

## Beggar-Thy-Neighbor Effects of Exchange Rates: A Study of the Renminbi<sup>†</sup>

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*This paper estimates the effect of China's exchange rate changes on exports of developing countries in third markets. The degree of competition between China and its developing country competitors in specific products and destinations plays a key role in the identification strategy. The strategy exploits variation across exporters, importers, products and time—afforded both by disaggregated trade data and bilateral exchange rates—to estimate this “competitor country effect.” There is robust evidence of a statistically and quantitatively significant effect. A 10 percent appreciation of China's real exchange rate boosts a developing country's exports at the product level on average by about 1.5–2.5 percent. (JEL F14, F31, F33, O19, O24, P33)*

Studying the effects of exchange rates is a hardy perennial of international macroeconomics. But nearly all the empirical research is focused on the impact on the country whose exchange rate changes.<sup>1</sup> There is less evidence on the effect of exchange rate movements on the exports of competitor countries, which in its adverse manifestation is dubbed the “beggar-thy-neighbor” effect. In a world besieged by accusations of “currency wars” and “negative spillovers,” owing to the extensive recourse to unconventional monetary policies and exchange rate depreciations, measuring this effect is important.

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<sup>1</sup> This is generally true of the older, voluminous literature on the trade consequences of exchange rates. Goldstein and Khan (1985) provide a survey and other contributions include Hooper, Johnson, and Marquez (2000); Thursby and Thursby (1987). It is also true of the more recent micro-literature on trade and exchange rates (Dekle and Ryoo 2007; Das, Roberts, and Tybout 2001; Forbes 2002; Berman, Martin, and Mayer 2012); and of the recent literature on the growth consequences of exchange rates (Dooley, Folkerts-Landau, and Garber 2003; Rodrik 2008; and Johnson, Ostry, and Subramanian 2010).

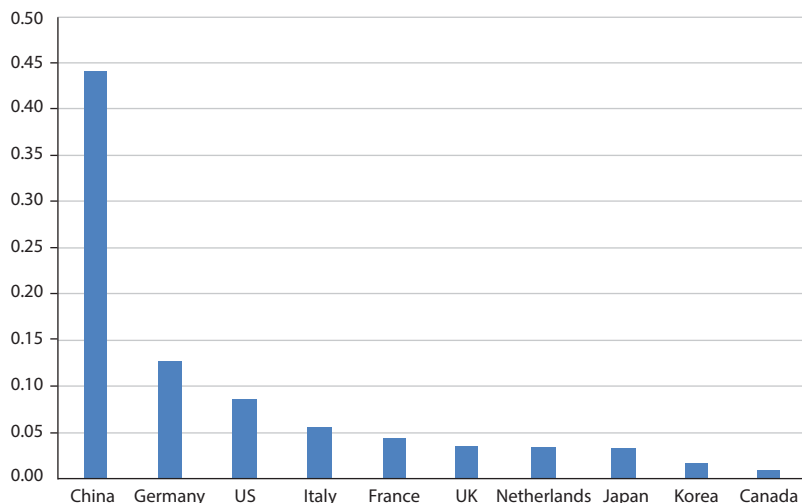


FIGURE 1. AVERAGE INDEX OF COMPETITION WITH TOP TEN EXPORTERS, 2014

*Notes:* The figure depicts an average index of competition (what we call in the text the “value-based index of competition” or VBI). It measures how the world’s top ten exporters of goods compete with all other countries. The index is first constructed at the exporter-importer-HS four-digit product level. For example, the index of competition with China is defined as  $I_g^{ij,VB} = \sum_{g'} \left[ \left( \frac{V_g^{ij}}{V_g^{ij}} \right) \times s_{g'}^{Cj} \right]$ , where  $s_{g'}^{Cj}$  is China’s share in total imports of six-digit line  $g'$ ;  $\frac{V_g^{ij}}{V_g^{ij}}$  is the share of six-digit line  $g'$  in the total exports of the four-digit product  $g$ . See equation (11) of the text for more details. To arrive at a single country-level measure for each country in the figure (say China), we take simple averages over all HS four-digit products and over all importers and exporters for the index of competition with China. Using the same formula, we construct indices for competition with other exporters—Germany, United States, etc. An index of zero means that the country is not a source of competition to any other country for any product. Its value increases as the country’s share in imports increases.

This paper examines the effect of movements in China’s exchange rate on exports of other developing countries in third country markets, which we will refer to throughout this paper as the “competitor country effect.” We do not take a position in this paper on whether the renminbi is undervalued or whether changes in China’s real exchange rate are attributable to nominal exchange rate policy, but simply focus on the trade consequences of these changes.<sup>2</sup>

The Chinese currency provides a suitable opportunity to study this effect because China is not only the world’s largest exporter of goods, it is also a highly diversified exporter, competing with a broad range of countries across the product spectrum. Figure 1 depicts a measure of how intensively each of the world’s ten largest exporters competes with all other countries. The measure, described in greater detail in Section I of the paper, takes a value of zero when the country is not a source of competition to any other country in any market for any product, and its value increases as the country’s presence in other markets increases. The value for China far surpasses that of all

<sup>2</sup>Du and Wei (2011) argue that a set of structural factors in China, by affecting savings and effective labor supply, can in principle explain the entire real exchange rate behavior, without much role for a nominal exchange rate policy. Also, Chinn and Wei (2013) argue that the nominal exchange rate regime, and hence nominal exchange rate policy, does not promote adjustment of the trade balance because it does not reliably induce a change in the real exchange rate in the “correct” direction. They do, however, acknowledge that movements in the real exchange rate may affect goods trade, which is the focus of the present paper.

the other major exporters, including the United States and Germany, whose aggregate exports are not much smaller than those of China. Not surprisingly, China's dominant size and encompassing scope have made its exchange rate policy one of the most controversial aspects of international macroeconomics during the 2000s. The policy has provoked expressions of concern not just from industrial countries, but also from developing countries like Brazil, India, Indonesia, and Singapore.<sup>3</sup>

We estimate the competitor country effect using a novel methodology that allows us to exploit variation across four dimensions: exporters, importers, products, and time. We use disaggregated trade data at the 6-digit level, spanning 121 developing country exporters and 56 large importers over the period 2000–2014. We also exploit the variation in China's exchange rate. Since we focus on the effects of China's exchange rate movements on exports of competitors in specific third country markets, we are able to use the bilateral exchange rate measures between China and the third country. In fact, there is significant variation in these exchange rates across countries and over time. Although China's exchange rate appreciated for much of the period against the dollar (26 percent over 2000–2014), this is not universally true vis-à-vis other currencies. For example, it depreciated substantially against the euro, for example, by 33 percent over 2000–2008, and also depreciated against sterling over much of the earlier part of the sample period (22 percent over 2000–2007).

Our empirical approach is motivated by an analytical framework that follows from Feenstra et al. (forthcoming). The framework leads us to develop an identification strategy that relies on the following reasoning: the more a country competes with China in a third market, the more a given depreciation of the renminbi is likely to hurt its exports in that market. We develop indices of competition between China and competing exporting countries at the exporter-importer-product level to implement this strategy. The empirical specification includes fixed effects that control for all observable and unobservable importer-exporter-product, importer-exporter-time, exporter-product-time, and importer-product-time varying characteristics which helps us overcome to a large extent the problem of omitted variables that plagues estimation of trade-exchange rate equations using aggregated data. Moreover, our estimates are less susceptible to reverse causality concerns since exports, measured at a highly disaggregated level, are unlikely to affect a macroeconomic variable like the exchange rate, particularly when the latter is the exchange rate of another country, China.<sup>4</sup>

We find robust evidence for the existence of a statistically and economically significant competitor country effect. In particular, exports to third markets of countries with a greater degree of competition with China tend to rise/fall significantly more as the renminbi appreciates/depreciates. Our estimates suggest that a 10 percent depreciation of the renminbi reduces a developing country's exports at the product-level on average by about 1.5–2.5 percent. For countries such as Nepal, Bangladesh, Philippines, Vietnam, and Cambodia, the effect can be twice as high, largely because they compete closely with China. We also find that the magnitude of

<sup>3</sup>See, for example, "Developing Countries Voice Complaints about Chinese Currency," *New York Times*, November 10, 2009; "Brazil and India Add to Pressure on China," *Financial Times*, April 21, 2010.

