndt and H. Kierzkowski. Oxford: Oxford University Press.

Data Appendix

There is no unique way of quantifying the magnitude and pattern of vertical specialization of trade.[5] The approach taken in this chapter relies on published international trade statistics on parts and components identified at the most highly disaggregated commodity level (that is, five digits). This method was pioneered by Yeats (2001) who used a list of commodity classifications based on Standard International Trade Classification (SITC) Revision 2 and extended by Athukorala (2005) using SITC Revision 3. We make extensions to Yeats (2001) and Athukorala (2005). Identification of trade in parts and components in this paper takes a more systematic approach following the commodity classification system provided by the UN Broad Economic Category (BEC), whereas Yeats (2001) and Athukorala (2005) simply identify a list of components by focussing on the product description at the five-digit level. The BEC classification system is intended to categorize product-based SITC trade statistics into an economic activity-based classification.[6]

Among seven major commodity categories under BEC, industrial supplies (BEC 2), capital goods (BEC 4), and transport equipment (BEC 5) include a subcategory for "parts and accessories". The corresponding subcategories are BEC22, BEC42 and BEC53. Not all of the items classified under BEC 22, 42 and 53, however, correspond with parts and components. Only the items under these three subcategories that at the same time correspond with SITC 7 (machinery and transport equipment) are identified as parts and components in this study. Limiting items to SITC 7 prevents the inclusion of some components traded as "products in their own right" under specific trade names (for example, automobile tyres, which belong to SITC 6). The final list prepared

[5] Feenstra and Hanson (1996) also develop a measure of international outsourcing in their widely cited papers. Their measure, however, captures only the *intensity* of foreign outsourcing for given industries, not the extent of the associated trade flows. Hence, we do not discuss the Feenstra–Hanson approach here. See Yamashita (2010) for more detailed discussion on this measurement issue.

[6] The original BEC was published in 1971, Revision 1 was issued in 1976 and Revision 2 in 1986. The BEC was developed in such a way that it would provide the elements that enable the construction of aggregates of trade goods approximately comparable with those for the three basic classes of goods in the 1968 Social National Account (SNA). See a more detailed description of the BEC at: http://unstats.un.org/unsd/cr/family2.asp?Cl=10.

through this procedure contains a total of 264 items.[7] We also define the final assembled products that are not specified as components within the machinery sector.

A focus on the machinery product category is justified for the following reasons. First, the United Nations' currently available commodity trade classification permits the systematic separation of trade in parts and components in the machinery and transport equipment industry of SITC 7. Vertical specialization of trade in other sectors such as clothing, chemicals and toys has been increasingly important, but the current data-recording system does not permit a satisfactory separation of those commodities. Second, many have argued that vertical specialization of trade in the high-tech machinery industry has been the driving force of the recent international fragmentation of production (Athukorala and Yamashita, 2006; Krugman, 2008). Furthermore, as shown in the China Custom Statistics, electronic and electrical machinery and transport equipment industries account for the bulk of processing exports that use most of the imported parts and components (Feenstra and Wei, 2010; Wang and Wei, 2010). Hence, the focus of this industry is not a major limitation.

Alternatively, some studies have used the input–output (I/O) table to quantify the degree of vertical specialization of trade for China (Dean et al., 2007; Hummels et al., 2001). The following formula is frequently employed to compute the extent of vertical specialization in trade (Dean et al., 2007; Ishii et al., 2001):

$$VS = \mathbf{u}\mathbf{A}^{\mathbf{m}}\left[\mathbf{I} - \mathbf{A}^{\mathbf{D}}\right]\mathbf{X},$$

where $\boldsymbol{u}$ is a 1 x n vector of 1s, $\boldsymbol{A^M}$ is an n x n imported coefficient matrix, $\boldsymbol{I}$ is the identity matrix, $\boldsymbol{A^D}$ is the n x n domestic coefficient matrix and $\boldsymbol{X}$ is n x 1 export vector. Hence, *VS* measures all the imported inputs including those iterated over the entire production system of China, which are used to produce exports from all n sectors. While the I/O table approach can precisely measure the degree of vertical specialization in trade, the long continuous-time period coverage of the data does not exist because of the very nature of the table. The state statistical agency normally publishes the I/O table every five years. In the case of China, a study by Dean et al. (2007) reports only two

[7] A complete list of parts and components identified by BEC is available from the author upon request.

years: 1997 and 2002. In addition, the I/O table focuses only on the import side by construction. The estimate of vertical specialization in trade confines only to the estimate of imported intermediate inputs used for exports. The trade data approach described above can, however, cover both the export and the import side. Dean et al. (2007) compared two alternative methods—trade data and the I/O table—of quantifying vertical specialization in trade for China and concluded that estimates from two methods do not differ significantly.