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Abstract

The People's Republic of China (PRC) has become an important importer for many countries. This paper investigates how turbulence in the PRC can spill over to trading partners through the trade channel. Exports from several East and Southeast Asian countries to the PRC exceed 10 percent of their GDPs. To shed light on countries' exposures to the PRC, this paper estimates a gravity model. The results indicate that Taiwan and the Association of Southeast Asian Nations are exposed to the PRC because they produce goods for the Chinese market and exposed to advanced economies because they ship parts and components to the PRC for processing and re-export to the West. South Korea is more exposed to a slowdown in advanced economies that purchase processed exports from the PRC than to a slowdown in the PRC. Major commodity exporters such as Australia, Brazil, Indonesia, and Saudi Arabia and exporters of sophisticated consumer and capital goods such as Germany and Switzerland are exposed to a slowdown in the Chinese domestic market. This paper also estimates import elasticities for the PRC. The results indicate that imports for processing into the PRC are closely linked to processed exports from China to the rest of the world and that ordinary imports are closely linked to Chinese GDP. The renminbi exerts only a weak impact on imports, however. The paper concludes by recommending that firms and countries diversify their export base and their trading partners to reduce their exposures to the PRC and to advanced economies.

Keywords: F32, F14, F22

JEL classification: PRC growth spillovers; Gravity model; Ordinary and processing trade; Import elasticities

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1. Introduction

The People's Republic of China (PRC) is the second largest economy in the world, the final link in East Asian supply chains, and a voracious consumer of natural resources. The value of the PRC's imports each year exceeds a trillion dollars. Many firms depend on exports to the PRC for a large share of their profits. The PRC's economy, after growing at close to double digit rates since the early 1990s, has encountered turbulence. Net capital outflows have accelerated since 2014 and generated depreciation pressures. Overcapacity has emerged in several sectors including steel, shipbuilding, and chemicals. Trade wars and economic challenges abroad are generating headwinds for the Chinese economy. How will imports from the PRC's trading partners be affected?

To answer this question, it is necessary to distinguish between different types of imports and different countries. For instance, imports for processing can only be used to produce goods for re-export while ordinary imports are destined primarily for the domestic market (see Gaulier, Lemoine, and Ünal, 2011). Xing (2015) presented econometric evidence indicating that processed exports flow disproportionately to high income countries. Imports for processing should thus depend on demand conditions and exchange rates in the high income countries purchasing the final good while ordinary imports should depend on demand conditions and exchange rates in the PRC. Countries such as Australia and Brazil that export raw materials such as iron ore should be especially affected by slowdowns in sectors such as steel that require natural resources.

Previous work has investigated the factors affecting the PRC's imports. Cheung, Chinn, and Qian (2012), for instance, employed dynamic ordinary least squares (DOLS) techniques and quarterly aggregate trade data over the 1994 – 2010 sample period. They reported that the exchange rate coefficient in a standard import equation enters with the wrong sign. Cheung, Chinn, and Fujii (2010) and Garcia-Herrero and Koivu (2007) also found that an appreciation of the renminbi is associated with a decrease in Chinese imports in many specifications. The incorrect sign is often explained by the fact that the PRC imports inputs from supply chain countries that are used to produce goods for re-export (see, e.g., Kamada and Takagawa, 2005). An exchange rate depreciation may increase exports and thus imported inputs.

To control for this, Cheung, Chinn, and Qian (2012) included exports in the import demand function for processed trade. They reported that in this case the exchange rate coefficient on imports for processing was correctly signed and statistically significant at the 10 percent level and that the elasticity equaled 1.1. They also reported that the coefficient on processed exports in the regression was statistically significant and slightly above unity.

Freund, Hong, and Wei (2011) employed annual data disaggregated at the Harmonized System (HS) 4-digit level between the PRC and all of its trading partners over the 1997-2005 period. Estimating a panel data set with the variables measured in first difference form, they reported correctly signed exchange rate elasticities of 0.2 for processed and ordinary imports. They also found that the income elasticities were small.

The IMF (2011) reported the results of a study using data disaggregated at the HS 6-digit level. Employing a partial equilibrium model and information from input-output tables, they first examined how relative price changes affect imports taking account of substitution elasticities and the quantity of imported inputs used to produce exports. They then determined how import demand is affected by shifts in the structure of exports. Finally, they performed simulations to calculate exchange rate elasticities. Aggregating the sectoral findings to the economy-wide level, they reported that a ten percent renminbi depreciation is associated with a two percent decline in imports.

This paper first investigates what countries are exposed to a slowdown in the PRC through trade. Table 1 reports countries' exports to the PRC in 2016 relative to their gross domestic products (GDPs) and their total exports.[1] The table also reports the ratio of processed exports to the sum of processed and ordinary exports. There are 13 economies in the table with export/GDP ratios exceeding 2 percent. The most exposed economies in Asia according to this criterion are Taiwan, South Korea, the Association of South East Asian nations (henceforth ASEAN), and Japan. Those most exposed outside of Asia are Australia, Switzerland, Saudi Arabia, Germany, and Brazil. Table 1 shows that more than half of Taiwan's and South Korea's exports are processed exports and a little less than half of ASEAN and Japan's exports are processed exports. For Australia, Switzerland, Germany, and Brazil the lion's share of exports are ordinary exports.

To shed further light on these countries' exposures to the Chinese economy, this paper employs a gravity model. The gravity model is a workhorse for explaining bilateral trade flows. It controls for distance and economic size. The results indicate that both Germany and countries exporting primary products such as Australia, Brazil, and Saudi Arabia export much more to the PRC than the model predicts. To investigate what countries are exposed to the Chinese domestic market and what countries are exposed to the markets purchasing processed exports from the PRC, the paper also uses a gravity model that differentiates between imports for processing and ordinary imports. Korea and Taiwan are large positive outliers in sending imports for processing to the PRC and Australia, Brazil, and Germany are large positive outliers in sending ordinary imports to the PRC.