<sup>4</sup>See Engel (2009) for a discussion of how hard it is econometrically to separate out the effect of exchange rates on trade.

the competitor country effect is greater for homogenous products with greater substitution possibilities than differentiated products. Further, this effect is attenuated for products in which China's exports rely more on foreign inputs (and hence have a lower degree of Chinese domestic value added). The estimated competitor country effects are robust to a variety of statistical tests, to alternative measures of exchange rates, to alternative disaggregation of the trade data, and to alternative timing of effects. They are also robust to incorporating the effect of competition from countries (other than China) whose currencies move with the renminbi.

A few recent studies examine the effects of China's export performance, rather than its exchange rate, on other Asian countries (Hanson and Robertson 2008; Eichengreen, Rhee, and Tong 2004; and Ahearne et al. 2003), and on US labor markets (Autor, Dorn, and Hanson 2013). A few other papers examine the impact of exchange rate changes but on variables other than trade. For example, Eichengreen and Tong (2015) have estimated the effect of renminbi revaluation on stock market valuations of foreign firms, and find that renminbi appreciation has a positive effect on stock prices.

Competitor country effects from exchange rate changes have been discussed in the literature, albeit without any systematic empirical examination of the phenomenon. For example, de Blass and Russ (2010) theoretically examine third-country effects of relative price shocks. Feenstra, Hamilton, and Lim (2002) conjecture that China's significant devaluation in 1994 curtailed export growth for South Korean chaebols. Similarly, Forbes and Rigobon (2002) survey the evidence for contagion through a trade channel, where sudden devaluation by one country may spread crisis to other countries that compete with it in a common export market.

Overall, there is no empirical study so far that identifies and estimates the effect of exchange rate changes on exports of other countries, even though this has been a central international concern going back to Robinson (1947) and the experience of the competitive devaluations prior to and during the Great Depression. This paper contributes toward filling this gap.

The rest of the paper is organized as follows. Section I sets out the analytical framework, Section II describes the estimation strategy and Section III, the data. The results are presented and validated in Section IV and Section V concludes.

## I. Analytical Framework

In order to motivate our empirical exercise we use a model with a nested CES preference structure developed by Feenstra et al. (forthcoming). The setting is as follows. There are  $J$  countries in the world,  $G$  different goods. Each country produces a range of distinct varieties of each good. There is a constant elasticity of substitution ( $\eta$ ) consumption index for the representative consumer in country  $j$ . Goods are differentiated not only by their characteristics, but also by their country of origin (Armington assumption), with a constant elasticity of substitution between domestically produced and foreign varieties of good  $g$  ( $\omega_g$ ), and a constant elasticity of substitution between different varieties of good  $g$  originating in different exporters ( $\sigma_g$ ). The same elasticity applies to different varieties of good  $g$  produced domestically.

Following Feenstra et al. (forthcoming), (equation (8)), and using the same notation—where the good will be denoted by subscripts, and exporter-importer pairs

by superscripts, we can express country  $j$ 's imports from country  $i$  (equivalent to exports of country  $i$  to country  $j$ ) of a particular good  $g$ ,  $V_g^{ij}$ , as follows:

$$(1) \quad V_g^{ij} = \left[ \kappa_g^{ij} \left( \frac{P_g^{ij}}{P_g^{Fj}} \right)^{1-\sigma_g} \right] \times \left[ (1 - \beta_g^j) \times \left( \frac{P_g^{Fj}}{P_g^j} \right)^{1-\omega_g} \right] \times \left[ \alpha_g^j \left( \frac{P_g^j}{P^j} \right)^{1-\eta} \right] P^j C^j.$$

That is, the share of import demand for good  $g$  from country  $i$ , ( $V_g^{ij}$ ) in total consumption of country  $j$ ,  $P^j C^j$ , depends on three sets of components:<sup>5</sup>

- the preference weight consumers in  $j$  attach to imports of good  $g$  from country  $i$ ,  $\kappa_g^{ij}$ , the price of  $g$  imports by  $j$  from  $i$ ,  $P_g^{ij}$ , relative to the price index of all  $g$  imports,  $P_g^{Fj}$  (or all foreign goods, and hence the superscript  $Fj$ ); and the elasticity of substitution between imported varieties of  $g$ ,  $\sigma_g$ ;
- the preference weight consumers in  $j$  attach to domestically produced units of good  $g$ ,  $\beta_g^j$ ; the price index of all  $g$  imports by  $j$ ,  $P_g^{Fj}$ , relative to the domestic price index of good  $g$ ,  $P_g^j$ ; and the elasticity of substitution between the home and foreign varieties of good  $g$ ,  $\omega_g$ ;
- the preference weight consumers in  $j$  attach to consumption of the  $g$  good,  $\alpha_g^j$ ; the price index of the  $g$  good,  $P_g^j$ , relative to the price index of all goods in  $j$ ,  $P^j$ ; and the elasticity of substitution between different goods,  $\eta$ .

We first establish the effect of a change in China's exchange rate vis-à-vis country  $j$ ,  $E^{Cj}$ , on country  $j$ 's imports of a particular good  $g$  from country  $i$ ,  $V_g^{ij}$ —what we define as the “competitor country effect.” We can express this as a chain effect, consisting of the effects of the change in the foreign price index on the import demand for good  $g$  from country  $i$ , the change in the price of the Chinese good on the foreign price index, and the change in the Chinese exchange rate on the price of the Chinese good:

$$(2) \quad \frac{\partial \ln V_g^{ij}}{\partial \ln E^{Cj}} = \frac{\partial \ln V_g^{ij}}{\partial \ln P_g^{Fj}} \times \frac{\partial \ln P_g^{Fj}}{\partial \ln P_g^{Cj}} \times \frac{\partial \ln P_g^{Cj}}{\partial \ln E^{Cj}}.$$

Now consider each term in the chain starting from the first term. Taking logs of equation (1) and differentiating with respect to  $P_g^{Fj}$  under the assumption that a change in  $P_g^{Fj}$  has a negligible effect on the aggregate price index for good  $g$  in country  $j$  ( $P_g^j$ ), we get<sup>6</sup>

$$\frac{\partial \ln V_g^{ij}}{\partial \ln P_g^{Fj}} = \sigma_g - \omega_g.$$

<sup>5</sup>Note that we use imports and exports interchangeably throughout this paper, based on the simple identity that imports of a country A from another country B are exactly the exports of B to A. In the empirical section, we use data reported by importing countries, which is generally regarded as more reliable than export data.

<sup>6</sup>We do, however, allow for a change in the price of imports of a good from China to affect say the US import price index of the good (see equation (5) below). The assumption that a change in say the US import price index does not affect the US domestic price index for a particular good is an innocuous assumption because any additional terms—for example aggregate destination-specific prices—will be absorbed in the very general fixed effects in the empirical estimation (see below).

This implies that the elasticity of demand for imports of good  $g$  from country  $i$  with respect to the foreign price index is simply the difference between the elasticity of substitution between imported varieties of  $g$ ,  $\sigma_g$ , and the elasticity of substitution between home and foreign varieties,  $\omega_g$ .

From Feenstra et al. (forthcoming), we have the price index for imported goods,  $P_g^{Fj}$ , (equation (3) in their paper):

$$(3) \quad P_g^{Fj} = \left[ \sum_{\substack{i=1 \\ i \neq j}}^J \kappa_g^{ij} (P_g^{ij})^{1-\sigma_g} \right]^{\frac{1}{1-\sigma_g}}.$$

Taking logs, differentiating with respect to the price of the Chinese good  $g$  in the  $j$  market,  $P_g^{Cj}$ , and simplifying, we get

$$\frac{\partial \ln P_g^{Fj}}{\partial \ln P_g^{Cj}} = \frac{\kappa_g^{Cj} (P_g^{Cj})^{1-\sigma_g}}{\sum_{i=1, i \neq j}^J \kappa_g^{ij} (P_g^{ij})^{1-\sigma_g}} = s_g^{Cj}.$$

This implies that the elasticity of the foreign price index for good  $g$  with respect to the price of the Chinese good  $g$  is equal to the expenditure on the Chinese good as a share of expenditure on all imports of  $g$ ,  $s_g^{Cj}$ .

