How Did Exchange Rates Affect Employment in US Cities?*

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Abstract

We estimate the effects of exchange rate on US employment, exploiting differences in industrial composition across major cities. We find that a 1% depreciation of export-weighted real exchange rate has a positive 0.98% direct effect on manufacturing employment. Its indirect effect on local nonmanufacturing employment rises with the size of the local manufacturing sector, consistent with the hypothesis that there exists a local spillover from the tradable to the nontradable sector. In cities with heavy concentration of manufacturing employment, the indirect effect is statistically significant and about 60% as large as the direct effect measured by the number of jobs.

JEL classification codes: F3, F1, J2

Key words: exchange rate, employment, and US cities.

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1 Introduction

Substantial US dollar depreciation is sometimes considered a solution to the problems of the large US current account deficit and declining manufacturing employment. However, existing studies report mixed evidence about the size of the effects of exchange rate movements on employment in advanced economies. Two early studies based on data from the US, Branson and Love (1988) and Revenga (1992), did report large estimated effects. Revenga (1992), for example, finds that the US dollar's appreciation in the early 1980s reduced employment by about 6%. Some later studies based on larger samples, however, report much smaller estimates of the employment effects in the US (Goldberg and Tracy, 2000; Campa and Goldberg, 2001; Klein, Schuh and Triest, 2003). Klein, Schuh and Triest (2003), for example, find that two consecutive annual 5.4% (one-standard deviation) appreciations of the cyclical component of the exchange rate reduce net employment growth in the manufacturing industries by 0.7%. Meanwhile, other recent papers report a large effect of exchange rate on employment in advanced economies, including Canada (Leung and Yuen, 2007; Huang, Pang and Tang, 2014), France (Gourinchas, 1999; Hatemi-J and Irandoust, 2006), Italy (Nucci and Pozzolo, 2010), and the US (Faria and León-Ledesma, 2005). In these papers, a 1% appreciation is typically associated with 0.5% to 1% decrease in employment.

Almost all of these previous studies focus on manufacturing industries, which are traditionally regarded as the tradable industries in an economy. Although the manufacturing sector plays an important role in the economy, its share in total employment is typically below 15% in developed countries. Consequently, if the exchange rate affects employment only in the manufacturing industries, its effect on national employment would likely be small. Meanwhile, there are a number of ways in which the exchange rate can affect nonmanufacturing industries, even if those industries have little or no exposure to international trade. For example, one such channel is a potential demand knock-on or spillover effect. If a depreciation strengthens the demand facing the domestic manufacturing industries, these industries, and their workers, will in turn demand more products and services from the domestic nonmanufacturing sector, potentially boosting its employment.

In this paper, we update the research on the employment effects of exchange rates with more recent data and using a novel source of variation, those arising from differences in local industrial composition. In addition, we broaden the analysis to include the exchange rate movement's indirect employment effect on the nonmanufacturing sector, which hires far more labor than the manufacturing industries. Specifically, we analyze the data from major US Metropolitan Statistical Areas (MSAs), which we will refer to as cities. These cities have different mixes of manufacturing industries that have potentially different trading partners. In a particular year, a specific city can be subject to larger or smaller exchange-rate changes than other cities because of different industrial compositions. We will exploit this variation of the exchange rate across cities to estimate their effects on manufacturing jobs.

To estimate the exchange rates' spillover effects on non-manufacturing industries, we exploit non-manufacturing products' relative lack of tradability. The key assumption is that the demand for non-manufacturing products is, in part, local. So the economic misfortune of a city's manufacturing industries has negative impacts on local non-manufacturing industries. The local connections could arise because the manufacturers source some of their inputs locally (think construction, maintenance or other business services that cannot be provided remotely), or because those manufacturers' employees must consume locally-produced goods and services like housing, retail and restaurant services. A similar assumption is used in Mian and Sufi (2012) in their estimation of the 2007-09 housing bust's knock-on effects on local nontradable sector's employment. In both cases, a negative local shock (housing bust in Mian and Sufi (2012), a rising trade-weighted exchange rate for local manufacturing industries in our study) is assumed to reduce employment in local nontradable industries through a demand channel. Crucial to our estimation strategy, we assume that nonmanufacturing products are nontradable. Of course some services are in fact tradable; some financial and technological services, for example, are provided remotely. We will test the robustness of our findings using a more refined approach to proxy for tradability, separating tradable service industries such as finance, insurance, transportation, technology and business management from other nonmanufacturing industries.

We also recognize that there are multiple forces working in the general equilibrium, and a local economy's responses to an external demand shock are shaped by fundamental factors in the local area and beyond. Under the demand spillover described above, employment in both the tradable and the nontradeable sectors respond positively to a demand increase that arises from the foreign exchange market. But competition for labor by the two sectors can increase economy-wide wages and suppress employment responses. Inter-city migration and exiting labor slack in the local and nearby areas, on the other hand, tilt the responses from the wage side to the employment side. We will use both employment and wage data to shed light on the relative dominance of these underlying forces in our sample period. But our reduced-form estimates, by their nature, are dependent on time-varying factors, and are therefore best interpreted as a description of recent US experience. One of our contributions is the focus on local heterogeneities in response to exchange-rate fluctuations, a subject that is little studied in the literature. But the focus on local differentials also imposes its own limits in the sense that the estimates are not easily aggregated up to the country level, because some of the mechanisms shaping the local responses, such as the ease of labor migration, are different at the national level than at the local level.

