Exchange Rate Adjustments and US Trade with China:

What does a State Level Analysis Tell Us?[1]

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Abstract

In this paper we explore the trade effects of bilateral real exchange rate changes between the 50 U.S. states and China over the period of 2005-2012. There is significant heterogeneity in the productive capacities of 50 states with major implications for their trade patterns. The empirical results based on state-level trade flows and state-level relative prices suggest that the long-run real exchange rates elasticity of US exports to China is in the range of [-3.77, -2.85] and that of Chinese exports to the US is in the range of [-0.23, -3.34]. We also find that state-level differences in human capital and financial development are significant determinants of their export performances with respect to China.

Keywords: Exchange rates, Bilateral trade, US trade deficit, China, State level analysis.

JEL codes: F14, F31, G15, E4

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1. Introduction

The issue of balance of payments imbalances has a long history in international economics going as far back as to the Gold Standard and later to the Bretton Woods system. In fact, a major motivation for the Bretton Woods agreement was to facilitate cooperation among member countries to avoid such imbalances. The only difference between then and now is the name of countries suffering from balance of payments disequilibrium, including, most importantly, the US. While the EconLit lists only seven papers published between 1970 and 2000 on the topic of "global (trade) imbalances and the US" (and shows no reference to China), there are 32 papers published since then and a quick Google Scholar search now provides links to thirteen thousand works.[1]

The origins of the current global imbalances debate can be traced back to the early 1980s, which marked the beginning of more than 30 years of continuous trade deficits for the U.S. (except for the single year of 1991 when it turned positive). While the initial attention was on the US – Japan imbalances, it has been more on the US – China imbalances since early 1990s. While the US run a bilateral trade surplus with China during the 1970s, it has been running a growing deficit since 1983, averaging -$1.95 billion during the 1980s (after 1983), -$49 billion during the 1990s, and -$233 billon between 2000 and 2013 (Figure 1). In 1983 the share of China in US (merchandise good) trade deficit was less than 0.5% but then increased to 9% in 1990, 19% in 2000, and 46% in 2013. In this debate, there are multiple explanations offered for the causes of the so-called "global imbalances" including excessive saving and low domestic absorption behavior of several East Asian countries including China, Japan and Korea as well as some European (i.e. Germany), and oil-exporting Middle Eastern countries (notably Saudi Arabia). The corollary to this explanation is the low saving rates observed in the US and in several leading Western economies such as France, Spain and UK.

<Insert Figure 1 Here>

Another major explanation for the global imbalances has been the use of exchange rate interventions by China as an industrial policy tool within its export-led growth model. Accordingly, China, like many other developing countries, is widely perceived as keeping its exchange rate undervalued, which works as a direct subsidy to its tradable goods sectors, in an attempt to gain competitive advantage against its main trading partners and emerging market rivals. One reason why the exchange rate policy of China took so much of the blame has to do with the fact that it is a relatively easier policy tool to adjust compared to other sources of imbalances such as the saving and absorption rates that require much longer time frames to adjust and may not be politically feasible, especially in the US.[2] After all, raising interest rates or taxes in an attempt to curb domestic absorption and raise saving rates are politically much less popular than putting pressure on China to revalue its currency. As is the case with any price distortion, China's (de facto) fixed exchange rate policy is argued to alter demand and supply conditions and create short-term biases in global and domestic investment and consumption decisions with significant long-term effects (Kim, 2014). In order to correct the subsequent trade imbalances, China is expected to appreciate its currency (RMB) and correct its misalignment with the US dollar (Chiu et al., 2010).

The bilateral nominal (real) exchange rate between China and the US went up (depreciated) by 220% (151%) between 1980-1990, and further by 60% (27%) between 1991 and 1994 and yet stayed at around the new rate up until 2005. In fact, the average annual percentage change in nominal (real) exchange rate was 0% (2%) between 1995 and 2004 (Figure 2). Partly in response to this increasing US pressure, China stopped pegging its currency to the US dollar on July 22, 2005. In this new regime of managed floating, RMB is allowed to fluctuate inside a small band centered around the dollar parity. Since then, the Chinese Central Bank allowed RMB to appreciate against the US dollars annually and the USD-RMB nominal (real) exchange rate appreciated by around 24% (29%) between 2005 and 2013. Nevertheless, the US trade deficit with China increased further jumping from $218 billion to $318 billion (in current prices) during the same period (Figure 1).

<Insert Figure 2 Here>

The effect of exchange rate changes on US bilateral trade with China, therefore, remains a pressing issue for the US as well as for the Chinese policy makers. In this paper we contribute to this debate by exploring the effect of bilateral real exchange rate movements on trade between the 50 US states and China. Unlike previous studies that neglected state level heterogeneity in their estimations, we control for this heterogeneity by using state level trade and real exchange rate data, capturing relative price differentials across 50 states. The state level data also allows us to control for differences in trade structures and accompanying differences in exchange rate elasticities across the 50 states. Last but not least, we control for two major sources of country (state) heterogeneity, which are the level of financial development and human capital. The empirical results using bilateral trade and real exchange rate data between 50 states and China during 2005-2012 and employing a dynamic system GMM method suggest that the long-run real exchange rates elasticity of US exports to China is in the range of [-3.77, -2.85] and that of Chinese exports to the US is in the range of [-0.23, -3.34]. We also find that state and country level differences in human capital and financial development have a significant effect on the export performances of the 50 US states as well China.

The rest of the paper is organized as follows: Section two presents a brief literature review and the relevance of our paper within existing research. The third section introduces the empirical methodology and data followed by empirical results. The last section concludes the paper.

2. Literature Review

Despite the attention Chinese exchange rate regime receives in the news, there is indeed no consensus on either the level of RMB misalignment or its direction. According to a widely cited study by Goldstein and Lardy (2004), for example, the RMB is undervalued in the order of 15 – 25 percent. Likewise, Zhang and Pan (2004) and Chang and Shao (2004) suggest a similar magnitude of undervaluation. On the other hand, McKinnon (2004), focusing on China's optimal currency regime, argues that the current system of fixed peg of RMB against USD combined with soft pegs of other regional currencies might be optimal or near optimal, thus suggesting no need for exchange rate adjustment. Surprisingly enough, Yang (2004) suggests that the RMB might in fact be overvalued.

There is also no consensus with regard to the amount of exchange rate appreciation needed for RMB to close the trade imbalance between China and the US. Obstfeld and Rogoff (2000a, 2000b), for example, suggest that RMB needs to appreciate by a minimum of 20% to balance the bilateral trade between US and China. Likewise, Obstfeld and Rogoff (2005) report that a one percent decrease in the ratio of US trade deficit with the rest of the world to the US GDP requires a real deprecation of the dollar between seven and ten percent. Furthermore, according to their estimates at least a 40 percent dollar depreciation is needed in order to rebalance the US current account with the rest of the world. On the other hand, Blanchard et al. (2005) estimate that a one percent reduction of the ratio of US trade deficit with China to the US GDP requires a depreciation of USD by 15 percent.