We assume that the price of the Chinese good in the  $j$  market,  $P_g^{Cj}$ , depends on the price in China,  $P_g^c$ , the exchange rate,  $E^{Cj}$  (defined in renminbi/importer currency), and an exponent that captures the extent of product-specific exchange rate pass-through from prices in China to  $j$ ,  $\mu_g^{Cj}$ :

$$(4) \quad P_g^{Cj} = P_g^c (1/E^{Cj})^{\mu_g^{Cj}}.$$

Differentiating with respect to the exchange rate,  $E^{Cj}$ , we have

$$\frac{\partial \ln P_g^{Cj}}{\partial \ln E^{Cj}} = -\mu_g^{Cj}.$$

Substituting for the partial derivatives in equation (2), we get

$$(5) \quad \frac{\partial \ln V_g^{ij}}{\partial \ln E^{Cj}} = -\mu_g^{Cj} s_g^{Cj} (\sigma_g - \omega_g).$$

This equation is intuitive because it captures the interplay between three elements that together determine the competitor country effect of China's exchange rate: the first is the extent of product-specific exchange rate pass-through from Chinese exchange rate to prices of Chinese goods in  $j$ ,  $\mu_g^{Cj}$ ; the second is the relative importance of China as a source of imports of good  $g$  in the importing country,  $s_g^{Cj}$ ; and the third is the difference between the elasticity of substitution between imported varieties of  $g$ ,  $\sigma_g$ , and the elasticity of substitution between the home and foreign varieties of  $g$ ,  $\omega_g$ . Equation (5) implies that a change in the Chinese exchange rate will have a negative effect on the import demand for good  $g$  only if: (i) the exchange

rate pass-through is non-zero, (ii) Chinese share in total imports of that good is strictly positive, and (iii) the elasticity of substitution across imported varieties is greater than that between imported and domestic varieties. Note that  $0 < \mu_g^{Cj} \leq 1$  is a necessary condition for a nonzero competitor country effect. Although a CES demand and a monopolistic competition market structure, which underlie our theoretical framework, would imply a complete pass-through or,  $\mu_g^{Cj} = 1$ , we allow  $\mu_g^{Cj}$  to vary in order to incorporate other models of demand and market structure (see, e.g., Burstein and Gopinath 2014), or models with imported intermediate inputs (e.g., Gron and Swenson 1996). Moreover, in the empirical analysis, we explore how the competitor country effect can vary across products depending on the pass-through as captured by the degree of domestic value added.

Feenstra et al. (forthcoming) find evidence for condition (iii) using disaggregated and concorded domestic production and import data for the United States. Their median estimates of the elasticity of substitution across imported varieties are 3.24 and 4.12 for the two methodologies they use, whereas the elasticities of substitution between imported and domestic varieties are significantly lower in up to one-half of the goods they analyze. Condition (iii) is also consistent with a widely maintained hypothesis in the traditional Computable General Equilibrium (CGE) model literature, known as the “rule of two,” that the elasticity of substitution across imports by sources ( $\sigma_g$ ) is equal to twice the elasticity of substitution between domestic goods and imports ( $\omega_g$ ) (Hillberry and Hummels 2013). Liu, Arndt, and Hertel (2003) also show econometric estimates are consistent with this hypothesis.

While equation (5) provides the motivation for our empirical analysis using the most disaggregated data we have, i.e., at the HS six-digit, to assess the impact of movements in the renminbi at a more aggregate level, we need to take into account the range of products where China and the exporter in question actually overlap. To find such variation across exporters, we consider country  $j$ 's imports at a higher level of aggregation, say the HS four-digit level, which can be expressed as follows:

$$(6) \quad V_g^{ij} = \sum_{g'=1}^G V_{g'}^{ij}.$$

The variable  $G$  denotes the number of HS six-digit lines in the four-digit product.<sup>7</sup> For notational simplicity, from now on, a good at a four-digit level of aggregation will be referred to as a “product” denoted by  $g$ , whereas a good at a six-digit level of aggregation will be referred to as a “six-digit line” denoted by  $g'$ .

Taking logs and differentiating equation (6) with respect to the exchange rate,  $E^{Cj}$  and simplifying, we get

$$(7) \quad \frac{\partial \ln V_g^{ij}}{\partial \ln E^{Cj}} = - \sum_{g'=1}^G \left( \frac{V_{g'}^{ij}}{\sum_{g'} V_{g'}^{ij}} \right) \mu_{g'}^{Cj} s_{g'}^{Cj} (\sigma_{g'} - \omega_{g'}).$$

<sup>7</sup>There is a standard mapping from the six-digit HS level to the four-digit HS level, available at <http://www.foreign-trade.com/reference/hscodet.htm>. For example, the two six-digit categories, 852810 for “Colour Television Receivers” and 852820 for “Black and White or Other Monochrome Television Receivers,” map on to the four-digit product 8528 for all “Television Receivers.”

This equation bears a simple relationship to equation (8). The exchange rate elasticity of imports at the HS four-digit product level is a weighted average of the elasticity of imports at the HS six-digit level, where the weights reflect the relative importance of each HS six-digit line  $g'$  in the HS four-digit exports of the competitor country  $\left(\frac{V_g^{ij}}{\sum_{g'} V_{g'}^{ij}}\right)$ .

In order to move from equation (10) to a specification that we can take to the data at the HS four-digit product level, we assume that the elasticities of substitution and the pass-through parameter are identical for all HS six-digit lines  $g'$  within each HS four-digit product  $g$ , i.e.,  $\mu_{g'}^{Cj} = \mu_g^{Cj}$ ,  $\sigma_{g'} - \omega_{g'} = \sigma_g - \omega_g$ . This is a *sufficient* assumption that allows us to rewrite equation (10) to obtain a relatively simple expression for the competitor country effect,  $\frac{\partial \ln V_g^{ij}}{\partial \ln E^{Cj}}$ ,

$$(8) \quad \frac{\partial \ln V_g^{ij}}{\partial \ln E_j^C} = I_g^{ij,VB} \times [-\mu_g^{Cj} \times (\sigma_g - \omega_g)],$$

where  $I_g^{ij,VB} = \sum_{g'=1}^G \left[ \left( \frac{V_{g'}^{ij}}{V_g^{ij}} \right) \times s_{g'}^{Cj} \right]$  is what we call the “value-based index of competition” (VBI) with China for the HS four-digit product  $g$  exported from  $i$  to  $j$ . This index includes two elements: the relative importance of China as a source of imports of a good  $g'$  in the importing country,  $s_{g'}^{Cj}$ ; and the relative importance of that good  $g'$  in the exports of the competitor country  $\left(\frac{V_{g'}^{ij}}{\sum_{g'} V_{g'}^{ij}}\right)$ . More formally,

the elasticity of country  $i$ 's exports to  $j$  of the HS four-digit product with respect to China's exchange rate vis-à-vis  $j$  is related to the weighted average of China's share in total imports in each constituent six-digit line which country  $i$  exports, where the weights are country  $i$ 's exports in the corresponding six-digit line as a share of its total exports in the four-digit product. For example, if the HS four-digit product, TVs, consists of only two items, color TVs and non-color TVs, our measure is simply the share of China in country  $j$ 's imports of each type of TV, weighted by the importance of each type of TV in country  $i$ 's TV exports to  $j$ . Equation (11) suggests that the elasticity of exports of a typical product to the importing country depends on the extent of pass-through,  $\mu$ ; the index of competition; and the two elasticities of substitution,  $\sigma$  and  $\omega$ . Equation (11) is the basis for our econometric specification.