In our estimation, we differentiate between import-weighted exchange rates and export-weighted exchange rates. An important reason is that the vast majority of the trade of the US is denominated by the US dollar (Goldberg and Tille, 2008). Under this invoicing practice, fluctuations in exchange rates do not necessarily lead to price changes for American importers, because foreign exporters may decide to absorb some of the exchange rate fluctuations to stay competitive in the US market (Bacchetta and Van Wincoop, 2005), even though the exchange-rate movements affect the prices they receive in their own currencies. One example of this incomplete exchange-rate pass through to US consumers is given in Goldberg and Knetter (1997). After a 34% appreciation of the Japanese Yen against the USD from 1994 to 1995, the price of an Toyota Celica made in Japan and sold in the US rose by less than 2 percent over the period. In contrast, foreign buyers of American products are fully exposed to the exchange rate risk, and hence more likely to respond to exchange rate fluctuations. In addition, import exchange rate affects the price of imported inputs. Therefore, the changes in import exchange rates and export exchange rates can have different effects on employment.

Our findings suggest that a depreciation in export-weighted exchange rates increases local employment in the manufacturing sector and employment in the nonmanufacturing sector. Meanwhile, depreciations in import exchange often do not affect employment. Importantly, we find that the exchange rates' effects on the nonmanufacturing employment are greater in cities that have a higher fraction of manufacturing employment. This is consistent with the hypothesis that the exchange rates indirectly affect the nonmanufacturing employment through their direct impacts on the manufacturing sector. The findings are robust when we broaden the definition of tradable industries to include tradable service industries.

For a more complete picture, we also examine the responses of wages. We find that average weekly wages per worker in local manufacturing and nonmanufacturing sectors both react positively to an exchange-rate depreciation. In contrast, growth in local hourly wage – which we cannot further breakdown by sector due to data constraint – is unresponsive. We infer from the findings that it is mainly the hours worked that drive the responses of weekly wages. We regard the findings, that hours worked per worker react in the same direction as does the number of workers, as corroborating evidence for exchange-rate movements' impact on employment. The lack of hourly-wage response may be a result of wage rigidity and the tightness of labor market conditions. But the exact causes are not explored in this paper.

Relative to the literature that studies the employment effects of exchange rates, our paper makes several contributions. First, we find from city-level data that exchange rate depreciations have a positive impact on employment in tradable industries. Our use of local data complements the previous literature that uses manufacturing industries as cross-section units. Second, to the best of our knowledge, our paper is the first to quantify the effects of exchange rates on employment in local nontradable industries. We thus broaden the scope of the analysis to include the much bigger service sector in the economy. Third, we highlight the heterogeneous effects of exchange-rate fluctuations across cities, in particular with regard to the vulnerability of heavily industrial areas in terms of local knockon effects from the manufacturing sector to the local service sector. Fourth, our results indicate that export and import exchange rates have different effects. Depreciations in export exchange rates are almost always associated with increased employment, whereas the effects of import exchange rates are often insignificant.

2 Empirical Specifications

2.1 Employment in tradable industries

Our empirical specifications for employment in tradable industries are modified from those of Campa and Goldberg (2001), who derive their regression specification from the profit maximization problem of a firm in an open economy environment. In their theoretical model, a firm produces domestically using labor, domestically produced inputs, and imported inputs, and sell the output in home and foreign markets.

In this setup, the exchange rate influences the demand for labor through two channels. First, an appreciation of the home currency make home products more expensive relative to foreign products, leading to a decrease in demand for home products and consequently demand for home labor. This effect is stronger for firms that export a large fraction of their output and firms that face a lot of foreign competition in home markets. Second, imported inputs become cheaper during appreciations of the home currency. Depending on whether imported inputs and domestic labor are complements or substitutes in production, cheaper imported inputs can increase or reduce demand of home labor. In particular, if imported inputs and labor are substitutes, then a reduction in price of imported inputs will depress demand for labor. However, if they are complements, then cheaper imported inputs will boost demand for labor, i.e. the effect of the second channel is opposite to the first channel.

Therefore we estimate the following equation

$$\begin{aligned}\Delta L^T_{c,t} =& \gamma_1 + \gamma_2 \Delta y^*_{c,t} + (\gamma_3 + \gamma_4 x_c + \gamma_5 m_c + \gamma_6 \alpha_c)\Delta e_{c,t} \\ &+ \gamma_7 \Delta L^T_{c,t-1} + f_c + f_t + u_{c,t}, \end{aligned} \tag{1}$$

where c is the index for cities. The variable $L^T_{c,t}$ is the total employment in tradable industries in city c, and $e_{c,t}$ is the city-specific exchange rate, constructed based on a city's composition of industries and those industries' main trading partners. We use Δ to indicate percentage (%) changes. The share of export sales in total industrial shipments (x_c), a measure of the export orientation, is based on its industrial composition and averaged over a period of time. The variable m_c, constructed similarly, measures import penetration and is defined as the fraction of import in total domestic sales. The variable α_c is the share of imported inputs in production in city c. The three variables α_c, x_c, and m_c are interacted with the exchange rate to capture the two channels of exchange rate effects discussed above. The variable $y^*_{c,t}$, the city-specific trade-weighted foreign GDPs, captures the foreign demand. Because of the existence of labor adjustment costs, current adjustment in labor likely depends on the adjustments made in the previous period; the regression thus has a term for lagged employment adjustment.