In the case of exchange rate elasticity of Chinese exports, there seems to be a consensus among empirical studies, employing a variety of econometric techniques, time periods and data structures (i.e. aggregate vs. disaggregate trade, firm level and/or industry level vs. country level).

Yue and Hua (2002), for example, report that appreciating RMB lowers Chinese exports. Likewise, Bénassy-Quéré and Lahrèche-Révil (2003) predict a significant decrease in Chinese exports to OECD and an increase in its imports from emerging Asia in response to an RMB appreciation. Eckaus (2004) also finds that the appreciation of the RMB lowers China's exports to the US.

On the other hand, Cerra and Dayal-Gulati (1999) find that the real exchange rate elasticity of Chinese exports (an increase is depreciation) is in the range of [1.65, -3.15] and of imports [2.52, -0.59], depending on short-run vs. long run conditions, type of goods, type of exporters and time period between 1983 and 1997. Their results suggest that in the case of China an RMB appreciation may actually increase rather than decrease Chinese trade balance by lowering imports and, at the same time, by lowering exports. That is both expenditure changing and switching effects might be at play here. The reason is that as export demand falls, it also lowers Chinese FX earnings and constrains aggregate demand. Given the export-oriented nature of Chinese output, falling foreign demand also lowers import demand through lower intermediate and final good demand for production, and through lower final consumption demand. In another study Cerra and Saxena (2003) find that RMB appreciation increases Chinese manufacturing exports because the domestic firms are subject to strict mandatory export planning and FX retention quotas. Accordingly, firms respond to appreciations (depreciations) by increasing (decreasing) export volumes, and meet their export value quotas that way. Focusing on bilateral and triangular trade relation in Asia, Thorbecke (2006) also reports "wrong" sign for the effect of exchange rates on US exports to China and several other Asian countries. Accordingly, while the elasticity coefficient is found to be significant and in the range of [-1.51, 0.84] (depending on trend assumptions) for US imports (i.e. Chinese exports), it is found to be -0.57 and insignificant for US exports to China. These findings are consistent with those of Chinn (2005a, 2005b) who show that the sum of export and import price (i.e. effective real exchange rate) elasticities for the total US trade is barely above one. That is given that the Marshall-Lerner condition is hardly met; a real depreciation would hardly improve the US trade balance. In fact, as pointed out by Chinn, given the already large US deficit a depreciation may cause a bigger trade deficit rather than a smaller one (i.e. Hirschman effect).

Furthermore, Deng (2008) finds that while both exchange rate and income effects govern U.S. imports from China, only the income effect is present in China's imports from the US. He also finds that the home country bias is stronger in China than in the US. Lau et al. (2004) examine the trade flow between China and the G3 countries and find that real exchange rate elasticity of G3's exports to China is significantly lower than that of their imports from China. In fact, they fail to detect any effect of real exchange rate changes on Chinese imports at all. Similarly, Yusoff and Sabit (2015) also fail to find any significant impact of an RMB appreciation on China's imports from ASEAN countries. Likewise, Jin (2003), Marquez and Schindler (2006) and Garcia-Herrero and Koivu (2007) report that while an RMB appreciation reduces China's exports to the US, it also reduces China's imports from the US, making the overall impact on the trade imbalance relatively small. Berman et al. (2012) offer a resolution to the puzzle as to why exchange rate depreciations may not affect export volumes. Accordingly, they find that high-performing French exporters, which account for a majority of French exports, respond to exchange rate depreciations by increasing their markups rather than their export volumes.

Despite a wide-range of studies looking at the effect of real exchange rate changes on US-China bilateral trade, surprisingly very few considered the effects of state-level heterogeneity, in terms of export and import demand equations, on US-China bilateral trade. Among the few, Gazel and Schwer (1998) and Cronovich and Gazel (1998), using the aggregate (national) effective real exchange rate (adjusted by state-specific trade weights) and state-level manufacturing exports data, find that a real dollar depreciation positively affects exports of a state to the rest of the world, while one-year lagged real exchange rate depreciation negatively affects exports. We contribute to this debate by exploring the effects of state-level variations in the real exchange rate and other time-state variant determinants of exports, including income levels, financial development and human capital. The use of state-level trade data also allows us to control for the heterogeneity across states and improve our identification with more robust results and stronger forecasting ability.

3. Empirical Analysis

3.1. Estimation Methodology

In the empirical analysis, we employ the following specification as in Cerra and Dayal-Gulati (1999), Eckaus (2004), Thorbecke (2006), Cronnovich and Gazel (1998), and Caglayan et al. (2013):

$$lnEx_{ijt} = \beta_0 + \beta_1 lnEx_{ijt-1} + \beta_2 lnRER_{ijt-1} + \beta_3 lnGDP_{it-1} + \beta_4 lnGDP_{jt-1} + \beta_5 V_i + \varepsilon_{i,t} \quad (1)$$

Where *i*, *j* and *t* refer to exporting country (state) *i,* importing state (country) *j* and year *t* (2005-2013 for exports to China, and 2008-2013 for imports of 50 states from China). *EX* is the real exports of state *i* (China) to China (state *i*) deflated by the relative export/import price index.[3] We use a dynamic export demand equation to control for adjustment lags and path dependency in international trade.[4] Therefore, we expect the lagged exports variable to be positive and significant. Given that our dataset is annual, to control for adjustment lags and also to avoid the risk of reverse-causality, we use one-period lagged values for all control variables.

RER is the real exchange rate between state (*i*) and China at time *t* (an increase is a real depreciation)[5] (Cronovich and Gazel 1998); GDP_i and GDP_j are the domestic and foreign real GDPs (state level for the US, and national level for China), which help control for market size and productive capacity (Krugman and Baldwin 1987; Thorbecke 2006; Caglayan et al., 2013) and are expected to have a positive effect on exports and imports.[6] We include state fixed effects (V_i) to control for unobserved state-specific characteristics, and ε is the error term.[7]

Regarding the effect of real exchange rate, we should note that both expenditure changing and switching effects are at play here. Assuming that i) the Marshall-Lerner condition holds, ii) the assumption of small-open economy is correct, and iii) the expansionary effects of a depreciation are larger than the contractionary ones (see, Krugman and Taylor, 1978), we expect an increase in *RER* (i.e. a depreciation) to increase exports and reduce imports of *i*. However, as suggested by Cerra and Dayal-Gulati (1999) as well as others, a real exchange rate depreciation may also increase import demand by: 1) stimulating domestic activity through higher exports; 2) by increasing imported intermediate and final capital goods demand for production to meet increasing export demand (especially when imported input-output ratio is high as in most developing countries); 3) increasing consumption through higher incomes; and 4) relaxing the foreign exchange gaps through higher foreign exchange earnings (as is the case with China). While not applicable to all countries equally, these four caveats might be particularly important for countries such as China given its export oriented nature. If this is indeed the case, an RMB appreciation is no guarantee for correcting the US trade deficit with China. In fact, the US exports to China may actually decrease after an RMB appreciation if it leads to a significant contraction in Chinese exports and consequently in its aggregate demand.