[1] The focus is on 31 major exporters from Asia and the rest of the world. These countries are listed at the end of Section 3.1.

The paper then investigates import elasticities for China. For processing trade, it reports that there is a close relationship between imports for processing and processed exports and that exchange rate elasticities are insignificant. For ordinary trade, it reports income elasticities of 1.6 and exchange rate elasticities that are correctly signed and equal to 0.4. These results imply that a reduction in processed exports driven by factors in advanced economies and a reduction in Chinese GDP matter for Chinese imports. A renminbi depreciation would only matter if it were large.

The next section employs a gravity model to investigate the countries that are exposed to the PRC through trade. Section 3 estimates trade elasticities. Section 4 concludes.

2. Using a Gravity Model to Investigate Imports into China

2.1 Data and Methodology

The gravity model is useful for estimating bilateral trade flows. Traditional gravity models posit that bilateral trade between two countries is directly proportional to GDP in the two countries and inversely proportional to the distance between them (Tinbergen, 1962). These models often include other factors affecting bilateral trade costs such as whether trading partners share a common language. Many have noted that the gravity model is one of the most successful empirical models in economics (see, e.g., Leamer and Levinsohn, 1995 and Baltagi, Egger, and Pfaffermayr, 2014).

Traditional gravity models take the form:

$$lnEx_{ijt} = \beta_0 + \beta_1 lnY_{it} + \beta_2 lnY_{jt} + \beta_3 lnDIST_{ij} + \beta_4 LANG + \beta_5 FTA_{ij} + \delta_i + \Omega_j + \pi_t + \varepsilon_{ijt} \quad (1)$$

where Ex_{ijt} represents exports from country *i* to country *j*, *t* represents time, *Y* represents GDP, *DIST* represents the geodesic distance between two countries, *LANG* is a dummy variables equaling 1 if the countries share a common language and 0 otherwise, *FTA* is a dummy variable equaling 1 beginning in the year when a free trade agreement enters in force between two countries and 0 before, and δi, Ωj, and π_t are country *i*, country *j*, and time fixed effects.

Anderson and Van Wincoop (2003) have constructed theoretical foundations for gravity models. They demonstrated that exports should depend on outward and inward multilateral resistance terms. These terms take into account that exports and imports between two countries depend, not only on trade costs between the two countries, but also on trade costs between third countries. As an example, trade between country *i* and country *j* can be affected if country *i* enters into an FTA with a third country *k*.

Theoretically based gravity models can be estimated by the equation:

$$lnEx_{ijt} = \beta_0 + \beta_1 lnDIST_{ij} + \beta_2 LANG + \beta_3 FTA_{ij} + \delta_i + \Omega_j + \pi_t + \varepsilon_{ijt} \qquad (2)$$

where the variables are as defined above. Here the distance and language variables capture trade costs for exports between countries *i* and *j* and the exporter and importer fixed effects variables capture the outward and inward multilateral resistance terms.[2]

The gravity models above are log-linear and have frequently been estimated using panel least squares methods. Santos Silva and Tenreyro (2006) demonstrated that this technique can

[2] Time-varying fixed effects are often included in equation (2). When estimated for this paper, however, results with time-varying fixed effects led to badly behaved residuals and R-squared statistics more that 20 percent lower than in the other specifications. Since the goal of using gravity models in this paper is prediction, results with time-varying fixed effects are not included.

lead to biased estimates when there is heteroskedasticity in the data-generating process. They found based on simulations that Poisson pseudo-maximum-likelihood (PPML) estimators often perform better both in terms of bias and efficiency.

In order to provide robust estimates of imports into the PRC, a variety of specifications are employed. These include the models in equation (1) and (2) and models estimated using both panel least squares and PPML techniques.

Data on exports and GDP are obtained from the CEPII-CHELEM data base. Data on distance and common language are obtained from www.cepii.fr. Distance is measured in kilometers and represents the geodesic distance between economic centers. Data on whether countries had an FTA in place are taken from the database entitled "Participation in Regional Trade Agreements" that is available from the World Trade Organization.[3]

The gravity model is estimated as a panel using annual data for the following economies: Australia, Austria, Brazil, Canada, the PRC, Denmark, Finland, France, Germany, India, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, the Netherlands, Norway, the Philippines, Poland, Saudi Arabia, Singapore, South Korea, Spain, Sweden, Switzerland, Taiwan, Thailand, Turkey, the United Kingdom, and the United States. The sample period extends from 1988 to 2015.[4]

2.2 Results

[3] This database is available at www.wto.org.

[4] Goods imports are employed because comprehensive data on services imports between the 31 countries over the sample period were not found. According to data from the State Administration of Foreign Exchange, goods imports have on average equaled more than 85 percent of goods and services imports into China since 2003. Thus this study focuses on the lion's share of China's imports.

Table 2 presents the results from estimating the gravity models. Columns (1) and (3) present results from PPML estimation and columns (2) and (4) from panel OLS estimation. Columns (1) and (2) present results from estimating equation (1) and columns (3) and (4) present results from estimating equation (2). The model performs well, with all of the coefficients of the expected signs and statistically significant at the 1 percent level.

To investigate which countries are more exposed to the PRC than one would expect based on distance, economic size, and the other gravity variables, Figure 1 plots the difference between actual exports to the PRC in 2015 and the average of predicted exports to the PRC in the four specifications.[5] In Figure 1, values above the diagonal line indicate that exports are more than predicted and values below the line indicate that exports are less than predicted. The vertical distance between the observation and the diagonal line measures the degree of over- or under-prediction. The results indicate that Australia's exports to the PRC were $51 billion more than expected, Germany's exports $33 billion more than expected, Brazil's exports $31 billion more than expected, Saudi Arabia's exports $11 billion more than expected, Taiwan's exports $30 billion more than expected, and Korea's $36 billion less than expected. Indonesia, Malaysia, and Japan also exported less than predicted.