Note that although the derivation of equation (11) assumes identical elasticities and pass-through parameter *within* the four-digit level, the assumption is not as stringent as it seems because the parameters are allowed to vary *across* HS four-digit products. In fact, there is some evidence to support the assumption. Using Broda-Weinstein (2006) estimates, we can show that elasticities look more similar within groups than across groups. We estimate the coefficient of variation (CV) across HS four-digit products to be 2.1. In contrast, the CV within four-digit products (computed across HS six-digit lines within the four-digit product) is estimated to be much lower at 0.66. These estimates offer some support for the sufficient assumption to derive equation (11).



With some additional symmetry assumptions, we can also compute an alternative index of competition where we rely on the overlap between China's exports and those of country  $i$  at the extensive margin. We first assume that for each six-digit line that  $i$  exports to  $j$  within a four-digit product, it exports the same amount. If  $i$  exports  $N_g^{ij}$  six-digit lines within the relevant four-digit product to  $j$ , then the first term in Equation (10) simplifies to  $1/N_g^{ij}$ . Next assume that in each six-digit line within the relevant four-digit product where  $i$  exports to  $j$ , China exports either a fixed share,  $s_g^{Cj}$ , or nothing;  $s_g^{Cj} = s_g^{Cj}$  for  $N_g^{Cj}$  lines or zero otherwise. Then summing the second ratio over the relevant six-digit lines gives us  $s_g^{Cj} \times N_g^{Cj}$ .

So that in this special case, equation (11) can be written as

$$(9) \quad \frac{\partial \ln V_g^{ij}}{\partial \ln E^{Cj}} = I_g^{ij,CB} \times [-s_g^{Cj} \times \mu_g^{Cj} \times (\sigma_g - \omega_g)],$$

where  $I_g^{ij,CB} = \frac{N_g^{ij,C}}{N_g^{ij}}$  is what we call the "count-based index" (CBI) of competition.

Essentially, the count-based index (CBI) measures the number of six-digit lines (within a four-digit product) that are exported by China and also by country  $i$  as a proportion of the total number of six-digit lines (within that four-digit product) exported by country  $i$ . The CBI, however, is based only on the extensive margin, and ignores the *value* of exports. Although this count-based index relies on symmetry assumptions, it provides a simple intuitive measure of competition, and helps address some of the endogeneity concerns that could arise with the VBI (see below).

## II. Estimation Strategy

Equations (11) and (12) motivate the estimation of the competitor country effect. They imply two key predictions which we can take to the data: (i) the effect is less than zero (under plausible assumptions on elasticities) and (ii) the magnitude of this effect depends on the index of competition between China and its competing exporters. The higher is the index of competition, the larger is the magnitude of the competitor country effect.

We rely on the following intuition based on equations (11) and (12) to develop an empirical strategy to identify the competitor country effect. For purposes of illustration, consider the exports of footwear to the United States from two countries in our data, Indonesia and Russia. Indonesia, with an average VBI of 0.8, has a relatively high index of competition with China, compared to say Russia, with an average VBI of 0.5, in the US market for footwear. Our theory suggests that when the renminbi depreciates vis-à-vis the US dollar, footwear exports from Indonesia to the United States are likely to fall more than footwear exports from Russia to the United States. In other words, greater the degree of competition with China, larger the reduction in exports, when the Chinese currency depreciates.

This identification strategy yields the following estimating equation:

$$(10) \quad \ln V_{gt}^{ij} = \beta I_g^{ij} \times \ln E_t^{Cj} + v_{jgt} + s_{igt} + \gamma_{ijt} + \theta_{ijg} + \epsilon_{ijgt},$$

where  $V_{gt}^{ij}$  is the value of exports of product  $g$  from country  $i$  to country  $j$ ;  $E_t^{Cj}$  is the Chinese exchange rate vis-à-vis  $j$  measured in renminbi per unit of  $j$ 's currency;  $I_g^{ij}$  is a measure of competition between country  $i$ 's exports and Chinese exports of product  $g$  in market  $j$ . As described in the analytical section, the measure will refer to either the count-based index of competition  $I_g^{ij,C}$  or the value-based index of competition  $I_g^{ij,V}$ . Note that the index does not have a time subscript that we explain below. Variables  $v_{jgt}$  and  $s_{igt}$  denote the importer-product-time and exporter-product-time fixed effects, respectively. The variable  $\gamma_{ijt}$  is the exporter-importer-time effect, and  $\theta_{ijg}$  denotes the exporter-importer-product fixed effects. Any omitted variable that does not vary across all the four dimensions—exporter, importer, product, and time—would be controlled for by the fixed effects. Since the exchange rate varies at the importer and time level, and the measure of competition with China must vary at least at the exporter and product level, the key interaction term is importer-exporter-product-time varying, and is not absorbed by one of the fixed effects.

We define “competitor country effect” as the effect of movements in China’s exchange rates on exports of other developing countries to third markets (e.g., the effects of movements in the renminbi vis-à-vis the US dollar on Indonesian exports to the United States). More formally, based on equation (13), it is defined as follows:

$$\frac{\partial \ln V_{gt}^{ij}}{\partial \ln E_t^{Cj}} = I_g^{ij} \times \beta.$$

That is, the competitor country effect is given by the product of the index of competition and the estimated coefficient on the interaction between the exchange rate and the index. A statistically significant estimate of  $\beta$  would imply that the competitor country effect depends significantly on the index of competition. Further, a negative estimate of  $\beta$  would imply that the competitor country effect is negative: the more a country is in competition with China in a given product exported say to the United States, greater would be a reduction ceteris paribus in that country’s exports of the product to the United States, when the Chinese exchange rate depreciates vis-à-vis the US dollar.

Econometrically, an advantage of the formulation in the estimating equation is that we can control for a wide range of omitted variables through a set of very general fixed effects. In fact, in our core estimations, we employ all three-way combinations of importer, exporter, product, and time fixed effects. The term  $v_{jgt}$  captures any observed as well as unobserved importer, product, and time varying characteristics: one example would be fiscal support for the car industry in the United States. Similarly, the term  $s_{igt}$  captures any exporter, product, and time-varying characteristics; for example, a productivity shock in Bangladesh that helped textile exports. Note that these fixed effects also encompass all country-time shocks both on the importer and exporter side, such as the business cycle in each country. The term  $\gamma_{ijt}$  captures any bilateral time-varying determinants of exports: for example, currency unions, and exchange rate pegs against particular currencies. The term  $\theta_{ijg}$  captures bilateral product-specific characteristics: for example, all preexisting preferential trade agreements that have product-specific tariffs and other barriers. The only factors that are not controlled for are policies of the importing country

that vary by source country, product, and time (for example, changes over time in product-specific preferential tariffs). The lack of a comprehensive database on trade policies at the importer-exporter-product-time level makes it difficult to control for such effects. Finally, it is worth noting that our estimation strategy also controls for any possible effect on competitor countries stemming from productivity or other developments in China, whether exogenous or induced by exchange rates: if these are time-varying and product-specific, they will be absorbed in the  $s_{igt}$  and  $v_{jgt}$  fixed effects. Furthermore, our estimating equation is less susceptible to reverse causality from exports to exchange rates because our dependent variable, disaggregated exports, is less likely to affect a macroeconomic variable like the exchange rate, especially since the latter is the exchange rate of another country.

What about reverse causality from exports to the index of competition? Our count-based index has the empirical virtue of being based on the extensive margin and not being measured in value terms; hence, it is less related to the left-hand side variable and less afflicted by reverse causality problem. The value-based index is potentially more vulnerable to the reverse causality problem because it is expressed in values, like the dependent variable. It is to minimize such endogeneity concerns that we compute both indices for the initial period of the sample (i.e., for the year 2000).