In Eq. (2) below we extend Eq. (1) by including two additional variables that are the levels of human capital (*HK*) and financial development (*CR*) in exporting states (country) to account for supply side effects.

$$lnEx_{ijt} = \beta_0 + \beta_1 lnEx_{ijt-1} + \beta_2 lnRER_{ijt-1} + \beta_3 lnGDP_{it-1} + \beta_4 lnGDP_{jt-1} + \beta_5 lnHK_{it-1} + \beta_6 lnCR_{it-1} + \beta_9 V_i + \epsilon_{i,t} \quad (2)$$

The level of human capital in each state and in China is captured by the percent of population aged 25 and above with at least a high school degree.[8] The level of financial development is measured by the ratio of total liabilities of all commercial banks to the state (Chinese) nominal GDP (i.e. Gross State Product, GSP) (Beck et al., 2009).

Given their dynamic nature, we estimate Equations (1) and (2) using the Blundell and Bond (1998) system GMM estimation, which also helps control for potential endogeneity and reverse causality problems.[9] The system GMM simultaneously estimates both the differenced equation and level equation by choosing the lagged values of both independent and dependent variables as instruments to mitigate the endogeneity issue. The presence of second degree autocorrelation is tested by an AR(2) test and the validity of instruments are tested by Hansen's J-Test. To avoid the problem of "too many instruments" (Roodman, 2009), we limit the instrument lags to $2 \leq t \leq 5$.

3.2. State Level Trade Flows

Choosing the most appropriate state-level exports data is critical to this analysis. There are two state-level export data series provided by the U.S. Census Bureau: one is based on the origin of movement (OM), and the other one is based on the origin of production (OP). Our research follows studies on regional trade and employs the OP series of state-level export data. OP data measure the merchandise goods produced by a state and consumed by the rest of the world outside the state, including foreign countries and other states. The OM series, on the other hand, do not capture the production origins of U.S. merchandise exports. So, the manufactured exports from non-industrial states tend to be overestimated. This is particularly true when commodities produced by out-of-state suppliers can be shipped from in-state distribution centers, and that shipments of manufactured commodities from in-state warehouses or distribution centers are arranged by exporters located out-of-state. In addition, the OM series have other statistical limitations, that is, in certain cases the origin of movement is not even the transportation origin. For instance, intermediaries located in inland states ship agricultural commodities down the Mississippi River for export from the port of New Orleans. In this case Louisiana is reported as the state of origin of movement simply because it is where the port is located.

There is significant heterogeneity in state level export performance to China. According to Figure 3, in 2005 top five states (California, Texas, Washington, New York, and Louisiana) captured a total of 51.2 percent of the total US exports to China, while the bottom five states (North Dakota, Wyoming, Montana, South Dakota, and Rhode Island) accounted for only 0.3 percent. In 2012, Washington replaced California and became the largest exporting state to China. Furthermore, in 2012 the top five states' (Washington, California, Texas, Louisiana, and New York) export shares to China decreased to 47.1 percent while at the same time the share of the bottom five states (Wyoming, North Dakota, Hawaii, New Mexico, and South Dakota) decreased to 0.2 percent. Figure 4 illustrates the heterogeneity among states in terms of the importance of exports in each state's GSP. Accordingly, the total exports of five leading states (Washington, Louisiana, Vermont, Alaska, and Idaho), reached an average of 0.97 percent of their GSPs in 2005; in contrast, the share of exports to GSP was only 0.07 percent for the bottom five states (North Dakota, Wyoming, Oklahoma, Montana and Florida). As of 2012, the average share of exports to China over GSP increased slightly to 0.08 percent at the lowest ranked five states (Wyoming, North Dakota, New Mexico, Hawaii and Florida), but it increased radically to 2.69 percent for the highest ranked five (Louisiana, Washington, Alaska, Vermont and South Carolina). The high level of heterogeneity in export performance across 50 states further support the need for a state-level analysis in empirical research on US trade imbalances with the rest of the world.

<Insert Figures 3&4 Here>

3.3. Bilateral Real Exchange Rate

The bilateral RER variable is created using the nominal USD-RMB exchange rate and corresponding state level and Chinese national average CPIs. The exchange rate data and CPI data are from the International Financial Statistics (IFS) of International Monetary Fund (Cerra and Dayal-Gulati 1999, Eckaus 2004; Thorbecke 2006).[10] The differences in the cost of living across states are measured by the Regional Price Parities (RPP) index of Bureau of Economic Analysis (BEA) using consumption goods and services (Aten and Martin 2012). As shown in Figure 5, RPP varies significantly across states. For example, in terms of cost of living, in 2012, the top five states (Hawaii, New York, New Jersey, California, and Maryland) paid, on average, 30.3 percent more on consumption purchases than the bottom five states (Mississippi, Arkansas, Alabama, Missouri, and South Dakota). This variance was even more salient in 2005 when the top five states (New York, Hawaii, California, New Jersey, and Connecticut) on average paid 70.4 percent more than the bottom five (West Virginia, North Dakota, Mississippi, Arkansas, and Alabama). Following the usual notation, we calculate the state-level bilateral USD-RMB real exchange rate as in Eq. (3):

$$RER_{ijt} = E_{ijt}P^*_{jt}/P_{it} \tag{3}$$

where E is the nominal exchange rate of the USD with RMB for state i (with i= 1 … 50) at time t, and it is the same across 50 states. P^* is the foreign (Chinese) price level and P is the (state-level) price level. Thus, an increase in *RER* represents a depreciation. We should point out that the use of state-level prices for bilateral real exchange rate measurement allows a more precise estimate of exchange rate movements and separates this paper from previous works such as Cronnovich and Gazel (1998), which uses a state-level trade-share weighted effective real exchange rate based on the national PPI.

<Insert Figure 5 Here>

Figure 6 compares the state level USD-RMB RER with the national nominal and effective RER, and reveals a larger appreciation rate of RMB against the USD at the state level than that at the country level. Between 2005 and 2012 the average state RER actually appreciated by 37.32 percent compared to the 19.33 (29.81) percent appreciation as reflected by the national effective RER (NER). Moreover, Figure 6 also reveals that the RER levels vary significantly across the 50 states, and in 2012 Mississippi led all states with the highest RER level of 0.188 while Hawaii had the lowest of 0.139. The summary statistics for all variables are given in Table 1.