Relative to Campa and Goldberg (2001), our specification adds cross-sectional fixed effects and year fixed effects. The inclusion of year fixed effects prevents us from using US GDP and factor prices, which are included in Campa and Goldberg (2001), because they do not vary across cities. The city-specific export orientation ratio (x_c), import penetration ratio (m_c), and the share of imported inputs (α_c), in their uninteracted forms, all drop out from the regressions, because they are constructed as time-invariant averages over a period and thus are absorbed by the city fixed effects.

In an alternative specification, we include both the import exchange rate and the export exchange rate, which are the exchange rates faced by importers and exporters, respectively. First, there are reasons to suspect that the import exchange rate may have weaker effects on domestic US prices relative to the export exchange rate's effects on foreign prices. The literature on exchange rate pass-through (Goldberg and Tille, 2008) documents that most of the international trade that flows to and from the US are invoiced in US dollars.[1] Consequently, domestic prices of imports in the US can be insensitive to the change in US dollar exchange rates (i.e., the exchange rate pass-through is low). In this case, the demands for imports and competing American products are not likely to change, leading to little adjustment in labor demand in the US. Meanwhile, US exports are mostly priced in US dollars. Buyers in foreign countries are likely more exposed to exchange rate fluctuations. Therefore, the effects of import exchange rates and export exchange rates are potentially different; our main specification acknowledges this possibility by treating

[1]The theory in Bacchetta and Van Wincoop (2005) suggest that when exporters in small open economies compete in the US market, it is often optimal for them to price in the US dollar because their market shares are small and because of the high level of substitutability between competing products. Goldberg and Tille (2008) make a similar point by emphasizing a "coalescing"effect in which exporters set prices in the US dollar to limit the changes in their prices relative to the competitors'.

the two exchange rates differently.[2]

Second, the effects of the import exchange rate on employment are more nuanced compared with the effects of the export exchange rate. When the export exchange rate depreciates, products from US firms become cheaper in foreign markets, leading to a stronger demand for them and in turn a stronger demand for labor by US firms. As for depreciations of the import exchange rate, there are competing effects. On the one hand, depreciations make foreign products more expensive and boost demand for home products and hence domestic labor. On the other hand, imported inputs become more expensive after depreciation, potentially having a negative impact on domestic labor demand if labor and imported inputs are complements in the production process.

With both import and export exchange rates on the right-hand side, the second specification is

$$\begin{aligned}\Delta L^T_{c,t} =&\gamma_1 + \gamma_2 \Delta y^*_{c,t} + (\gamma_3 + \gamma_4 x_c)\Delta e^x_{c,t} + (\gamma_8 + \gamma_5 m_c + \gamma_6 \alpha_c)\Delta e^i_{c,t} \\ &+ \gamma_7 \cdot \Delta L^T_{c,t-1} + f_c + f_t + u_{c,t}, \end{aligned} \tag{2}$$

where $e^i_{c,t}$ and $e^x_{c,t}$ are import and export exchange rates. In all regressions, we remove the sample mean from all the right-hand side variables that are subject to interactions, hence, γ_3 and γ_5 measure the marginal effects of export and import exchange rate at the sample mean.

Here we briefly discuss our pre-regressions hypotheses. First, we expect depreciations ($\Delta e^i < 0$ or $\Delta e^x < 0$) to have a positive impact on labor demand by increasing the market share of domestic firms in home and foreign markets. Thus, it is likely that $\gamma_3 < 0$ in both equations (1) and (2). We also expect the impact to be greater in industries with higher trade openness, thus $\gamma_4 < 0$, and $\gamma_5 < 0$ in those equations as well. Secondly, if labor and

[2] Nucci and Pozzolo (2010) also distinguish between import and export exchange rates. They find that appreciations of the export exchange rate reduced employment in Italian firms, while appreciations of import exchange rates boost employment.

imported inputs are complements,[3] we expect that $\gamma_6 > 0$ in both equations (1) and (2) because depreciations raise the cost of imported inputs. Lastly, because depreciations in the import exchange rate increase demand for products of domestic firms but also increase cost of imported inputs, the marginal effect of the import exchange rate on employment measured at mean is ambiguous. That is, the sign of γ_8 in equation (2) is ambiguous.

2.2 Employment in nontradable industries

Our next step is to estimate whether the exchange rates affect employment in the nonmanufacturing industries or, alternatively, a more finely defined set of nontradable industries.

Compared to firms in a tradable industry, firms in a nontradable industry do not compete with foreign firms in the output market. One channel through which the exchange rates affect the employment in nontradable industries is in the demand by the tradable industries for outputs of nontradable industries. Based on the 2002 Input-Output tables for the US, for the 86 manufacturing industries,[4] the average share of inputs from nonmanufacturing industries is 28.4%. Besides the input-output linkages between the tradable and non-tradable industries, the demand spillover can also arise from the tradable sector's workers' demand for locally produced consumption goods and services (Mian and Sufi, 2012). Therefore, we posit that in cities with a higher fraction of employment in tradable industries, the exchange rates will have greater effects on the employment in nontradable

[3] Although the recent literature on international trade and output comovement emphasize the idea that imported and domestic inputs are complements in production (Burstein, Kurz and Tesar, 2008; di Giovanni and Levchenko, 2010; Johnson, 2012), to the best of our knowledge, there are very few empirical papers that estimate the complementarity or substitutability between imported inputs and labor. Based on data of manufacturing industries in West Germany, Falk and Koebel (2002) find that the use of imported inputs did not have significant negative effects on demand for different types of labor. Jara-Diaz, Ramos-Real and Martinez-Budria (2004) estimate that intermediate inputs and labor were complements in the industry of electricity generation in Spain.