### III. Data

We focus on the period 2000–2014, during which concerns about China's exchange rate policy have been most debated. For this period, we compile disaggregated data on bilateral exports from the UN Comtrade database. We collect data reported by the importing countries, which is generally regarded as more reliable than data on exports (i.e., exports from  $i$  to  $j$  are measured by imports of  $j$  from  $i$ ). The data are for roughly 4,400 non-oil HS six-digit lines covering 1,200 four-digit products. We cover the 56 major importing countries (making sure that we include all countries that together accounted for over 90 percent of total exports of developing countries) and 121 developing country exporters, which are potentially in competition with China.<sup>8</sup> The list of developing countries is based on World Bank country classification, and is comprised of all low and middle-income countries (2010 GNI per capita of \$12,275 or less).

The trade data are reported in current US dollars. The presence of the very general fixed effects has the consequence of implicitly deflating the trade data. The data are implicitly deflated by prices that vary by importer, product, and time; by importer, product, and exporter; and by exporter, product, and time. They are, however, not deflated by prices that vary along all four dimensions (importer, exporter, product, and time).

<sup>8</sup>The list of importing and exporting countries and summary statistics on the key variables are provided in the online Appendix. In principle, we could include all exporting countries in our sample. We choose to restrict the analysis to developing country exporters, largely due to computational constraints. However, this restricted choice also stems from the fact that developing countries compete more with China than industrial countries do: the average index of competition between the former set and China is about 0.4 and 0.9, respectively for the value based and count based indices of competition. The corresponding numbers for industrial countries are 0.1 and 0.7, respectively.

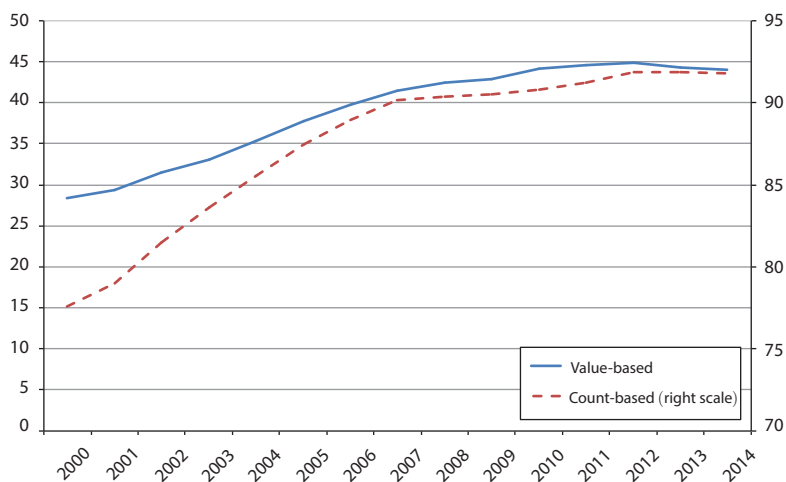


FIGURE 2. AVERAGE INDEX OF COMPETITION WITH CHINA, 2000–2014

*Notes:* The figure shows averages over time for the count-based and value-based indices of competition. The indices are measured at the exporter-importer-HS four-digit product level. The construction of these indices is described in the text and in the notes to Figure 1.

Exchange rate data are from the IMF's International Financial Statistics (IFS) database. The key price that determines the transmission mechanism of exchange rate changes is the price in the importing market charged by China's exporters. Our core exchange rate measure will, therefore, be the bilateral exchange rate for China vis-à-vis the importing country (measured as renminbi per importing country currency), deflated by China's CPI. We use the term "real exchange rate" throughout the paper to denote this measure. For robustness, in the empirical analysis, we also use alternative exchange rate measures.

*Index of Competition.*—Before we present the econometric results, it is worth looking at some basic data. Figure 2 plots China's average index of competition (where the average is over all exporters and products). The index is measured in two ways consistent with the discussion in the analytical section. Both the CBI and VBI rise over time, consistent with China becoming a bigger and more diverse exporter. The CBI shows, in particular, that by 2014, on average, China occupies nearly all the product space of other developing country exporters. The map in Figure 3 shows the average index of competition (for illustration, the VBI) by quartiles, with the darkest shade representing the countries in the top quartile. Countries in the top quartile include those in South and South-East Asia, such as Nepal, Bangladesh, Cambodia, and Vietnam, but also countries in Africa, such as Botswana, Mauritius, and Cameroon. China's overlap with all regions has also risen steadily over time, with the level of the overlap greatest with other exporters in Asia, and least with developing country exporters in Eastern Europe and Central Asia.<sup>9</sup>

<sup>9</sup>The online Appendix presents additional statistics on the VBI and CBI.

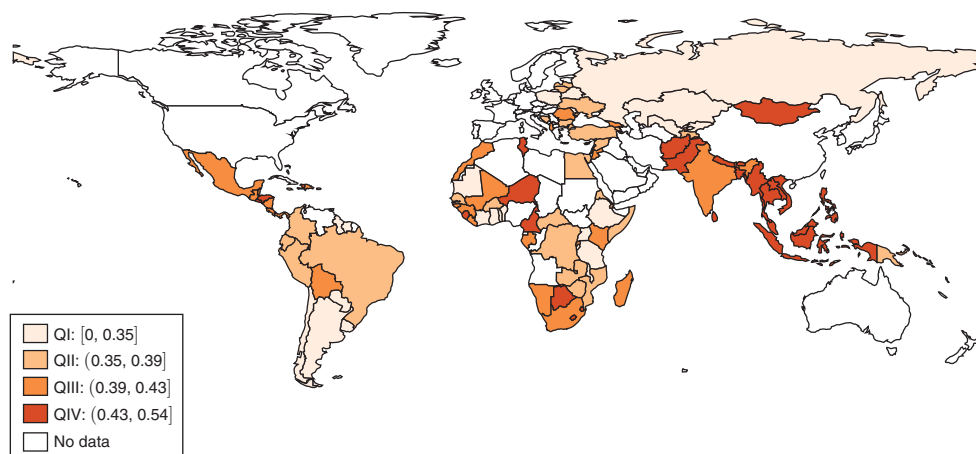


FIGURE 3. VALUE-BASED INDEX OF COMPETITION (by Quartiles)

## IV. Results

### A. Main Findings

All results are presented first for the simpler count-based index (CBI), followed by those for the value-based index (VBI). In Table 1, we present the baseline results. Our core sample has nearly 7.8 million observations. Columns 1–4 use the CBI, while columns 5–8 use VBI. In both cases, the number of fixed effects progressively increase across the specifications, with a comprehensive set of fixed effects in columns 4 and 8, making the specification a very demanding one. These will constitute our core specifications. The standard errors for all regressions are clustered at the importer-exporter-product level. We find that the coefficient on the interaction term between the Chinese exchange rate and the index of competition is consistently negative and significant at the 1 percent level. In other words, a depreciation of the Chinese exchange rate vis-à-vis say the dollar is associated with a greater reduction in a developing country's exports of a particular product say to the United States, the more that country is in competition with China in that product in the United States.

### B. Robustness Checks

One potential omitted variable issue arises in regard to our core specification. Our finding that the typical developing country's exports are adversely affected when China's currency depreciates has not yet addressed an important question: what if other countries respond to China's depreciation by devaluing their own currencies? In Table 2, we control for this possibility. Among developing countries, which are the top exporters, we identify those whose currencies are most closely correlated with that of China (in real effective terms). We interact the exchange rates of each of these countries with the respective index of competition of each with the exporting country, where the index is defined analogous to that of China.