<Insert Figure 6 Here>

<Insert Table 1 Here>

4. EMPIRICAL RESULTS

Table 2 reports regression results from Equations (1) and (2) for state-level US exports to China. The results in columns (1)-(4) suggest a significantly negative effect of real exchange rate variable on real exports of state *i* to China. The predicted elasticity coefficient is in the range of [-3.77, -2.85] and is quite large. This result is consistent with previous literature that report the "wrong sign" for US exports (see, for example, Cerra and Dayal-Gulati, 1999; Jin, 2003; Lau et al., 2004; Thorbecke, 2006; Marquez and Schindler, 2006; and Garcia-Herrero and Koivu, 2007). Accordingly, after accounting for the inter-state heterogeneity of price levels and state-specific fixed effects, we find that a one percent depreciation of the USD-RMB real exchange rate decreases state *i*'s exports to China by [-3.77, -2.85]%.[11]

Turning to other variables of interest, we find that state level incomes (*RGSP*) have a positive effect on exports, though at changing significance levels. The importer GDP variable, on the other hand, has a significantly positive effect on US exports. Accordingly, the income elasticity of state *i,*'s exports to China is found to be in the range of [1.2, 2.0]. That is, a one percent increase in Chinese GDP tends to increase state level exports to China up to two percent. The human capital variable (*HK*) appears to have a positive and significant effect on state level exports. Given that the regressions include state-fixed effects, this is indeed an important finding showing the significance of state-level variation in educational outcomes and human capital. The (state level) bank credit to GDP ratio variable (*CR*), however, appears with the wrong sign (negative) when included alone but becomes positive and significant when we control for human capital differences.

<Insert Table 2 Here>

In Table 3 we present results from Eqs. (1) and (2) this time for the Chinese exports to state *i*. Consistent with other studies, we find that a real exchange rate appreciation has a significantly negative effect on Chinese exports to state *i*.[12] The estimated exchange rate elasticity is in the range of [-0.23, -3.34]. We also find that Chinese exports are significantly income elastic with the coefficient estimates being in the range of [0.17, 4.14]. That is a one percent increase in real GSP boosts Chinese exports to state *i* up to four percent. Increasing Chinese GDP is also found to have a significantly positive effect on its exports, possibly reflecting supply side factors. Consistent with previous studies and also similar to the US case, we find the human capital and credit availability variables to be positive and significant. We should also note that in both tables, the legged dependent variable is economically and statistically significant, supporting the gradual adjustment assumption. Last but not least, the long run exchange rate elasticities are also quite large and are in the range of [-14.57, -3.076] for the US and [11.17, 0.82] for China (an increase in RER is a depreciation in both cases here).[13] In all regressions, the validity of the instruments is supported by the Hansen's J-test and we do not detect any significant autocorrelation of order two.

<Insert Table 3 Here>

4.1 Sensitivity Analysis

In order to test the robustness of our results we have undertaken a variety of (unreported) sensitivity checks.[14] First, we included both current RER and the one-year lagged RER in an effort to explore any delayed effects of RER on exports. We also explore the effect of longer legs by including both one and two-year lagged RER variables. Third, we test for the presence of any sample selection problem given that the exports to GSP ratio varies significantly across states (Figure 4). To this end, we dropped the bottom two (Wyoming and North Dakota) and the top two outliers (Washington and Louisiana) from the sample and repeated regressions from Tables 2 and 3. Lastly, we repeated the regression analysis using the fixed effect estimator. The (unreported) regression results were similar to those reported and are available upon request.

5. CONCLUSION

In this study we investigate the exchange rate elasticities of bilateral trade between the 50 US states and China between 2005 and 2012. Our study differs from previous work on multiple accounts. First, instead of focusing on aggregate trade, we directly control for the effects of state level heterogeneity in US exports and imports by using a state-level panel data. Secondly, we utilize a state-level real exchange rate variable, which captures state-level variation in prices. To this end, we construct the RER between RMB and USD using the state-level RPP to capture the heterogeneity in real purchasing power across 50 states. Third, we control for two major sources of state-level heterogeneity in export and import performance, which are the level of human capital formation, and financial depth. Last but not least, we adopt a dynamic export (import) function with adjustment lags and employ the Blundell and Bond (1998) system GMM method to control for reverse causality and potential endogeneity problems. The estimation results are consistent with the previous work revealing a "wrong sign" for the US exports to China. That is, unlike the predictions of the small open economy models, our results suggest a significantly negative effect of domestic currency (i.e. USD) depreciation on US exports to China with the coefficient estimates being in the range of [-3.77, -2.85]. On the other hand, the appreciation of RMB is found to have a significantly negative effect on Chinese exports to the US with the coefficient estimates being in the range of [-0.23, -3.34].

The U.S. trade deficit with China rolled to 295.3 billion dollars (or 1.8 percent of the US GDP) in 2013, which consisted of $160.6 billion of exports and $455.9 billion of imports. A back-of-the-envelope calculation can be made based on the most optimistic estimates of the RER elasticities of U.S. exports and imports with China in this paper. That is let us assume that the RER elasticity of US exports to China equals -2.96 and that of Chinese exports equals -3.34. Between 2005 and 2013 the average annual growth rate of US exports (imports) to (from) China was 16.4 percent (9.9 percent), and the average appreciation rate of RMB in relation to the USD was 1.8 percent. Keeping the US exports and imports at their levels in 2013, and using the aforementioned average growth rates and appreciation rates, we can construct the following equation:

$$160.6 * (1+0.164+(-2.96*0.018)^n = 455.9 * (1+0.099+(-3.34*0.018)^n,$$

Where n is the number of years needed to eliminate the US trade deficit with China. The calculation yields a value of 15.6 for *n*, indicating that the RMB needs to keep appreciating against the USD at an annual rate of 1.8 percent for the next 16 years in order to eliminate the trade imbalance between the US and China. Therefore, although the RER could be used to adjust the U.S. trade deficits with China, the whole process in completion of the adjustment, however, may take another 16 years under the most optimistic estimation.

ENDNOTES

[1] We did the search on 3/9/2015 using these key words in the abstracts. Google Scholar provides only 240
[1] We did the search on 3/9/2015 using these key words in the abstracts. Google Scholar provides only 240
links for reference to "Global Imbalances" prior to 2000.

[2] Since 2003 the Congress have been trying to pass multiple bills aimed at addressing China's currency policy by putting a tariff/quota on China using its "exchange rate manipulation" as the justification. The congressional concerns about undervalued currencies have recently moved beyond China to include several other countries as well (Morrison and Labonte, 2013).

[3] To be more specific, because of a lack of state-level export/import price deflators, state level exports to China were deflated by US export price index for all commodities, and Chinese exports to a state were deflated by US import prices index for all commodities from China. Price indexes are retrieved from BLS at http://www.bls.gov/mxp/.

[4] The demand side adjustment to relative price changes may take more than a year (Garcia-Herrero and Koivu, 2007).

[5] In the US exports to China equation, an increase in RER is a real depreciation, and in the Chinese exports to the US equation it is an appreciation.