Figure 2 plots the analogous results for 2014. The figure indicates that Australia's exports to the PRC were $71 billion more than expected, Germany's exports $50 billion more than expected, Brazil's exports $31 billion more than expected, Saudi Arabia's exports $27 billion more than expected, Taiwan's exports $37 billion more than expected, and Korea's $27 billion less than expected. Indonesia and Malaysia exported less than predicted to the PRC in 2014.

[5] Results for each of the four specifications individually are available on request.

In every year since the Global Financial Crisis of 2008, exports from Germany, Australia, Brazil, Saudi Arabia, and Taiwan to the PRC have been large positive outliers. Exports from Korea, on the other hand, have on average been $20 billion less than predicted since 2011.

To shed further light on these patterns, Table 3 reports the leading export categories from the countries listed in Figures 1 and 2. The table is ordered so that the leftmost column presents data for the economy with the largest ratio of exports to China relative to GDP, the second column from the left presents data on the economy with the second largest ratio of exports to GDP, and so on. For the six most exposed economies (Taiwan, Malaysia, Korea, Thailand, Singapore, and the Philippines), exports of electronics products predominate. The category 'electronic parts and components' is the largest for five of the six most exposed economies, and on average across the six economies equals one-third of their exports to China. The share of all electronics products relative to total exports ranges from 39 percent for Thailand to 64 percent for Malaysia. Thus, one reason why Asia's exports to China are large is because China is part of the regional electronics value chain.

For Australia, Brazil, and Indonesia, commodities and primary products make up most or virtually all of the exports. For Saudi Arabia, crude oil makes up 67 percent of its exports. For Germany, exports related to the automobile industry comprise more than 30 percent of exports. Sophisticated machinery, capital goods, and machine tools also make up a large shares of Germany's exports. Japan's exports to the PRC are diversified, with no single category exceeding 10 percent of its exports to China.

Another way to investigate what the PRC is importing from these countries is to estimate a gravity model including processing and ordinary trade separately. As Gaulier, Lemoine, and Ünal (2011) discussed, imports for processing are goods that are imported under a special customs regime and that can only be used to produce goods (processed exports) for re-export and ordinary imports are intended primarily for the domestic market.

In this gravity model the PRC is treated as two separate economies. The first receives imports for processing (primarily parts and components) from other countries and ships processed exports (final assembled goods) abroad. The second purchases ordinary imports (imports for the domestic market) from other countries and ships ordinary exports (exports with high domestic value added) abroad.

Data on ordinary and processing trade over the 1992 to 2016 sample period come from the China Customs Statistics. Data are obtained for the following economies: Australia, Austria, Brazil, Canada, China (ordinary trade), China (processing trade), Denmark, Finland, France, Germany, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, the Netherlands, the Philippines, Singapore, South Korea, Spain, Sweden, Taiwan, Thailand, the United Kingdom, and the United States. The other data for the gravity model are obtained from the sources listed above and the model is estimated for the same four specifications discussed above.

Figure 3 plots the average of predicted and actual imports for processing into the PRC in 2016 across the four specifications and Figure 4 plots this for ordinary imports into the PRC in 2016. Korea and Taiwan stand out as clear positive outliers in processing trade, with Korea exporting $36 billion more than predicted and Taiwan exporting $49 billion more than predicted. Exports from Malaysia, Thailand, and the Philippines are more than predicted. Exports from Indonesia are much less than predicted, indicating that Indonesia has succeeded less than its ASEAN neighbors in joining regional value chains.

In Figure 4, Australia, Brazil, and Germany and Taiwan are positive outliers in ordinary trade. Australia's predicted exports equaled $5 billion, and its actual exports equaled $63 billion.

Brazil's predicted exports equaled $3 billion, and its actual exports equaled $38 billion. Germany's predicted exports equaled $20 billion, and its actual exports equaled $67 billion. Taiwan's predicted exports equaled $35 billion, and its actual exports equaled $50 billion. For Brazil and Australia, Table 3 indicates that this surplus reflects commodity exports. For Germany, Table 3 indicates that the surplus reflects exports related to the auto and machinery industries. For Taiwan, Table 3 indicates that the surplus reflects electronics exports. Japan exported $12 billion more than predicted and Korea $5 billion less than predicted. Korea's shortfall in overall exports to the PRC seen in Figure 1 thus reflects lower than expected exports aimed at the local market rather than a shortfall of parts and components destined for assembly in PRC and re-export to the rest of the world.

Are the results for Korea driven by foreign value-added that is incorporated into Korea's exports instead of domestic value-added? Korea's exports of parts and components to China are primarily electronics goods. Korea's domestic content in electronics parts and components (ep&c) production has become large as companies such as Samsung and LG have invested heavily in plant, equipment, and technology. One way to observe this is to look at the value of ep&c exports from Korea to the world divided by the value of ep&c imports into Korea from the world. Many countries in Asia rely heavily on value-added from ep&c imports in order to produce ep&c exports.[6] For Korea, this ratio grew from 1 in 2001 to almost 2 in 2016.[7] Thus Korea's outsized parts and components exports to China that are evident in Figure 3 reflect more and more value-added coming from Korea.

[6] For instance, Hiratsuka (2011) documented how companies in Thailand assemble hard disk drives using imported printed circuit boards, pivots, voice coils, bases, media, and other core components.
[7] This ratio is calculated using data from the CEPII-CHELEM database.