[4] They are the 86 four-digit manufacturing industries defined in the North American Industry Classification System (NAICS). In the regressions in Table 8, we use the 82 four-digit manufacturing industries for which the relevant data are available.

industries. We thus estimate the following equation

$$\Delta L^N_{c,t} = \theta_1 + (\theta_2 + \theta_3 TS_{c,t-1})\Delta e_{c,t} + \theta_4 TS_{c,t-1} + \theta_5 \Delta L^N_{c,t-1} + f_c + f_t + v_{c,t}, \qquad (3)$$

where the variable $L^N_{c,t}$ is the employment in nontradable industries in city c in year t. The variable $TS_{c,t-1}$ is the one-year lag of the fraction of employment in tradable industries in total employment. The variables f_c and f_t are city and year fixed effects. The error term is $v_{c,t}$.

Because depreciations indirectly raise the demand for products of nontradable industries, we expect that $\theta_2 < 0$ and $\theta_3 < 0$. Of course, changes in import exchange rates may also affect the labor decision of firms in nontradable industries through the channel of imported inputs. That is, depreciations increase the cost of imported inputs used by nontradable firms. But since we do not have the information on the share of imported inputs for firms in nontradable industries, any effects of import exchange rates via the channel of imported inputs would be absorbed in the mean effect of the exchange rate, the coefficient θ_2.

Due to the presence of lag dependent variables in panel regressions, we use the Arellano-Bond GMM estimator (Arellano and Bond, 1991) to estimate all equations. In the Arellano-Bond GMM estimator, if the error terms are not auto-correlated, all admissible lags of regressors are valid instruments in formulating the moment conditions. We include two lags of the dependent variables in the regressions such that in all regressions after which the AR(2) test statistics can be computed, the statistics do not reject the null hypothesis that there are not auto-correlations in the error terms.[5] If there is only one lag of the dependent variables, the tests reject the null of serial-uncorrelated errors that is necessary for identification. Because the efficiency gain of two-step GMM tends to be small in finite samples in dynamic panel regression with first-differenced data (Bond, Hoeffler

[5]Because our data are from 2003 to 2010, the inclusion of two lags and use of the third lag as instruments effectively reduce our sample period to 2006 to 2010.

and Temple, 2001), we use the one-step GMM in all estimations. Finally, we base our statistical inferences on robust standard errors.

3 Data

Our sample includes 268 MSAs that have more than 100,000 residents in the 2000 Census. The total population of these MSAs in 2000 was 187.17 million, accounting for 66.51% of the total population of the US. Beginning at the level of 87.56 million in 2003, total employment in these MSAs increased to 93.01 million in 2007 before dropping to 87.50 million in 2010 due to the recession. Meanwhile, total manufacturing employment dropped continuously throughout the 7-year period, from 9.53 million to 7.63 million.

We use employment data from 2002 to 2010. We choose the starting year of 2002 because this is the first year when consistency in the number of MSA-year observations appears to have emerged. The number of MSA-industry observations with positive employment was 38,841 in 2000, 36,518 in 2001 and 51,477 in 2002. The number stays consistently at about 51,000 between 2002 and 2010. There are no justifications for the very large fluctuations from 2000 to 2001 and especially from 2001 to 2002. We suspect that incomplete reconstruction associated with the adoption of the 2002 NAICS is responsible.

Although the main purpose of the paper is to examine the effects of exchange rates on employment in cities, we first construct industry-specific exchange rates, the import penetration ratios, the share of imported inputs, and the export orientation ratios for four-digit NAICS manufacturing industries because the construction of MSA-level variables relies on these industry-specific variables.

For each industry, we construct the trade-weighted exchange rates and export-weighted foreign real GDP growth by using the trade data compiled by Feenstra, Romalis and Schott (2002) and the exchange rate and GDP data from the International Monetary Fund. Based on data from the Annual Survey of Manufacturing, we compute the export orientation ratios as the fraction of export in total shipment, and the import penetration as the fraction of import in total industry-level trade. Following the method of Campa and Goldberg (1995) and Campa and Goldberg (1997), we construct the share of imported inputs by combining information of industry-level import penetration and the inter-industry links documented from the 2002 Input-Output tables for the US. Details of the construction of these industry-level variables can be found in the appendix.

At the MSA level, the Quarterly Census of Employment and Wages (QCEW) program of the Bureau of Labor Statistics (BLS) provides employment data on each four-digit NAICS industry. We assume that the typical firm in an industry in a city shares the same features as the national industry. We then use the features of the national industries to construct the city-specific exchange rates, import penetration, export orientation, and real GDP growth in trade partners. For an individual city indexed by c, the change in exchange rate (denoted as $\Delta e_{c,t}$) is the weighted average of changes in exchange rates for the group of manufacturing industries in the city; the weights are the lag employment in each manufacturing industry in MSA c. The construction of city-specific import penetration, export orientation, and real GDP growth in trade partners is similar.