[6] The home bias effect, however, would cause the importer market size variable to be negative.

[7] We do not include year fixed effects, as they would have removed the effect of nominal exchange rates on state level exports.

[8] We should note that because of data unavailability the age cut-off point for *HK* in China is 15.

[9] In the regression analysis we identify RER_{ijt-1}, GDP_{it-1} and GDP_{jt-1} as endogenous variables.

[10] A common concern with the use of CPI, rather than PPI, is that it includes non-tradables and therefore may bias the real exchange rate measurement (Cronovich and Gazel, 1998; Kıpıcı and Kesriyeli, 1997). However, due to data unavailability on PPI, we opted in to use the CPI series.

[11] In a survey study Chinn (2004) finds that the range of U.S. exchange rate elasticities of imports and exports is quite wide, with a scope ranging from near zero to larger than unity.

[12] Note that, unlike in Table 2, an increase in RER here is an appreciation.

[13] The long run elasticities are calculated based on $\beta_2/(1-\beta_1)$.

[14] The regression results from the sensitivity checks are available in an online appendix.

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APPENDIX

A1. Variable Definitions and Data Sources

$Exports_{ijt}$ (Exports of State *i* to China in year *t* in USD): TradeStats Express™ - State Export Data, Office of Trade and Industry Information (OTII), Manufacturing and Services, International Trade Administration (ITA), U.S. Department of Commerce.

$Exports_{jit}$ (Exports of China to State *i* in year *t* in USD): TradeStats Express™ - State Import Data, OTII, Manufacturing and Services, ITA, U.S. Department of Commerce.

Nominal exchange rate (E, dollar per RMB): International Financial Statistics (IFS) of IMF.

CPI_{China} (Consumer Price Index of China, base year=2010): China Statistical Yearbook, multiple years, National Bureau of Statistics of China.

CPI_{USA} (Consumer Price Index of USA, base year=2010): IFS, IMF

RPP: Regional Economic Accounts, Bureau of Economic Analysis (BEA) Regional Price Parities are expressed relative to the national average which is set at 100 for each year).

RER (State level real exchange rate between USD and RMB, US Dollars per RMB): Computed by the authors using data on the USD-RMB NER, CPI, and RPP.

Y_{China}(Chinese real GDP in constant 2009 dollars): Bank national accounts data, and OECD National Accounts data files.

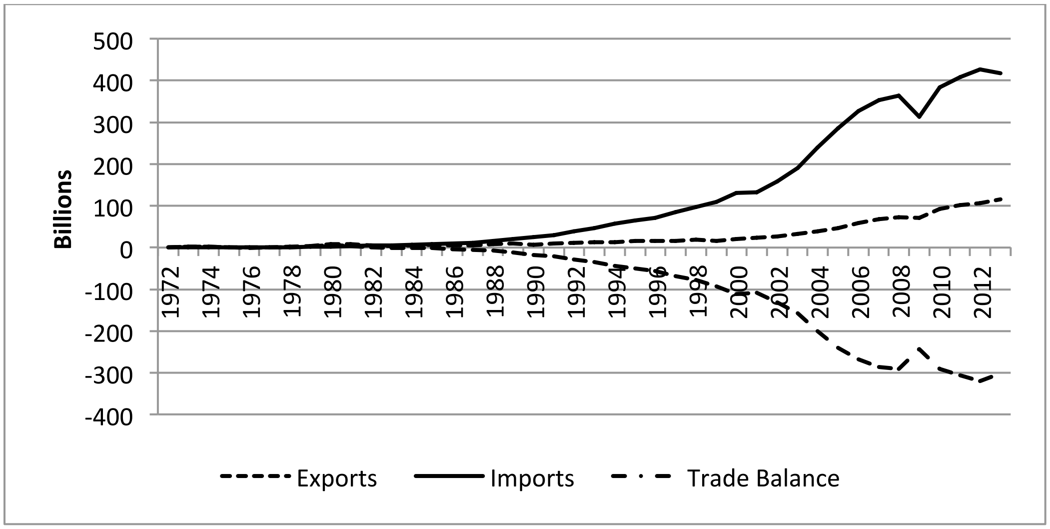
Y_i (RGSP, real state-level GDP in constant chained 2009 dollars): Regional Economic Accounts, Bureau of Economic Analysis (BEA).

HK_{USA} (USA, Percent of population aged 25 and above with a high school degree or above): Community Survey, American Fact Finder, US Census Bureau.

HK_{Chn} (China, Share of High School Graduates in Chinese population aged 15 – 64): Annual National Data, National Bureau of Statistics of China

CR (total liabilities of all commercial banks in state i (China) over state nominal GSP): Historical Statistics on Banking (HSOB), Federal Deposit Insurance Cooperation (FDIC; National Data, National Bureau of Statistics of China.

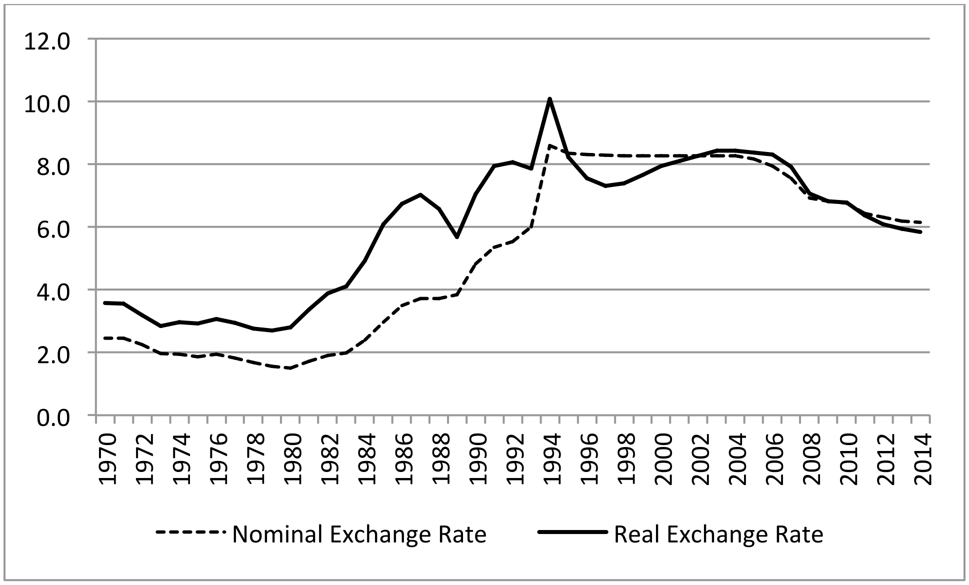
Figure 1: US Real Merchandise Goods Exports and Imports to and from China, 1972-2013.



Notes: Exports and imports are real total merchandise trade in (constant) billion dollars (deflated by US GDP deflator, 2010=100).

Source: IMF, Direction of Trade Statistics (2015) and authors' calculations.