For ordinary exports from Korea such as smartphones, computers, and cosmetics that are destined for the Chinese market, much of the value-added also comes from Korea.[8] To the extent that ordinary exports from Korea have more foreign value-added than processed exports do, the exposure of Korean firms to the Chinese market would be even less than that implied by Figure 4. Thus the results reported here for Korea should be robust to considerations of foreign value-added incorporated into Korean exports.

This evidence for Korea may shed light on a finding of Inoue, Kaya, and Ohshige (2015). Using a Global Vector Autoregressive model and quarterly data over the 1979Q1-2014Q3 period, they reported that a one percent negative Chinese gross domestic product shock would only reduce Korean GDP by 0.07 percent. If Korean firms are more exposed to countries buying final exports from China than to the Chinese domestic market, it makes sense that a slowdown in China would have an attenuated effect on the Korean economy.

3. Using the Imperfect Substitutes Model to Estimate Import Elasticities for China

In the same way that the gravity model is a workhorse for estimating bilateral trade flows, the imperfect substitutes model is a workhorse for estimating trade elasticities. As discussed by Goldstein and Khan (1985), the imperfect substitutes model implies that imports should depend on the real exchange rate and on real GDP in the importing country:

$$\ln(im_t) = \alpha_1 + \alpha_2 \ln(rer_t) + \alpha_3 \ln(Y_t) + \varepsilon_t \quad (3)$$

where im_t represents real imports, rer_t represents the real exchange rate, and Y_t represents domestic real GDP.

[8] Kim (2016) noted that, unlike Japanese firms, some Korean firms employ a closed internal system whereby they source parts and components locally.

For ordinary imports, the specification in equation (3) is employed. For imports for processing, following the work of Ahuja *et al.* (2012), Baak (2014), Cheung, Chinn, and Qian (2012), Nishimura and Hirayama (2013), and others, the equation is modified. Processed exports are included as a right hand side variable to explain imports for processing. Since imports for processing cannot flow to the Chinese market but can only be used to produce goods for re-export, this is a better scale variable for processing trade.

Annual data over the 1992-2016 period are obtained from China Customs Statistics on imports for processing and ordinary imports from 24 leading exporting countries into the PRC. The exporting economies are Australia, Austria, Brazil, Canada, Denmark, Finland, France, Germany, Indonesia, Ireland, Italy, Japan, Malaysia, Mexico, the Netherlands, the Philippines, Singapore, Korea, Spain, Sweden, Taiwan, Thailand, the United Kingdom, and the United States. Annual data for total processed exports are also obtained from China Customs Statistics.

Import unit value indices are used to deflate Chinese imports and export unit value indices are used to deflate Chinese exports. These data come from the World Bank and are obtained from the CEIC database.

Data on real GDP and the real exchange rate are obtained from the CEPII-CHELEM database. Real GDP is measured in 2011 dollars. The bilateral real exchange rate between the PRC and country *j* is measured in purchasing power parity terms, as in Freund, Hong, and Wei (2011) and Tang (2014). An increase in the exchange rate variable represents an appreciation of the renminbi, implying that the coefficient on the exchange rate will be positive if an RMB appreciation increases exports.

In November 2012, Xi Jinping became the Secretary General of the Communist Party of China and vowed to crack down on corruption. One form of corruption that aroused media commentary was government officials receiving and wearing expensive imported luxury goods. Qian and Wen (2015) reported that the anti-corruption campaign resulted in a large drop in luxury imports. To control for this, a dummy variable is included in the regression for ordinary imports that equals 1 in 2013 and 2014 and 0 otherwise.

To specify the econometric model a battery of panel unit root tests and Kao residual cointegration tests are performed. The results point to a cointegrating relationship for the specification with ordinary imports but some ambiguity for the specification with imports for processing. Panel dynamic ordinary least squares (DOLS), a technique for estimating cointegrating relations, is thus employed for ordinary imports. Both DOLS and panel ordinary least squares (OLS) are employed for imports for processing. DOLS is a fairly robust estimator (see, e.g., Kao and Chiang, 2000, and Wagner and Hlouskova, 2010). The results reported below for imports for processing are very close using either panel DOLS and panel OLS. Thus we should be able to draw inferences about trade elasticities for imports for processing.

3.2 Results

Table 4 presents the results from estimating the import elasticities. Column (1) presents the findings for imports for processing using panel OLS estimation, column (2) presents the findings for imports for processing using panel DOLS estimation, and column (3) presents the findings for ordinary imports using panel DOLS estimation.

The results in columns (1) and (2) point to a tight link between imports for processing and processed exports. The coefficient on processed exports equals 0.86 for the OLS estimation and 0.75 for the DOLS estimation. The IMF (2005) noted that imports for processing should vary one-for-one with processed exports. Cheung, Chinn, and Qian (2012) reported that the coefficient on processed exports in the regression for imports for processing was slightly above unity. The results reported here are consistent with the IMF's claim and with Cheung *et al*.'s findings.

The coefficient on the real exchange rate in the regressions for imports for processing in columns (1) and (2) equals 0.02 for the OLS estimation and -0.06 for the DOLS estimation. These coefficients are not statistically significant. These values are less than the values of 0.2 found by Freund, Hong, and Wei (2011) and the IMF (2011) and much less than the elasticity of 1.1 reported by Cheung, Chinn, and Qian (2012).

The results in column (3) indicate that the income elasticity for ordinary imports equals 1.55 and is statistically significant at the 1 percent level. Thorbecke (2016) reported income elasticities averaging close to 2 for imports of consumer goods (a subset of ordinary imports) into the PRC.