TABLE 1—EXPORTS FROM DEVELOPING COUNTRIES AND CHINESE EXCHANGE RATES: BASELINE SPECIFICATION

Dependent variable = log(exports) at (exporter, importer, four-digit product, year) level								
	Count-based index of competition				Value-based index of competition			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Index of competition with China × log(exchange rate of importer with respect to China)	-0.307 (0.001)	-0.302 (0.001)	-0.200 (0.001)	-0.270 (0.002)	-0.230 (0.002)	-0.306 (0.001)	-0.169 (0.001)	-0.376 (0.004)
Observations	7,786,042	7,786,042	7,786,042	7,786,042	7,786,042	7,786,042	7,786,042	7,786,042
Fixed effects								
exporter × importer × product	No	No	No	Yes	No	No	No	Yes
exporter × importer × time	No	No	Yes	Yes	No	No	Yes	Yes
exporter × product × time	No	Yes	Yes	Yes	No	Yes	Yes	Yes
importer × product × time	No	Yes	Yes	Yes	No	Yes	Yes	Yes

Notes: Exchange rate of importer with respect to China is measured as renminbi/importer currency, deflated by the Chinese CPI. The index of competition with China in columns 1–4 is defined at the four-digit product level, and is equal to the share of six-digit lines within a four-digit product that  $i$  exports to  $j$ , that China also exports to  $j$ . The index of competition in columns 5–8 is defined as the summation over all six-digit lines within the four-digit product of the following: share of China in overall imports of a six-digit line multiplied by the share of the six-digit line in total four-digit product exports from the exporter to the importer. The index of competition in all the columns is measured in the year 2000. The regression sample includes years from 2000–2014. Standard errors denoted in parentheses are clustered at the importer × exporter × product level.

In columns 1 and 4, we include countries whose exchange rates have a correlation coefficient relative to the renminbi that is greater than 0.7. So we add two additional regressors (one for each country) to the core specification. In each case, the regressor is the interaction between the country's exchange rate and that country's index of competition with other countries. In columns 2 and 5, we repeat this procedure to include countries whose correlation coefficients with the renminbi are higher than 0.4. In columns 3 and 6, the threshold correlation coefficient is 0.3. For presentational reasons, we only show the impact on the main coefficient of interest, namely that relating to China. This coefficient remains significant at the 1 percent level, although it is reduced in magnitude. Overall, these results suggest that our main finding related to the competitor country effect of the Chinese exchange rate remains strong and robust to inclusion of possible omitted variables. Thus, exporters competing with China suffer because of a renminbi depreciation and not (or not just) because they are adversely affected by the depreciation of currencies that closely track the renminbi.

We also find statistically significant and negative coefficients on the interaction terms for the other countries. Hence, the competitor country effect we estimate is not specific to China, and is more general. Unsurprisingly, the indices of competition are much lower for all the other countries. Therefore, the magnitude of the competitor country effect which is given by the coefficient multiplied by the index is much smaller for the other countries than for China.

TABLE 2—ROBUSTNESS TO OMITTED VARIABLES

Dependent variable = $\log(\text{exports})$ at (exporter, importer, four-digit product, year) level						
	Count-based index of competition			Value-based index of competition		
	(1)	(2)	(3)	(4)	(5)	(6)
Index of competition with China $\times$ $\log(\text{exchange rate of importer with respect to China})$	-0.070 (0.004)	-0.143 (0.005)	-0.203 (0.007)	-0.257 (0.005)	-0.223 (0.006)	-0.193 (0.007)
Observations	6,845,080	5,923,277	5,001,048	6,845,080	5,923,277	5,001,048
Controls						
Index of competition with other country $\times$ $\log(\text{exchange rate of importer with respect to that country})$						
Malaysia, Poland (correlation $\geq 0.7$ )	Yes	Yes	Yes	Yes	Yes	Yes
Mexico, Thailand (correlation $\geq 0.4$ )	No	Yes	Yes	No	Yes	Yes
Brazil, India (correlation $\geq 0.3$ )	No	No	Yes	No	No	Yes
Fixed effects						
exporter $\times$ importer $\times$ product	Yes	Yes	Yes	Yes	Yes	Yes
exporter $\times$ importer $\times$ time	Yes	Yes	Yes	Yes	Yes	Yes
exporter $\times$ product $\times$ time	Yes	Yes	Yes	Yes	Yes	Yes
importer $\times$ product $\times$ time	Yes	Yes	Yes	Yes	Yes	Yes

*Notes:* The control countries are among the top ten exporters in the world, whose real effective exchange rates are highly correlated with the Chinese. Exchange rate of importer with respect to e.g., China is measured as renminbi/importer currency, deflated by the Chinese CPI. The exchange rate of importer with respect to other countries is also measured in a similar way. The index of competition in columns 4–6 is defined as the summation over all six-digit lines within the four-digit product of the following: share of China/Malaysia/South Africa, etc., in overall imports of a six-digit line multiplied by the share of the six-digit line in total four-digit product exports from the exporter to the importer. The index of competition with China/Malaysia/South Africa, etc., in columns 1–3, is defined at the four-digit product level, and is equal to the share of six-digit lines within a four-digit product that  $i$  exports to  $j$ , that China/Malaysia/South Africa also exports to  $j$ . The index of competition in all the columns is measured in the year 2000. The regression sample includes years from 2000–2014. Standard errors denoted in parentheses are clustered at the importer  $\times$  exporter  $\times$  product level.

In Table 3, we test whether our results are robust to alternative time frames for exchange rate effects to be felt. In column 1, we drop the years of the global financial crisis. In columns 2 and 3a, we restrict the sample to years before and after the global financial crisis, respectively. The interaction term remains negative and statistically significant; the magnitude of the effect, however, doubles in the post-crisis period. We examine closely why the estimated coefficients increase substantially, and whether the postcrisis coefficients are driven by a different sample, or is it indeed that the effect has become more important over time. In order to answer this question, we restrict the post-crisis regression to the pre-crisis exporter-importer-product sample. Column 3b shows that the estimated coefficients in the postcrisis period reduce substantially once we restrict to the pre-crisis sample. Therefore, it is the changing sample, rather than the different time period that is driving the coefficient in column 3a. A closer look at the precrisis and post-crisis samples reveals that trade in the latter sample comprises a higher share of homogenous products, and a higher share of observations from upper middle-income countries, and in particular from Europe—both of which exhibit larger competitor country effects (Table 4 and online Appendix Table A4).

Our core specification uses annual data. To test whether the results hold for the medium run, we use a long difference approach suggested by Acemoglu and

TABLE 3—ROBUSTNESS TO TIMING AND SYMMETRY OF EFFECTS

Dependent variable = log(exports) at (exporter, importer, four-digit product, year) level											
	Drop crisis years 2008, and 2009 (1)	Pre- crisis (2000– 2007) (2)	Post- crisis (2010– 2014) (3a)	Postcrisis; precrisis exporter × importer × product sample (2010– 2014) (3b)	Long- difference (2000, 2014) (4)	1-year lag exchange rate (5)	2-year lag exchange rate (6)	Lagged dependent variable included (7)	Depre- ciation episodes (8)	Appre- ciation episodes (9)	Interaction (10)
<i>Count-based index of competition</i>											
Index of com- petition with China × log(exchange rate of importer with respect to China)	–0.270 (0.002)	–0.255 (0.003)	–0.700 (0.009)	–0.281 (0.017)	–0.264 (0.034)	–0.227 (0.003)	–0.204 (0.003)	–0.318 (0.003)	–0.546 (0.011)	–0.332 (0.002)	–0.415 (0.003)
log(exports)— one year lag								0.299 (0.000)			
Index of com- petition with China × log(exchange rate of importer with respect to China) × depreciation											–0.031 (0.001)
<i>Value-based index of competition</i>											
Index of com- petition with China × log(exchange rate of importer with respect to China)	–0.391 (0.004)	–0.346 (0.006)	–0.883 (0.020)	–0.355 (0.008)	–0.507 (0.077)	–0.305 (0.006)	–0.279 (0.007)	–0.449 (0.006)	–0.811 (0.023)	–0.426 (0.005)	–0.600 (0.007)
log(exports)— one year lag								0.300 (0.000)			
Index of com- petition with China × log(exchange rate of importer with respect to China) × depreciation											–0.022 (0.001)
Observations	6,687,230	3,709,448	2,977,782	2,384,839	982,701	5,295,788	4,683,641	5,295,685	1,136,753	4,159,035	5,295,788

*Notes:* See notes to Table 1 for definitions of the count-based and value-based indices of competition. Exchange rate of importer with respect to China is measured as renminbi/importer currency, deflated by the Chinese CPI. In column 1, the sample excludes 2008 and 2009. Columns 2 and 3 restrict the sample to 2000–2007 and 2010–2014, respectively. In column 4, we restrict the sample to two years—2000 and 2014. Exchange rate is lagged by one year in column 5, and by two years in column 6. log(exports) lagged by one year is included as an additional explanatory variable in column 7. The index of competition is measured in the year 2000 in all the columns. In columns 8 and 9, depreciations and appreciations are defined by those observations whereby the exchange rate increased and decreased, respectively. All regressions include exporter × importer × time, exporter × product × time, importer × product × time, and exporter × importer × product fixed effects. Standard errors denoted in parentheses are clustered at the importer × exporter × product level.