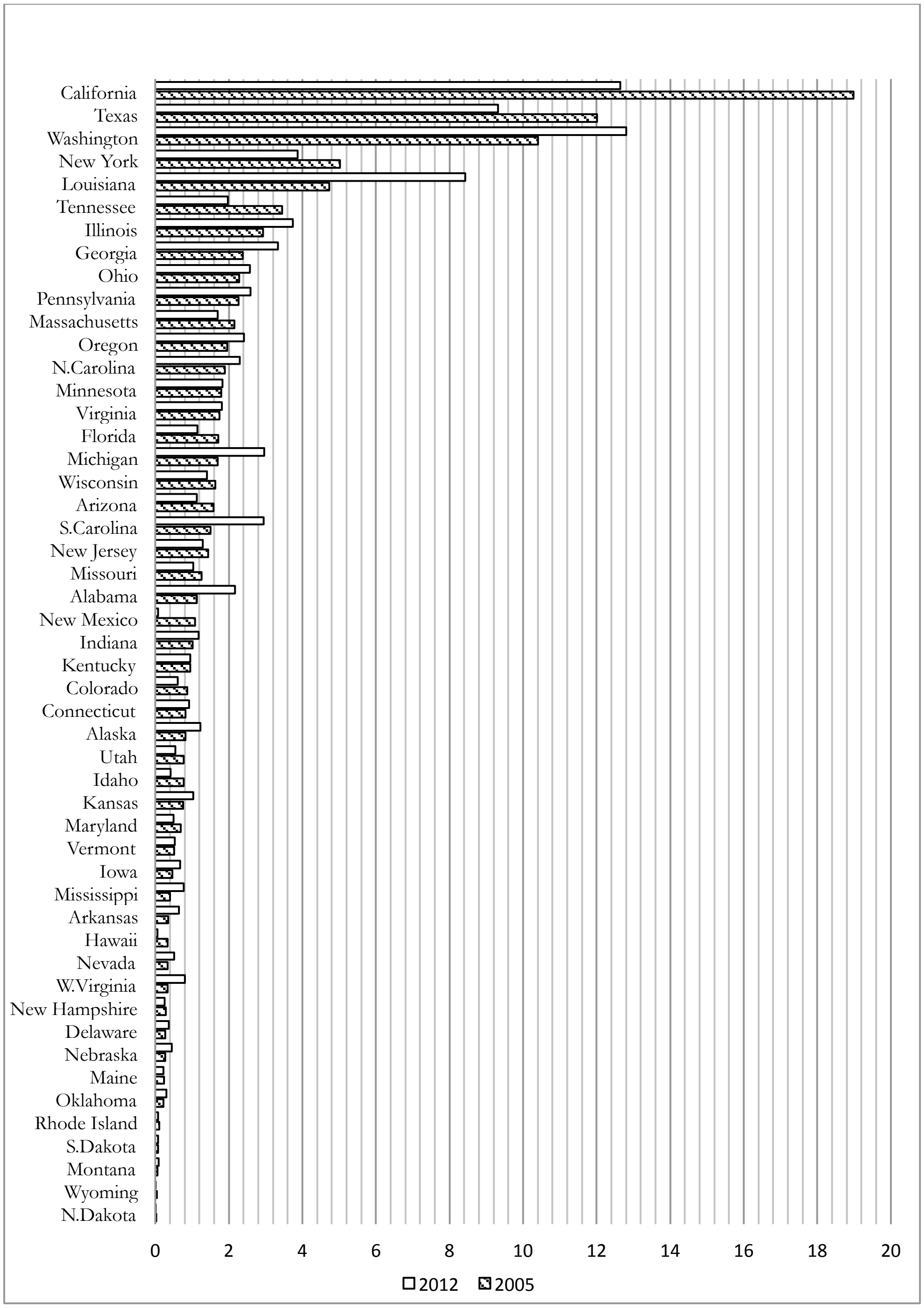
Figure 2: US-China Bilateral Nominal and Real Exchange Rate, 1970-2014



Notes: An increase represents depreciation.

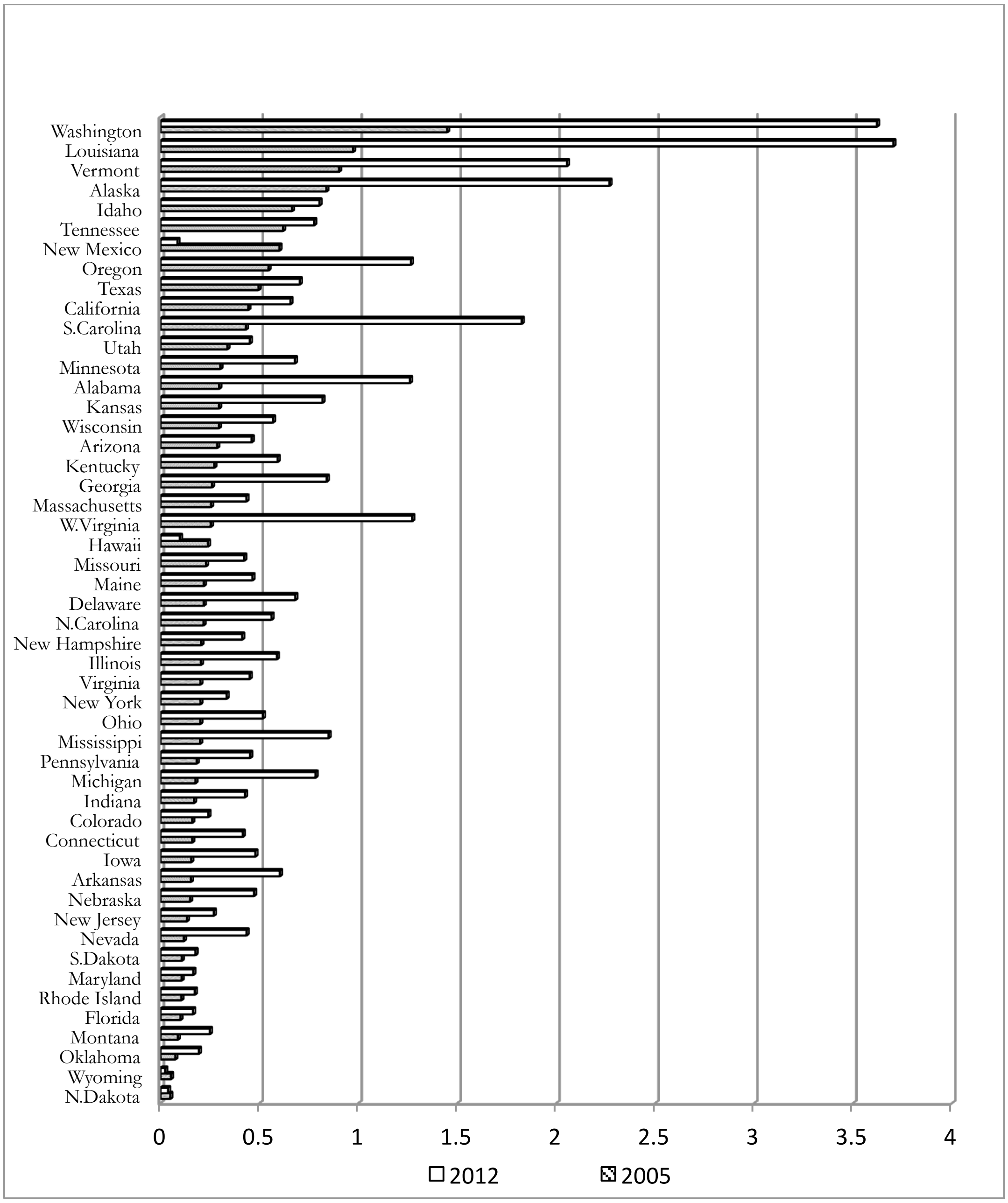
Source: World Bank (2015) and authors' calculations.