The exchange rate elasticity for ordinary imports equals 0.38, and is statistically significant at the 1 percent level. This coefficient implies that a 10 percent RMB depreciation would reduce ordinary imports by 3.8 percent. This relatively small effect may reflect the fact that the lion's share of the PRC's ordinary imports has been inputs into the production process such as minerals, machinery, and base metals rather than final goods (see, e.g., Feenstra and Wei, 2010, and Gaulier, Lemoine, and Unal, 2011). Even in 2016, only 11 percent of the PRC's total imports were consumption goods. Inputs into the production process may be more sensitive to the business cycle and less sensitive to price changes than consumer goods.[9]

[9] Investigating only consumption imports, Thorbecke (2016) reported exchange rate elasticities averaging unity.

The important implication of these findings is that countries exporting to the PRC are exposed to a slowdown in the rest of the world that would reduce the PRC's processed exports and to a slowdown in the PRC that would reduce its ordinary imports. They are not very exposed to a depreciation of the renminbi, unless the depreciation is large.

4. Conclusion

This paper has investigated countries' exposures to the PRC through trade. It finds that, although several countries export a lot to the PRC, the story is complicated. Korea, for instance, is more dependent on exporting parts and components that are used to produce final goods for re-export to advanced economies than it is on exporting to the Chinese domestic market. Taiwan exports a lot of goods in both the processing and the ordinary customs regimes, so it is exposed to slowdowns in both developed economies and in China. Malaysia, the Philippines, and Thailand also export a lot in both categories. Since China is a large economy that is nearby, these ASEAN neighbors are vulnerable to a downturn in China. In addition, countries exporting commodities and primary products such as Australia, Brazil, Indonesia, and Saudi Arabia and countries exporting sophisticated consumer and capital goods such as Germany and Switzerland are exposed to a slowdown in China.

This paper also reports trade elasticities for China's imports. Imports for processing are sensitive to processed exports and ordinary imports are sensitive to Chinese GDP. Their responses to exchange rates, though, are small. This implies that a slowdown in China's processed exports or Chinese GDP would matter more for imports than a renminbi depreciation unless the depreciation far exceeds historical experience. For instance, between January 1994 and July 2016, the largest fall in the real effective renminbi exchange rate over a 12 month period was 10 percent.[10] The results reported in Table 4 indicate that a 10 percent depreciation would reduce ordinary imports by only 4 percent and not affect processed exports.

Several policy lessons flow from the findings in this paper. Countries such as Australia and Indonesia whose exports include a large share of primary products are very exposed to a slowdown in China. They should seek to diversify their export base to include more manufactured products. Indonesia should also seek to strengthen its connection to global value chains (GVCs) by improving infrastructure and human capital and by fighting corruption. Joining GVCs would promote technological upgrading by allowing domestic workers to acquire new skills and domestic firms to learn new management techniques (see Kawai and Lee, 2015).

Korea and Taiwan are especially exposed to a slowdown in processing trade. Their challenge is compounded because the PRC's high investment levels in recent years have enabled firms in the PRC to substitute parts and components produced in China for imported parts and components (see, e.g., Kuijs, 2011 and Knight and Wang, 2011). Korean and Taiwanese firms should innovate and produce cutting edge intermediate goods to ensure that their products remain in demand in China.

All of East and Southeast Asia including China would benefit if multinationals and others involved in processing trade could find new sources of demand and become less dependent on demand in the West.

It is an old saw in economics that diversification reduces risk. In the face of slowdowns in China and the rest of the world, this maxim is especially relevant. Companies and countries should diversify their export base, diversify their trading partners, and reduce their exposure to

[10] These data come from the Bank for International Settlements (www.bis.org)

the PRC or any other single country. They should also specialize and find niches where they have comparative advantage.

From China's perspective, the results seem to imply that a depreciation would not harm imports. However, the exchange rate responses are larger for imports of medicines, foods, and other goods purchased by Chinese consumers (Thorbecke, 2016). Given the PRC government's desire to transition to a consumption-oriented economy, this gives policymakers one more reason to avoid a large renminbi depreciation.

Table 1 Exports to China as a Percentage of GDP and as a Percentage of Total Exports and the Share of Processed Exports Relative to Processed Plus Ordinary Exports

Exports to China Relative to GDP		Exports to China Relative to Total Exports		Processed Exports/ (Processed Exports + Ordinary Exports)	
Country	Percent	Country	Percent	Country	Percent
Taiwan	19.6	Taiwan	37.1	Taiwan	57.3
Malaysia	17.3	Malaysia	21.1	Malaysia	41.2
South Korea	10.1	South Korea	29.0	South Korea	53.5
Thailand	9.5	Thailand	16.9	Thailand	37.2
Singapore	6.8	Singapore	13.1	Singapore	34.3
Philippines	5.8	Philippines	26.4	Philippines	47.5
Australia	4.6	Australia	29.6	Australia	2.53
Switzerland	4.1	Switzerland	9.0	Switzerland	5.46
Saudi Arabia	3.5	Saudi Arabia	6.7	Saudi Arab.	35.9
Japan	2.6	Japan	20.1	Japan	35.6
Germany	2.5	Germany	6.4	Germany	8.64
Indonesia	2.3	Indonesia	13.3	Indonesia	10.8
Brazil	2.3	Brazil	21.1	Brazil	7.8
Netherlands	1.4	Netherlands	2.4	Netherlands	14.5
Finland	1.2	Finland	5.1	Finland	18.3
Ireland	1.1	Ireland	2.6	Ireland	38.9
Denmark	1.1	Denmark	3.6	Denmark	11.8
Sweden	1.0	Sweden	3.8	Sweden	17.6
Canada	1.0	Canada	4.3	Canada	9.55
Mexico	1.0	Mexico	2.6	Mexico	28.4
Austria	0.9	Austria	2.5	Austria	12.5
France	0.7	France	3.6	France	18.8
UK	0.7	UK	4.4	UK	12.2
Norway	0.6	Norway	2.6	Norway	54.6
Italy	0.6	Italy	2.6	Italy	13.3
US	0.6	US	9.4	US	18.4
India	0.6	India	4.8	India	17.2
Poland	0.5	Poland	1.3	Poland	12.2
Spain	0.5	Spain	2.0	Spain	9.00
Turkey	0.3	Turkey	1.6	Turkey	7.17

Source: CEPII-CHELEM Database, China Customs Statistics, and calculations by the author.