Johnson (2007). Thus, in column 4, we use observations only for 2000 and 2014 and find that the results remain similar to the baseline, with the magnitude of the interaction coefficient increasing by a little relative to the core specification. In columns 5



TABLE 4—EXPORTS FROM DEVELOPING COUNTRIES AND CHINESE EXCHANGE RATES: PRODUCTS DISTINGUISHED BY DEGREE OF DIFFERENTIATION

	Dependent variable = log(exports) at (exporter, importer, four-digit product, year) level					
	Count-based index			Value-based index		
	Homogeneous (1)	Differentiated (2)	Interaction (3)	Homogeneous (4)	Differentiated (5)	Interaction (6)
Index of competition with China × log(exchange rate of importer with respect to China)	−0.333 (0.003)	−0.233 (0.002)	−0.215 (0.001)	−0.500 (0.015)	−0.349 (0.008)	−0.297 (0.004)
Index of competition with China × log(exchange rate of importer with respect to China) × Dummy for homogeneous			−0.138 (0.001)			−0.188 (0.005)
Observations	2,839,949	5,120,744	7,960,693	2,839,949	5,120,744	7,960,693

*Notes:* Goods are classified into homogeneous or differentiated according to Rauch's liberal classification at the six-digit level. Exchange rate of importer with respect to China is measured as renminbi/importer currency, deflated by the Chinese CPI. The index of competition in all the columns is measured in the year 2000. The regression sample includes years from 2000–2014. All regressions include exporter × importer × time, exporter × product × time, importer × product × time, and exporter × importer × product fixed effects. Standard errors denoted in parentheses are clustered at the importer × exporter × product level.

and 6, we use one- and two-year lags for the exchange rate, respectively, and find that the exchange rate effect persists, although the magnitude declines over time.

To assess long-run effects, we estimate our baseline regression including the lagged dependent variable (column 7, Table 3).<sup>10</sup> The key exchange rate variable is significant for both indices of competition. Interestingly, the implied long-run effect of the exchange rate in this specification (0.22 and 0.64 for the count and value-based indices of competition, respectively) is greater than the effect in the core specification. Given the limitations of this regression, this result must be treated with caution, but it is not inconsistent with the notion that exchange rate changes have large long-term effects.

We also test for asymmetric exchange rate effects in columns 8–10 of Table 3. The richness of our sample, in particular, the variation across importing countries and time, allows us to distinguish episodes of depreciations and appreciations and test whether there are differential effects. The results show that the third market effect is significant in episodes of both depreciations and appreciations, although it is significantly greater in the former (column 10).<sup>11</sup>

<sup>10</sup> We recognize that there may be a downward bias that afflicts, in particular, the lagged dependent variable. The bias, however, tends to decrease with a large number of cross-section units (Buddelmeyer et al. 2008).

<sup>11</sup> We subject the core specification in Table 1 to a variety of robustness tests—(i) dropping outliers, (ii) alternative assumptions on clustering of standard errors, (iii) alternative initial years for the index of competition, (iv) alternative indices such as the Finger-Krenin index of competition, (v) alternative measures of exchange rates, such as nominal and real effective exchange rates, and the relative price of tradables to non-tradables from the Penn World Tables, (vi) alternative disaggregation of the trade data at the HS six and two-digit levels, (vii) across exporters from different regions, and (viii) across exports of different product categories—consumer, primary,

### C. Competitor Country Effect and Product Characteristics

Having established the average competitor country effect, we now analyze how the effect varies depending on product characteristics. Equations (11) and (12) suggest that the competitor country effect should vary according to two product attributes: elasticity of substitution between different imported varieties and exchange rate pass through. Higher the elasticity, and greater the pass through, the larger should be this effect.

First, we analyze how the competitor country effect varies by the degree of substitution between products. We partition the data into homogenous (i.e., those with a greater degree of substitutability) and differentiated products based on Rauch's (1999) classification.<sup>12</sup> As shown in Table 4, columns 1, 2, 4, and 5, we find that the coefficients on the interaction between the index of competition and exchange rates are higher in magnitude for homogenous products than for differentiated ones. Columns 3 and 6 confirm that the differences between the coefficients for the two types of goods are statistically significant. The differences are substantial: for the count-based and value-based indices, the coefficients on homogenous goods are over 40 percent greater than that for differentiated goods.

Second, we explore how the competitor country effect is related to China's critical role in the global supply chain, which is well recognized in the literature. Thorbecke and Smith (2010), for example, examine the impact of an Asia-wide currency appreciation by constructing a single integrated exchange rate variable to measure changes in the relative foreign currency costs of China's entire output of processed exports. One of the key features of Chinese manufacturing exports has been the extent to which they have relied on foreign intermediate inputs (Kee and Tang 2016; Koopman, Wang, and Wei 2012). The greater the reliance on foreign inputs (lower the domestic value added), the more an exchange rate depreciation will increase input costs and hence dampen the competitive advantage from a depreciation. In other words, a greater reliance on foreign inputs is analytically analogous to a lower pass-through which would dampen the competitor country effect (Ahmed, Appendino, and Ruta 2015). We test this proposition in the data. We use the classification in Koopman, Wang, and Wei (2012) to divide our data into two samples: those characterized by a high degree of foreign inputs and those with a low degree.<sup>13</sup>

In Table 5, we estimate our core specification for each of these samples. We find that, consistent with our hypothesis, our competitor country effect is in fact dampened—but not eliminated—for products with a high degree of foreign inputs (compare columns 2 versus 1 and 5 versus 4). Columns 3 and 6 confirm that the differences between the two samples are statistically significant: the coefficient on the

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capital and intermediate. We find that the results hold across all the different specifications. Please see the online Appendix for details.

<sup>12</sup>Note that Rauch's classification is available at the SITC four-digit; we concord it to HS six-digit level using standard concordance tables, and then partition the data into homogenous and differentiated using Rauch's liberal classification (reference priced goods are included in the homogenous category). We then aggregate the data to the HS four-digit level.

<sup>13</sup>The classification of sectors by domestic value added is restricted to manufacturing, and is based on ISIC data which we concorded with HS four-digit data.

TABLE 5—EXPORTS FROM DEVELOPING COUNTRIES AND CHINESE EXCHANGE RATES: PRODUCTS DISTINGUISHED BY DOMESTIC VALUE ADDED

Dependent variable = log(exports) at (exporter, importer, four-digit product, year) level						
	Count-based index			Value-based index		
	High domestic value added (1)	Low domestic value added (2)	Interaction (3)	High domestic value added (4)	Low domestic value added (5)	Interaction (6)
Index of competition with China × log(exchange rate of importer with respect to China)	−0.265 (0.003)	−0.238 (0.002)	−0.240 (0.003)	−0.320 (0.005)	−0.316 (0.005)	−0.336 (0.007)
Index of competition with China × log(exchange rate of importer with respect to China) × Dummy for high domestic value added			−0.022 (0.005)			−0.023 (0.011)
Observations	2,690,901	3,965,566	6,656,467	2,690,901	3,965,566	6,656,467

*Notes:* Regressions are restricted to manufacturing only. The data on share of domestic value added for products in the manufacturing sector is from Koopman, Wang, and Wei (2012). Goods are classified into high and low value added based on values above and below the median. See notes to Table 1 for definitions of the count-based and value-based index of competition. Exchange rate of importer with respect to China is measured as renminbi/importer currency, deflated by the Chinese CPI. The index of competition in all the columns is measured in the year 2000. The regression sample includes years from 2000–2014. All regressions include exporter × importer × time, exporter × product × time, importer × product × time, and exporter × importer × product fixed effects. Standard errors denoted in parentheses are clustered at the importer × exporter × product level.