Figure 3: State's Share of the US Exports to China 2005 - 2012, in Percentage



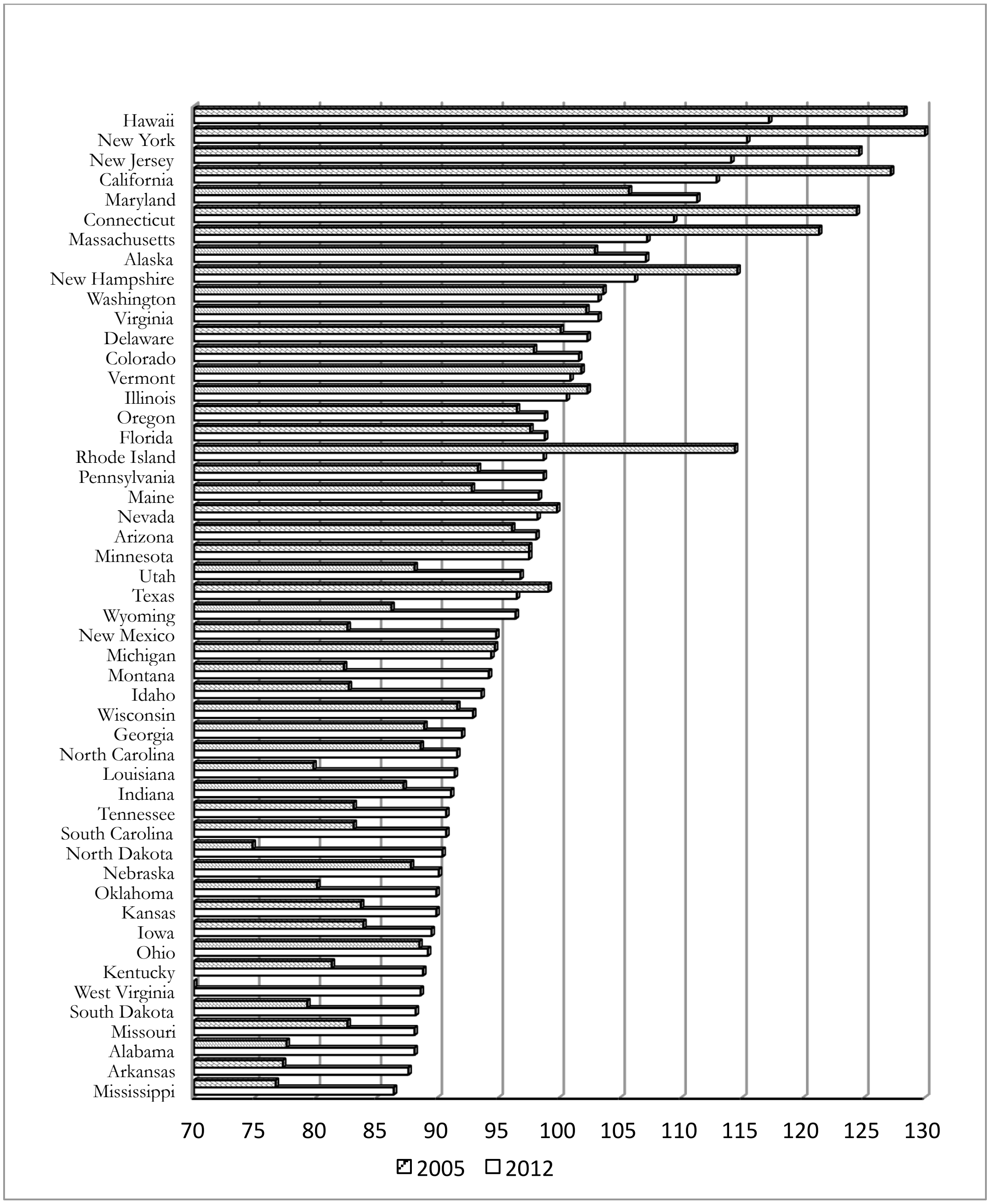
Source: TradeStats Express, OTII, Manufacturing and Services, ITA, U.S. Department of Commerce, and authors' calculations.

Figure 4: State Exports to China as Share of State-Level GSP, 2005-2012, in Percentage