Table 2 Panel OLS and PPML Gravity Estimates, 1988-2015

	(1)	(2)	(3)	(4)
Distance	-0.59***	-0.78***	-0.56***	-0.77***
	(0.02)	(0.01)	(0.00)	(0.01)
Common Language	0.28***	0.40***	0.28***	0.40***
	(0.03)	(0.01)	(0.00)	(0.01)
Free Trade Agreement	0.68***	0.71***	0.78***	0.74***
	(0.03)	(0.02)	(0.00)	(0.03)
Exporter GDP	0.68***	0.79***		
	(0.02)	(0.05)		
Importer GDP	0.66***	0.93***		
	(0.02)	(0.03)		
Constant	-4.46***	-8.86***	17.6***	18.9***
	(0.70)	(1.14)	(0.00)	(0.16)
Estimation Technique	PPML	OLS	PPML	OLS
Fixed Effects Specification	Exporter, Importer, Time	Exporter, Importer, Time	Exporter, Importer, Time	Exporter, Importer, Time
Adjusted R-squared		0.85		0.83
No. of observations	26040	25990	26040	25990
Sample Period	1988-2015	1988-2015	1988-2015	1988-2015

Notes: The table contains panel ordinary least squares (OLS) and Poisson Pseudo Maximum Likelihood (PPML) estimates of gravity models. Bilateral exports from 31 major exporters to each of the other 30 countries over the 1988-2014 period are included. For the panel OLS estimates, heteroskedasticity-consistent standard errors are in parentheses. For the PPML estimates, Huber-White standard errors are in parentheses.
*** denotes significance at the 1% level.

Table 3 Leading Export Categories to China in 2016 (with percent of total exports from the exporter to China in parentheses)

Taiwan	Malaysia	South Korea	Thailand	Singapore	Philippines	Australia
Electronic components (44.5)	Electronic components (54.1)	Electronic components (25.9)	Computer equipment (14.8)	Electronic components (31.6)	Electronic components (40.4)	Iron ores (54.2)
Optics (7.6)	Refined petroleum products (4.9)	Optics (10.2)	Electronic components (11.1)	Plastic articles (13.7)	Computer equipment (20.3)	Coals (9.3)
Plastic articles (6.9)	Computer equipment (4.7)	Electrical Apparatus (9.4)	Nonedible agricultural prod. (9.0)	Refined petroleum products (11.3)	Non-ferrous ores (7.58)	Non-edible agricultural prod. (5.8)
Electrical Apparatus (5.3)	Electrical Apparatus (4.0)	Basic organic chemicals (7.2)	Plastic Articles (7.4)	Precision instruments (5.2)	Electrical apparatus (5.4)	Non-ferrous ores (5.0)
Telecomm-unications equipment (4.9)	Plastic articles (2.6)	Plastic articles (6.9)	Jewelry, works of art (6.2)	Computer equipment (4.2)	Telecomm-unications equipment (3.9)	Non-monetary gold (3.3)
Basic organic chemicals (4.6)	Telecomm-unications equipment (2.6)	Telecomm-unications equipment (5.8)	Telecommunications equipment (6.1)	Electrical apparatus (4.2)	Coals (3.4)	Non-ferrous metals (2.4)
Non-ferrous Metals (2.5)	Fats (2.4)	Specialized machines (3.6)	Other edible agricultural prod. (5.6)	Basic organic chemicals (3.9)	Other edible agricultural prod (2.6)	Cereals (1.4)
Yarns & fabrics (2.1)	Basic organic chemicals (2.3)	Refined petroleum products (3.4)	Optics (5.2)	Paints (3.8)	Electrical equipment (2.5)	Meat & fish (1.3)
Computer equipment (2.0)	Non-ferrous ores (2.1)	Vehicles components (3.3)	Basic organic chemicals (5.0)	Telecomm-unications equipment (3.7)	Refined petroleum products (1.7)	Crude Oil (1.3)
Miscellaneous hardware (1.9)	Precision Instruments (2.0)	Computer equipment (2.7)	Electrical Apparatus (3.5)	Miscellaneous manuf. Articles (2.6)	Optics (1.5)	Pharmaceut-icals (1.0)
Specialized machines (1.9)	Non-ferrous metals (1.7)	Misc. hardware (2.7)	Plastics (3.2)	Specialized machines (2.4)	Precision Instruments (1.3)	Beverages (0.7)
Iron & Steel (1.6)	Natural gas (1.7)	Iron Steel (2.2)	Misc. Hardware (1.9)	Engines (1.3)	Non-ferrous metals (1.2)	Other edible agriculture (0.7)
Machine tools (1.4)	Toiletries (1.6)	Engines (1.9)	Engines (1.7)	Toiletries (1.7)	Plastic articles (1.1)	Preserved fruits (0.5)