Tables 1 and 2 summarize the exchange rate, employment growth, shares of employment in different types of industries for the industry-level and MSA-level samples, respectively. Even though the import penetration ratios and export orientation ratios rose on average in the years for which data are available, both ratios differ substantially across industries. In the MSA sample, the average share of manufacturing industries in total employment decreased from 13.08% to 10.60% from 2003 to 2010.

In Figure 1, we plot the real trade-weighted US dollar exchange rate index, published by the Federal Reserve (Loretan, 2005). During the period of 2003 to 2010, the US dollar experienced real depreciations in most years. The summary statistics for the industry-specific and city-specific exchange rates indices in Tables 1 and 2 suggest that in any given year, there are considerable variations in exchange rate movements faced by individual industries and cities.

When constructing the real trade-weighted US dollar exchange rate, we follow Loretan (2005) and assign weights to a broad set of currencies based on import and export trade volume. The 10 economies that are assigned highest weights in our data, with their weights indicated in parenthesis, are the Euro area (18.8%), Canada (16.43%), China (11.35%), Japan (10.58%), Mexico (10.04%), the UK (5.17%), Korea (3.86%), Taiwan (2.87%), Hong Kong (2.33%), and Malaysia (2.24%). Together, the 10 economies receive a total weight of 83.67%. We also run bivariate regressions of monthly changes in the real trade-weighted US dollar exchange rate on changes in each individual currency and present the R^2 values in Table 3. With R^2 values greater than 0.4, the Euro, the Canadian dollar, the Korean won, and the British pound are significantly correlated with the real trade-weighted US dollar exchange rate. Meanwhile, the correlation of the Japanese yen, the Chinese yuan, and the Hong Kong dollar are low, with R^2 values no greater than 0.1.[6]

Before moving to a regression analysis in the next section, we compute the correlation between employment in manufacturing and nonmanufacturing sectors, and import and export exchange rates at the city level. The correlation coefficient between employment in manufacturing industries and export exchange rates is -0.19, statistically significant at 1% level. For nonmanufacturing employment and export exchange rates, the number is -0.25, also significant at 1% level. Meanwhile the correlation between manufacturing employment and the import exchange rates is 0.06, significant at 1% level. With a correlation coefficient of -0.02 that is insignificant at 10% level, nonmanufacturing employment is practically

[6] During our sample period of 2003 to 2010, the change in the trade-weighted US dollar exchange rate indicates that the US dollar had experienced a real depreciation of 23.91%. As shown in Table 3, seven currencies had appreciated against the US dollar in real terms. In the order of the magnitude of appreciation, they are the Canadian dollar (36.73%), the Chinese yuan (23.79%), the Euro (15.22%), the Malaysian Ringgit (18.11%), the Japanese yen (15.07%), the Korean won (6.64%), and the new Taiwan dollar (5.07%). Meanwhile, the Hong Kong dollar, the Mexican peso, and the British pound had depreciated against the US dollar in real terms, by 10.08%, 7.18%, and 6.13%, respectively.

uncorrelated with import exchange rate. Therefore, it appears that import exchange rates affect employment in a different way from the export exchange rates.

Finally, a demand shock, whether arising from the foreign exchange market or elsewhere, will have wider impacts than just on employment (the extensive margin of the labor market). It would also affect hours worked per worker (the intensive margin) and possibly on hourly wage rates as well. The employment/hour and wage responses will in turn depend on the tightness of labor market in the local area or elsewhere via labor migration, as well as the rigidity of wages in the short run, especially against negative shocks. The QCEW has information on average weekly wages per worker by city. The weekly wage is influenced by both changes in hours worked per worker per week, as well as by changes in the hourly wage rate. We will use this weekly wage as an alternative dependent variable, both for robustness check and for a more complete picture of the labor-market responses.

The QCEW does not have data on hourly wage rates. That information is available in another Bureau of Labor Statistics database, the Occupational Employment Statistics (OES), which has the wage-rate data by city and occupation based on surveys. Compared to the QCEW, which is from economic censuses, the survey-based data is necessarily noisier. OES has another disadvantage that that it does not break down the wage-rate information by industry or sector at the city level. But we can still use it to find out whether and how local wage-rates, as a whole, respond to the exchange-rate movements, and to make inference on the responses of hours worked.

4 Regression Results

4.1 The Effects of the Exchange Rates on Manufacturing Employment

Our first set of regressions, based on equations (1) and (2), assess the effect of exchange-rate movements on city-level manufacturing employment. The dependent variables are the growth rates of total employment in manufacturing industries in a city. Using manufacturing industries as the proxy for tradable industries, we interpret the estimated exchange-rate effects as the direct effects on the tradable sector. Our regressions involve interacted variables. For easier interpretations, we have removed the sample means from the independent variables before interacting them. As a result, the coefficient on the export exchange rate is the effect of the export exchange rate on employment evaluated at the sample mean.

We present the benchmark regression results in Table 4. There are multiple columns, reflecting different ways that the exchange rates enter the right-hand side. We hypothesize that the import and export exchange rates can have different effects on employment; but we also realize that the two exchange rates are highly correlated. For completeness, we present findings from a range of different specifications. In column (1) of Table 4, we do not distinguish between the import and export exchange rates. Instead, we use a single measure of the exchange rate that is the simple average of the import and export exchange rates. It is this average that enters the right-hand side and is interacted with the import penetration, export penetration, and the share of imported inputs. In column (2), we use only the export exchange rate and its interaction with export orientation. In column (3), we use only the import exchange rate and its interaction with import penetration and share of imported inputs. In column (4), the most general and our preferred specification, we include both import and export exchange rates and their respective interaction terms. Column (5) uses an alternative dependent variable that is the average weekly wage rate per worker. The QCEW does not provide information on hourly wage rates. So we are unable to further breakdown the changes into those in hours worked and those in hourly rates.