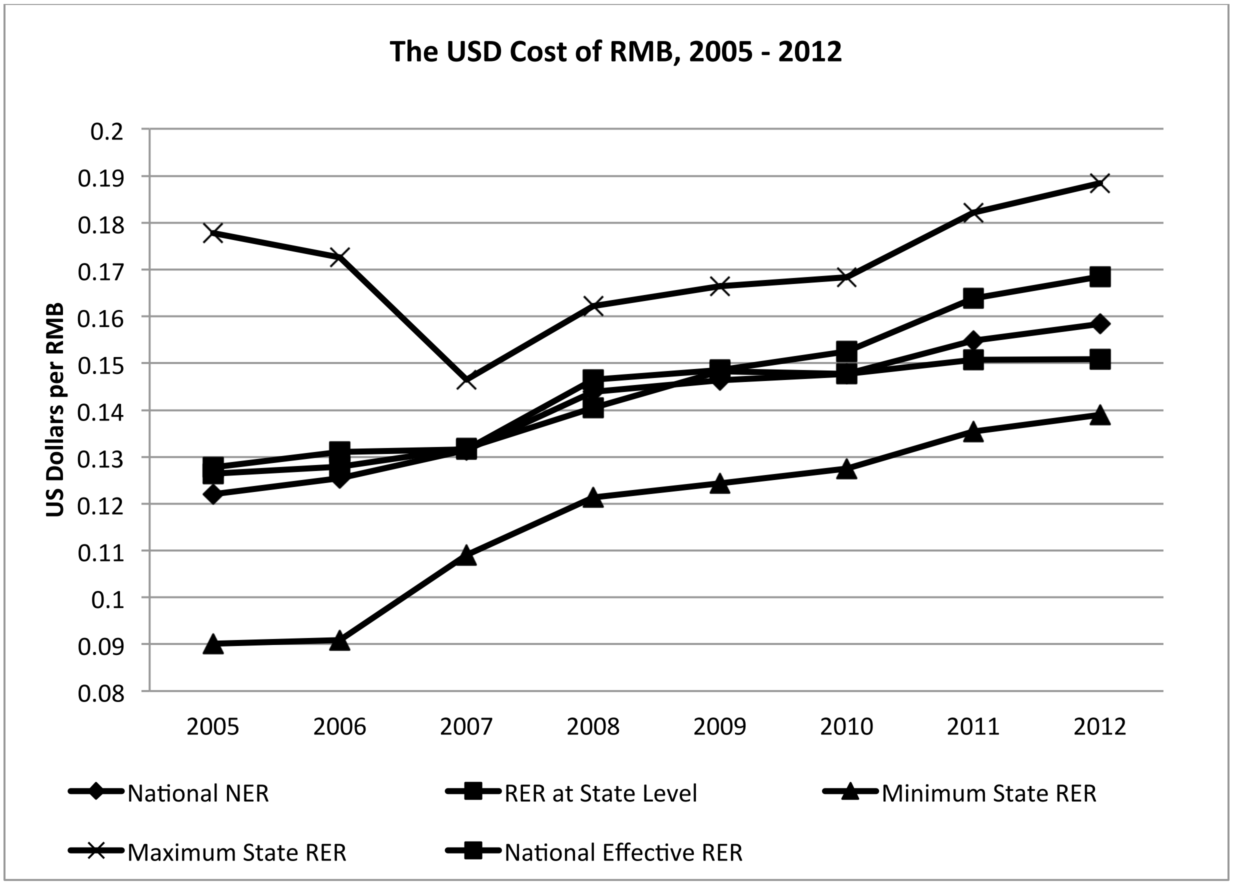
Source: TradeStats Express, OTII, Manufacturing and Services, ITA, U.S. Department of Commerce, and authors' calculations.

Figure 5: State-Level Price Parities in 2005 and 2012



Source: Regional Economic Accounts of BEA, and authors' calculations. The average of all 50 states is 100.

Figure 6: The USD-RMB Nominal and Real Exchange Rates, National vs. State Averages, 2005 - 2012



Source: BEA and authors' calculations.

Table 1: Summary Statistics

	Obs	Mean	Std	Min	Max
$ln\ Ex_{USA,t}$	400	8.774	0.656	6.565	10.152
$ln\ Ex_{Chn,t}$	250[a]	9.323	0.727	7.635	11.106
$NER_{i,t}$	400	0.1335	0.016	0.122	0.1584
$RPP_{i,t}$	400	0.967	0.102	0.664	1.334
$RER_{i,t}$	400	0.143	0.025	0.081	0.198
$ln\ Y_{Chn}$	400	12.509	0.137	12.285	12.670
$ln\ RGSP_{i,t}$	400	11.238	0.446	10.402	12.303
HK_{USA}	400	0.867	0.035	0.751	0.934
HK_{Chn}	400	0.014	0.001	0.011	0.015
CR_{Chn}	400	1.805	0.136	1.624	1.973
CR_{USA}	400	1.345	4.583	0.035	53.366

Notes: Ex_{USA} is the real exports from state i to China; Ex_{Chn} is the real exports from China to state i. *NER* is the national level nominal exchange rate between USD and RMB, US Dollars per RMB; *RPP* is the state level regional price parities; *RER* is the state level bilateral real exchange rate; Y_{China} is the real GDP of China; *RGSP* is the real state level GDP; HK_{USA} is the state level percentage of high school graduates; HK_{Chn} is the percentage of high school graduates in China; CR_{Chn} is bank liabilities to GDP ratio in China; CR_{USA} is state level bank liabilities to GSP. [a]The state imports data is available for the period 2008–2012, therefore the entry in the 4th column is actually comparing the mean of state imports from china in 2008 and that in 2012.

Table 2: Estimation Results for state level exports to China

	(1)	(2)	(3)	(4)
$ln\ Ex_{ijt-1}$	0.727***	0.797***	0.075	0.241
	(0.158)	(0.142)	(0.265)	(0.382)
$ln\ RER_{it-1}$	-3.769***	-2.957***	-2.845***	-3.615**
	(0.895)	(0.655)	(0.995)	(1.499)
$lnRGSP_{it-1}$	0.196	0.558**	0.517	1.026
	(0.295)	(0.252)	(1.478)	(0.704)
$ln\ Y_{Chn,t-1}$	2.034***	1.221***	2.067***	1.921**
	(0.411)	(0.329)	(0.509)	(0.759)
$ln\ HK_{it-1}$		12.374***		34.306*
		(3.118)		(20.443)
$ln\ CR_{it-1}$			-1.039**	1.285*
			(0.441)	(0763)
Hansen's J-test	0.194	0.117	0.267	0.268
AR(2) test	0.301	0.943	0.462	0.747
State fixed effects	Yes	Yes	Yes	Yes
Num. of instruments	9	12	15	14
Num. of groups	50	50	50	50
Num. of obs.	350	350	350	350

Notes: *Ex* is the real exports from state i to China; *RER* is the level of real exchange rate; RGSP is the real state gross product; Y_{Chn} is the real GDP of importer (China), *HK* is the percentage of high school graduates in state *i*, and *CR* is the total bank liabilities to GSP ratio. All test statistics are given by their p-values. Robust standard errors are in parentheses. ***, ** and * denote significance at the 0.01, 0.05 and 0.10 level, respectively.

Table 3: Estimation results for Chinese exports to state *i*

	(1)	(2)	(3)	(4)
$ln\ Ex_{ijt-1}$	0.491**	0.828***	0.361***	0.721***
	(0.217)	(0.137)	(0.081)	(0.144)
$ln\ RER_{it-1}$	-3.338***	-1.921***	-1.818***	-0.228
	(0.823)	(0.512)	(0.374)	(0.672)
$ln\ Y_{Chn,t-1}$	2.732***	1.822***	0.666***	0.381
	(0.331)	(0.189)	(0.074)	(0.406)
$ln\ RGSP_{it-1}$	4.142**	0.179	1.344***	0.452*
	(1.867)	(0.285)	(0.166)	(0.257)
$ln\ HK_{it-1}$		13.590***		4.341**
		(0.877)		(2.251)
$ln\ CR_{it-1}$			2.616***	1.818***
			(0.116)	(0.399)
Hansen's J-test	0.291	0.134	0.164	0.110
AR(2) test	0.786	0.297	0.280	0.271
State fixed effects	Yes	Yes	Yes	Yes
Num. of instruments	9	17	21	20
Num. of groups	50	50	50	50
Num. of obs.	150	200	200	200

Notes: For variable definitions refer to Tables 1 and 2.