core interaction term is about 15 percent greater (in absolute value) for the sample with the lower degree of foreign intermediate inputs in the case of the count-based index and 25 percent greater for the value-based index.<sup>14</sup>

#### D. Discussion of Magnitudes

Recall from equation (14) that the competitor country is given by  $\frac{\partial \ln V_{gt}^{ij}}{\partial \ln E_t^{Cj}} = I_g^{ij} \times \beta$ . Our estimations identify  $\beta$ , which we can multiply by the relevant value of the index of competition to obtain the average competitor country effect. The range of estimates for different combinations of the two indices of competition and estimates of  $\beta$  are shown in Table 6. For the baseline estimate of our elasticity (columns 4 and 8 in Table 2) and for the median index of competition, we get a total effect of  $-0.24$  and  $-0.14$  for the count and value-based indices, respectively. The estimates imply that a 10 percent depreciation/appreciation of the renminbi is associated with a reduction/increase in developing country exports at the product level to a third market of roughly 1.5–2.5 percent.

<sup>14</sup>The same result holds for an alternative classification by share of processing exports (with high domestic value added products being those with low share of processing) due to Koopman, Wang, and Wei (2012). The extent of pass-through is also likely to depend on whether trade is governed by contracts (see e.g., Hellerstein 2008) and the currency in which goods are priced; for example, goods priced in dollars are likely to see less pass-through than goods priced in the national currency of the exporter (see Gopinath, Itskhoki, and Rigobon 2010). The absence of a sufficiently disaggregated cross-country database on measures of pass-through precludes us from including these additional dimensions in our analysis.

TABLE 6—RANGE OF ESTIMATED SPILLOVER EFFECT OF A 10 PERCENT DEPRECIATION OF CHINESE EXCHANGE RATE

Beta coefficients	Count-based index			Value-based index		
	Baseline	Minimum	Maximum	Baseline	Minimum	Maximum
Percentile of the index of competition						
10	0.00	0.00	0.00	-0.01	0.00	-0.02
50	-2.42	-0.63	-6.29	-1.39	-0.62	-3.26
90	-2.70	-0.70	-7.00	-3.33	-1.50	-7.82

Notes: For the count-based index, the baseline, minimum, and maximum values of the estimated coefficients correspond to column 4, Table 1; column 1, Table 2; and column 3, Table 3, respectively. For the value-based index, the baseline, minimum, and maximum values of the estimated coefficients correspond to column 8, Table 1; column 7, Table 1; and column 3, Table 3, respectively.

For countries that are in the ninetieth percentile in terms of competition with China, the range of baseline estimates increases to 3–3.5 percent for the two indices. If we use the higher values of  $\beta$  corresponding to, e.g., coefficients for the postcrisis period (column 3 in Table 3), the magnitude of the estimates increases substantially. For the indices of competition in the ninetieth percentile, the competitor country effect could be as high as 8 percent for a 10 percent change in the renminbi.<sup>15</sup>

How do our empirical estimates compare with those suggested by the analytical framework? Equations (11) and (12) yield the formula for the magnitude of competitor country effect as predicted by theory. From the existing literature, we can obtain estimated values for each of the parameters. Of course, there is wide variation in each of these, but some ballpark estimates are the following:  $\sigma = 3$ ,  $\omega = 1.5$ ,  $\mu = 0.4$ , and  $s = 0.4$ . The estimates of  $\sigma$  (the elasticity of substitution between imported goods, or the micro-Armington elasticity) and  $\omega$  (the elasticity of substitution between domestic and imported goods, or the macro-Armington elasticity) are based on the “rule of two” expressed in the CGE literature (see Hillberry and Hummels 2013 and Liu, Arndt, and Hertel 2003), namely that the former are twice as large as the latter. The pass-through coefficient ( $\mu$ ) is an average of the estimates from Campa and Goldberg (2005) for industrial countries and the estimates of Gopinath, Itskhoki, and Rigobon (2011) for the United States.<sup>16</sup> The average share of China,  $s$  in the markets of each of the importing countries is obtained from our data.

Combining these estimates with the average value of the index of competition for the value ( $I_{ijg}^{VB}$ ) and count-based ( $I_{ijg}^{CB}$ ) indices from our data (of 0.4 and 0.9, respectively), yield a magnitude of the competitor country effect of  $-0.22$  for the count-based index and  $-0.24$  for the value-based index. For the count-based index, the theoretical and our baseline empirical estimates ( $-0.2$  based on column 4 in

<sup>15</sup>Note that even using the estimates from Table 2, where we control for movements in other currencies, the competitor country effect of China’s exchange rate movements is in the range of 1–2 percent. We also conduct another exercise where we assume that a movement in the renminbi is followed by movements in other correlated currencies. Based on our estimates from Table 2, the overall effect of movements in all these currencies is also in the range of 1.5–2.5 percent. This is due to the fact that competitor country effect of other currencies is much smaller in magnitude than China’s. Although the coefficients on the interaction terms are similar, the indices of competition are much smaller for the other countries.

<sup>16</sup>Goldberg and Knetter (1997) and Goldberg and Hellerstein (2008) also provide evidence on pass-through and its decline over time. Xing (2010) looks specifically at pass-through of Chinese exchange rates to import prices in the United States and Japan, and estimates pass-through coefficients of 0.23 and 0.56 for the United States and Japan respectively.

Table 1) are very close. For the value-based index, our baseline empirical estimates ( $-0.15$  based on column 8 of Table 1) are a little below those derived from theory. One possible explanation is that residual measurement errors impart a natural attenuation bias to the econometric estimates.

Overall, the baseline estimates in this paper suggest that a 10 percent depreciation/appreciation in the renminbi exchange rate vis-à-vis an importing country decreases/increases on average developing country exports by about 1.5–2.5 percent. Given close to 50 percent *appreciation* of China's real exchange rate vis-à-vis the US dollar over 2000–2014, our findings suggest that this could have been associated with about a 7.5–12.5 percent increase in the typical developing country's exports to the United States, with much greater effects for countries in closer competition with China.<sup>17</sup>

## V. Conclusion

To our knowledge, this paper is the first systematic attempt to quantify the effect of exchange rate changes on the exports of competitor countries to third markets—the competitor country effect—that exploits the rich variation afforded by disaggregated trade data. We study the case of China and find that its exchange rate changes can have significant and robust competitor country effects.

These findings may have important policy implications for developing countries and for the multilateral system if real exchange rate movements (or the lack thereof) stem from policy action. Since we have found that the resulting competitor country effects are significant, one country's policies can have substantial export implications for other countries. In these circumstances, designing and implementing multilateral rules on exchange rate policies to manage and minimize the competitor country effects may be necessary (Mattoo and Subramanian 2009).

Importantly, we would emphasize that this paper identifies precisely and in a robust way a very specific mechanism of influence from exchange rates to trade (the “competitor country effect” of Chinese exchange rate movements on exports of competitor countries to third markets). There could be other effects on developing country exports to China that we do not measure. For example, a depreciation of the renminbi could increase developing country exports of raw materials and intermediate goods to China to be used in the production of China's exports to third countries. Similarly, if China's depreciation boosts its own growth, that could increase its demand for all goods and services, which could also lead to greater developing country exports. Thus, the effect of China's exchange rate movements on overall exports of other countries remains an open question. Also, this paper has focused on the effects of the exchange rate on the intensive margin of exports, i.e., how much is exported, and not on the extensive margin, i.e., on whether a country exports at all. Finally, we have not directly estimated any effects of China's exchange rate movements on its own exports. Further research is needed to identify precisely all these other effects.

<sup>17</sup>Note that the renminbi-dollar rate appreciated by only 26 percent in nominal terms; however the appreciation is much higher in real terms when we take into account Chinese inflation.

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