Table 3 (continued). Leading Export Categories of Major Exporters to China in 2014 (with percent of total exports from the exporter to China in parentheses)						
Switzerland	Saudi Arabia	Japan	Germany	Indonesia	Brazil	
Non-monetary gold (63.1)	Crude oil (66.5)	Electronic components (10.2)	Cars and cycles (15.4)	Coals (19.8)	Other edible agricultural prod (36.2)	
Pharmaceuticals (13.0)	Basic organic chem. (16.0)	Electrical apparatus (9.1)	Vehicles components (10.2)	Fats (12.3)	Iron ores (22.9)	
Clock making (4.8)	Plastic articles (11.0)	Specialized machines (7.2)	Electrical apparatus (8.4)	Refined petroleum products (7.4)	Crude oil (14.2)	
Machine tools (2.1)	Natural gas (2.0)	Plastic articles (6.2)	Precision instruments (7.0)	Paper (5.4)	Paper (5.6)	
Precision instruments (2.0)	Refined petrol-eum products (1.4)	Vehicles components (4.8)	Miscellaneous hardware (6.5)	Wood articles (4.6)	Meat & Fish (4.3)	
Specialized machines (1.6)	Unprocessed minerals (1.1)	Optics (4.6)	Engines (5.7)	Natural gas (4.5)	Ships (2.5)	
Basic organic chemicals (1.5)	Non- ferrous ores (0.4)	Engines (4.4)	Specialized machines (5.4)	Iron & steel (4.4)	Sugar (2.0)	
Jewelry, works of art (1.4)	Yarns fabrics (0.3)	Miscellaneous hardware (4.4)	Aeronautics (5.4)	Crude oil (4.4)	Non-ferrous ores (1.6)	
Electrical apparatus (1.3)	Cars & cycles (0.3)	Basic organic chemicals (4.4)	Machine tools (3.3)	Non-edible agricultural prod. (4.2)	Leather (1.6)	
Engines (1.2)	Basic inorganic chemicals (0.3)	Cars and cycles (3.9)	Pharmaceuticals (3.1)	Electrical apparatus (3.5)	Iron Steel (1.2)	
Miscellaneous hardware (1.0)	Non-ferrous metals (0.2)	Telecommunications equipment (3.8)	Plastic articles (2.8)	Toiletries (3.1)	Engines (1.1)	
Miscellaneous manuf. Articles (0.9)	Jewelry, works of art (0.1)	Precision instruments (3.7)	Electronic components (2.3)	Basic organic chemicals (3.0)	Nonferrous metals (1.1)	
Toiletries (0.6)	Engines (0.1)	Iron Steel (3.1)	Electrical equipment (1.9)	Leathers (2.3)	Aeronautics (0.9)	

Source: CEPII-CHELEM Database and calculations by the author.

Table 4 Panel DOLS and OLS estimates of import elasticities for processing and ordinary imports, 1992-2016

	(1)	(2)	(3)
Processed Exports	0.86***	0.75***	
	(0.044)	(0.02)	
Real GDP			1.55***
			(0.04)
Real Exchange Rate	0.02	-0.06	0.38***
	(0.06)	(0.09)	(0.15)
Import Category	Imports for Processing	Imports for Processing	Ordinary Imports
Estimation Technique	OLS	DOLS	DOLS
Fixed Effects Included	Yes	Yes	Yes
Adjusted R-squared	0.90	0.95	0.92
No. of observations	600	600	550
Sample Period	1992-2016	1993-2016	1992-2016

Notes: OLS represents Panel Ordinary Least Squares and DOLS represents Panel Dynamic Ordinary Least Squares. For the DOLS, lag length for each cross section is selected based on the Schwarz Criterion. For the OLS estimation, White standard errors are reported. For the results in column (2), the sample begins in 1993 because the Schwarz Criterion selected one lag for every cross section. An increase of the bilateral real exchange rate implies an appreciation of the renminbi. The predicted sign of the coefficient is positive.
*** (**) denotes significance at the 1% (5%) level.

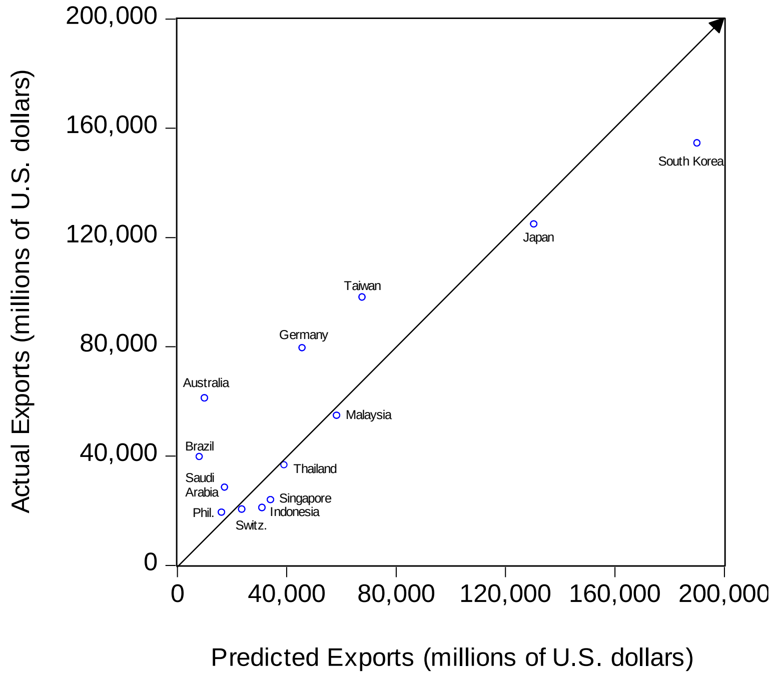

Fig 1 Actual and Predicted Imports into the PRC from its Trading Partners in 2015.
Note: Predicted exports are determined by a gravity model for trade between 31 leading exporters over the 1988-2015 period.
Source: CEPII-CHELEM Database and calculations by the author.