A few patterns are evident in Table 4. First, when we do not distinguish between import and export exchange rates, the effects of depreciations in the average exchange rate on employment (measured at the sample mean) are positive, but not statistically significant. Note that under our definition of real exchange rate, the exchange rates depreciate when the exchange indices decrease. Hence, a negative coefficient on the exchange rate variable implies depreciations have positive effects on employment.

Second, the export exchange rate has significant positive effects on employment, either in column (2) when it enters the regressions without the presence of the import exchange rate, or in column (4) when it enters the regression simultaneously with the import exchange rate. In column (2), the estimate suggests that if a city experiences a depreciation in the export exchange rate that is 1% larger in magnitude than that of the average city, then the manufacturing employment will rise by 0.98%. The estimated effect is slightly larger (1.22%) in column (4) where both the export exchange rate and import exchange rate are included. This finding supports our hypothesis that the effects of a depreciation in export exchange rates are positive ($\gamma_3 < 0$). When the exchange rate depreciates, a higher export orientation ratio magnifies the positive effects of exchange rate on employment, as indicated by the negative sign on the interaction term between export exchange rate and export orientation. This finding is consistent with the hypothesis that a higher export orientation ratio increases the sensitivity of demand to exchange rate ($\gamma_4 < 0$).

Third, on average, the import exchange rate does not have significant effects on employment, even if we exclude the export exchange rate from the regression, as we have done in column (3). As discussed in section 2, a number of factors can lead to an insignificant employment effect of the import exchange rate. One is the low degree of exchange rate pass-through. International trade flows into the US are primarily priced in US dollar. As a result the pass-through of exchange rate to domestic prices is low in the US; changes in the import exchange rates may not move international relative prices enough to trigger significant changes in US employment. Another possible explanation is that for firms which rely heavily upon imported intermediate products, a depreciation of the US dollar may increase the cost of production, countering the positive effects of lower output prices in the international market.

Fourth, when the import exchange rate depreciates, a city with a higher import penetration ratio will have lower growth in manufacturing employment, as suggested by the positive sign on the interaction term between import exchange rate and import penetration. Meanwhile, a high share of imported inputs do not have significant effects, providing no support for our hypothesis that a higher share has negative effects during depreciations ($\gamma_6 > 0$). The negative effect of high import penetration during depreciations contradicts our hypothesis ($\gamma_5 < 0$). This may be due to the measurement errors in the construction of share of imported inputs. It may also arise from the high correlation between import penetration and the share of imported inputs, which is 0.65 in our sample. As a result of the correlation, the coefficient on import penetration may capture the negative effects of a high share of imported inputs during depreciations.

Column (5), which uses the growth in average weekly wage per worker as the dependent variable, follows the specification that focuses on the export-exchange rate, though the results presented here are robust to other specification as well. According to the estimates presented in this column, an exchange-rate depreciation increases the weekly wage by 0.15% for an average city, an estimate that is statistically significant at the 10% confidence level. The response increases in magnitude with exports orientation, though that interactive effect is not significant. We note that the wage responses can arise from changes in hours worked (salaried workers' over time or hourly employees' hours) or from changes in wage rates, or both. Given the lack of wage-rate data in QCEW, we are not able to examine the responses in further detail.

4.2 The Effects of the Exchange Rates on Nonmanufacturing Employment

In this subsection, we estimate equation (3), in which the dependent variable is the employment in the nonmanufacturing sector, as opposed to the earlier regressions that look at the manufacturing employment. The purpose is to check whether exchange rate movements affect the employment in the non-tradable sector, proxied by nonmanufacturing industries. Acknowledging that manufacturing industries are only a proxy for the tradable sector, we will explore, in the next subsection, an alternative classification that reflects a broader definition of tradability.

The dependent variable in this subsection is the growth in total employment in all nonmanufacturing industries in a city. As in the previous subsection, we use four different specifications for the exchange rates to enter the regressions. Columns (1)-(4) present the estimates. Column (5)-(7) use weekly wages and other variables as alternative dependent variables; their purpose is to check for robustness and to provide a more complete picture.

From the regression results reported in Table 5, we first observe that the coefficients on the exchange rates themselves are not significant. Meanwhile, the interactions between exchange rates and the share of employment in manufacturing industries are negative, suggesting that it is important to take into account the interactions between exchange rates and employment share of manufacturing industries. The negative sign of the interactive effect indicates that in a city with a large share of employment in manufacturing industries, if the exchange rate depreciates, then employment in nonmanufacturing industries will increase more substantially. This finding provides supporting evidence for the hypothesis that exchange rates indirectly affect employment in nonmanufacturing industries ($\theta_3 < 0$). Because theory suggests that import exchange rate should have a negligible effect due to the lack of pass-through into import prices, and because statistically significant effect is mainly associated with the export exchange rate, we use column (2) of the table to discuss the quantitative.