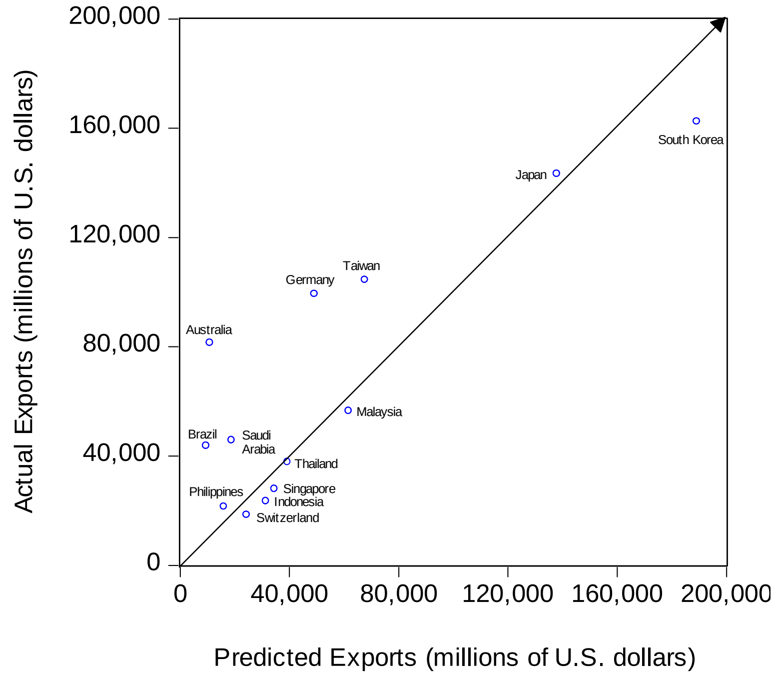

Fig 2 Actual and Predicted Imports into the PRC from its Trading Partners in 2014.
Note: Predicted exports are determined by a gravity model for trade between 31 leading exporters over the 1988-2015 period.
Source: CEPII-CHELEM Database and calculations by the author.

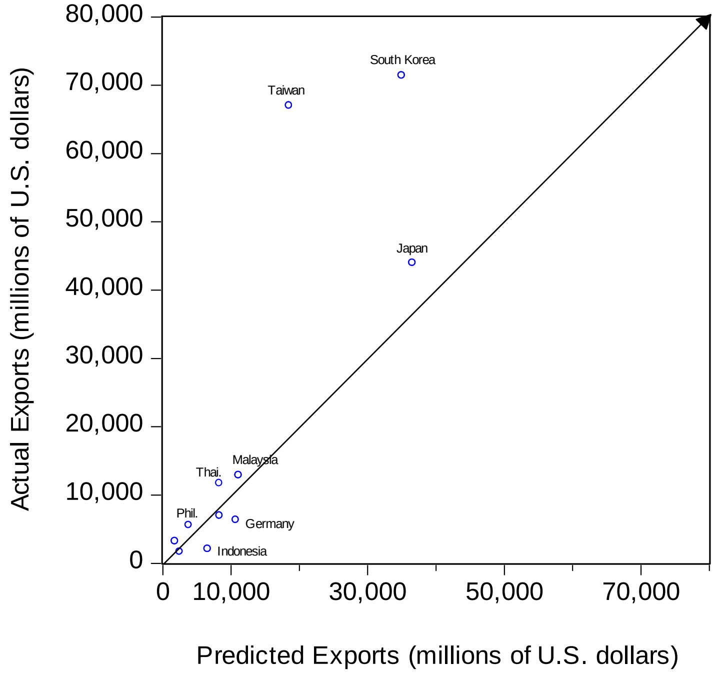

Fig 3 Actual and Predicted Imports for Processing into the PRC from its Trading Partners in 2016.
Note: Predicted exports are determined by a gravity model for trade between 26 leading exporters over the 1992-2016 period.
Source: CEPII-CHELEM Database and calculations by the author.

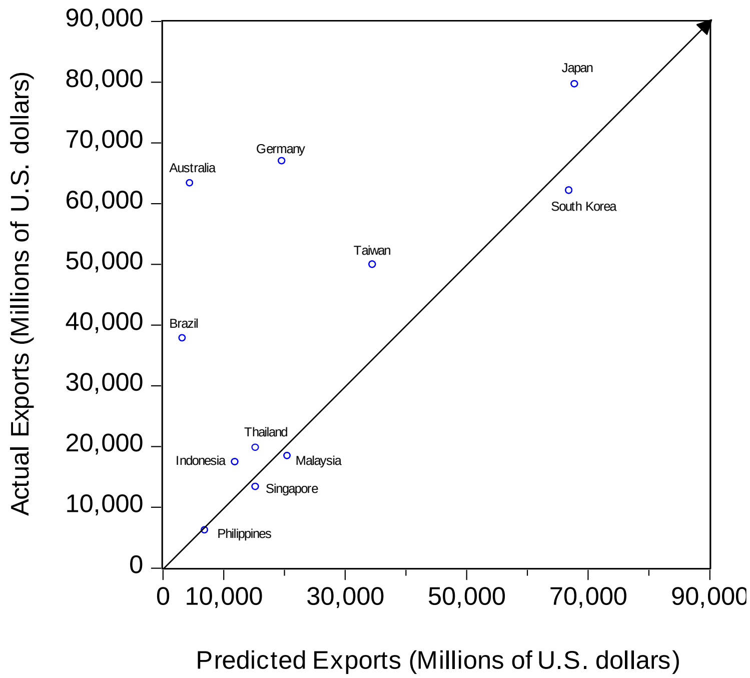

Fig 4 Actual and Predicted Ordinary Imports into the PRC from its Trading Partners in 2016.

Note: Predicted exports are determined by a gravity model for trade between 26 leading exporters over the 1992-2016 period.

Source: CEPII-CHELEM Database and calculations by the author.

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