Quantitatively, the estimated indirect effect at the sample mean (-0.08 in column 2) is not trivial. The value is small, but the employment base is large, because the nonmanufacturing sector accounts for 88% of the total employment across our sample of major cities. When the export exchange rate depreciates by 1%, the estimated employment elasticity of -0.08 implies a 0.07% change in total employment ($0.08\% \times 0.88 \approx 0.07\%$). In comparison, the manufacturing sector accounts only for 12% of the employment. The estimated employment elasticity of -0.98 in the sector - from column 2 of Table 4 - is equivalent to 0.12% of total employment ($0.98\% \times 0.12 \approx 0.12\%$). The comparison suggests that, in terms of the number of jobs affected, the exchange rate movement has a knock-on indirect effect that is 60% as large as the direct effect. Of course, the indirect effect lacks statistical significance at the sample mean. But the knock-on effect rises in both size and statistical significance with the share of manufacturing sector. In cities where just above a quarter employment is in the manufacturing sector, the estimated indirect effect becomes significant at 5%. To be precise, when the manufacturing share reaches 26.8%, or 14.5% above the national mean, the estimated indirect effect is 0.22% ($0.08\% + 0.009\% \times 14.5 \approx 0.22\%$), with a standard error of 0.11%. Using this estimate, we calculate that the direct effect is 0.25% of total employment ($0.98\% \times 0.268 \approx 0.26\%$), while the indirect effect is 0.15% of the employment ($0.22\% \times 0.732 \approx 0.15\%$). Again, the indirect effect is about 60% as large as the direct effect.

Third, when we include both import and export exchange rates and their respective interactions with the share of employment in manufacturing industries, the coefficients on interactions have negative signs, as hypothesized, but they are not statistically significant. The insignificance may be because the effects of import and export exchange rates on employment of nonmanufacturing industries are similar, so the partial effects are not precisely estimated.

We now move on to examine wage responses. As we have done earlier for the manufacturing sector, we will use the preferred specification (the one in column 2 that uses export exchange rates) for the analysis.

Columns (5)'s dependent variable is the growth in average weekly wages per worker in the nonmanufacturing sector. The estimated effect has the same sign as the estimated employment effect reported earlier. First, an exchange rate depreciation positively affects the wage growth, though the estimate is statistically insignificant for an average city. Second, the effects magnitude is stronger in cities that have greater shares of manufacturing employment. The interactive effect, with strong statistical significance, is consistent with the hypothesized demand-spillover mechanism from the manufacturing sector to the local service sector. In cities where the manufacturing share is 15% above the sample mean, the indirect wage effect is 0.35% per 1 percentage-point depreciation in the value of the USD (calculated as $0.05\% + 0.02\% \times 15 = 0.35\%$), and the estimate is statistically significant at the 5% confidence level. These findings, consistent with those reported earlier on employment, again highlight the vulnerability of heavily-industrial cities to exchange-rate fluctuations.

Columns (6) and (7) use growth in hourly wage rate and hours worked, respectively, as the dependent variables. As stated earlier, the QCEW does not have data on hourly wage rate, but we can obtain the data on hourly wages from the Occupational Employment Statistics (OES), a survey-based database with wage-rate information at the city level, but without breaking it down by sector or industry. Despite the data imperfection, there can still be valuable information to help provide a clearer picture about the underlying mechanisms. In particular, a demand or employment spillover from the tradable sector to the nontradable sector, in the case of a beneficial shock, is more likely to happen in a labor market that is not too tight. Otherwise, the competition for labor between the sectors would have lead to higher wages over all but little changes in total employment. A substantial degree of labor slack (in the local area or elsewhere via migration), on the other hand, would tilt the responses back to employment. In the case of a negative demand shock, if wages remain rigid, the fall in employment and hours would be greater than when wages are flexible. It follows that whether or not wage rates respond to exchange-rate movements is important for us to understand the employment responses.

Column (6)'s dependent variable is the growth in average hourly wage rate for the local economy as a whole. Its estimates indicate that exchange-rate movements have little impact on the wage rate. The estimate has the unexpected sign, but is close to zero in magnitude, and the t-statistics is about 0.25. There is an interactive effect, with an unexpected sign and borderline statistical significance, associated with the share of manufacturing employment. But even in cities with very high level of manufacturing share (15% more than the sample mean), the detected effect is still statistically insignificant. The wage rate thus does not seem to react to the exchange-rate changes.

How about hours worked per week per worker? To find out the hour response, we use the average hourly wage rate for the entire local economy to proxy for the hourly wage rate in the nonmanufacturing sector, which accounts for more than 85% of the total employment. With this proxy, we back out the changes in the approximated hours worked and use its growth as the dependent variable in column (7). The estimates reported in the column suggest that exchange-rate changes indeed affect the intensive margins of employment. The estimated hours effect is in the same direction as the employment effect: a depreciation is associated with rising hours per worker. More importantly, there is a strongly significant interactive effect indicating that the response of hours worked in the nonmanufacturing sector is greater in cities that have higher shares of manufacturing employment. Again consider a city where the manufacturing share is 15% above the sample mean, the hour response is 0.45% per 1 percentage point depreciation, relative to 0.21% employment response from the same calculation. Both effects are significant at the 5% confidence interval.

Taking the findings together, we interpret them as evidence that in the US data from 2002 to 2010, the demand spillover effect from the tradable sector to the nontradable sector dominates potential competition between the two sectors for labor. As a result, employment and hours both respond in the same direction to exchange rate fluctuations, while leaving hourly wage rates little changed.

We should mention the caveats behind the conclusion; our estimates rely on cross-city variations. To the extent that the exchange rate shocks have nationwide wage impact, we would not be able to pick up those impacts. Secondly, our estimation may be overly influence by short-run fluctuations. In the longer run, the wage rates likely respond as well. Ebenstein et al. (2014) report that global trade lowers worker wages through the reallocation of workers from higher-wage jobs to lower-wage jobs. To the extent that a persistent change in the exchange rate leads to industry restructuring, it affects wage rates in the long run. Longer-term wage responses can also arise from changes in factors behind inter-city wage differentials such house prices. Saks (2008), for example, reports that different cities respond to an increase in labor demand differently; those that have more regulatory barriers to housing construction tend to see a greater increase in housing prices and a smaller increase in employment in the long run. Neither can we ignore the potential measurement issues. The hourly wage rates are from surveys instead of employment censuses. The extra noise in the dependent variable might have contributed, at least in part, to the lack of statistical significance for the estimated wage-rate effect. Finally, the wage and employment responses are not some structural invariant parameters. They are likely dependent on the degree of labor slack and the ease of inter-city migration. Our estimates may be specific to the time period.

4.3 Alternative Definition of Tradable and Nontradable industries

In the literature that studies the effects of exchange rates on trade and the labor markets, it is conventional to focus on the manufacturing industries, probably due to the availability of high-quality data and the fact that manufacturing products are more easily transportable than some (but not all) products from the service industries. In the previous two subsections, we follow this convention, defining tradable industries as manufacturing industries and the other industries as nontradable.

This narrow definition of the tradable sector may have become a less accurate approximation, however, with the service industries becoming more and more important not just as a share of GDP, but also a share of international trade. In 2006, for instance, the export of total private services amounted to $403 billion dollars, and the import amounted to $307 billion. In comparison, the total export and import values of the manufacturing industries were $779 billion and $1,451 billion, respectively, in the same year. In this subsection, we adopt an alternative classification of industries that reflects a broader definition of tradable industries. Specifically, we expand the definition of the tradable sector to include both (a) all manufacturing industries (NAICS 31-33), and (b) tradable service industries: transportation (NAICS 48), information (NAICS 51), finance and insurance (NAICS 52), professional, scientific, and technical services (NAICS 54), and management of companies and enterprises (NAICS 55).[7]

The main concern about the alternative classification is with the tradable service industries. The existing data on trade in service available from the Bureau of Economic Analysis (BEA)[8] does not provide a great amount of details. The breakdown of the data does not correspond to the NAICS classification. In addition, for most years, the BEA only provides the total export and import amount of private services. Because of these data limitations, we aggregate the data of these five tradable industries and treat them as a single tradable service industry. Although we believe it is important to incorporate the trade in service, we recognize our treatment of the data of the tradable service industries can result in another inaccurate measurement of the tradable industries because of the assumptions involved.

We treat the five service industries above as tradable for two reasons. First, the components in the service trade covered by the BEA largely correspond to these five in-

[7]Products of the industries of agriculture, forestry, fishing and hunting (11) and mining (21) are tradable, but we do not include them here because they do not account for much employment in cities.

[8]Available at: http://www.bea.gov/international/international_services.htm.

dustries as a group. Second, the work of Jensen and Kletzer (2005) provides evidence of high tradability of these industries. The idea behind the method of Jensen and Kletzer (2005) is that highly tradable industries tend to have high geographic concentration. Meanwhile, if an industry, such as retail trade, is present in all locations, then the level of tradability must be low. Jensen and Kletzer (2005) compute a gini coefficient for each industry to measure the unevenness in spatial distribution. They use a gini coefficient of 0.1 as the cutoff between tradable and nontradable industries: an industry with a gini coefficient greater than 0.1 is considered tradable. If a two-digit NAICS industry has a larger fraction of employment in tradable sub industries, the two-digit NAICS industry is also likely to be tradable. All of the five 2-digit service industries listed above have a large fraction of employment in tradable subindustries, with the minimum being 57.19% in transportation (NAICS code 48). Our treatment of the service industries is very similar to Spence and Hlatshwayo (2011), who also make use of findings of Jensen and Kletzer (2005).

Because we now classify five service industries as tradable, we reconstruct the exchange rate faced by the tradable industries in cities. Specifically, we redefine the MSA exchange rate $e_{c,t}$ as the weighted sum of the exchange rate for the group of manufacturing industries ($e^m_{c,t}$) for MSA c, and the exchange rate for the group of tradable service industries ($e^s_{c,t}$) for MSA c:

$$e_{c,t} = \frac{l^m_{c,t-1}}{l^m_{c,t-1} + l^s_{c,t-1}} \cdot e^m_{c,t} + \frac{l^s_{c,t-1}}{l^m_{c,t-1} + l^s_{c,t-1}} \cdot e^s_{c,t},$$

where $l^m_{c,t}$ and $l^s_{c,t}$ are employment of the group of manufacturing industries and the group of tradable service industries in MSA c in period $t-1$. The construction of city-specific import penetration, export orientation, and real GDP growth in trade partners is similar.

We re-estimate the direct effects of the export exchange rate and report the results in column (1) of Table 6.[9] Due to the lack of data on export orientation ratios and import

[9]Because both theory and empirical evidence suggests that import exchange rate does not play a

penetration ratios for the tradable service industry, we do not include the interaction between exchange rates and these ratios. Overall, the signs of the coefficients are similar to the benchmark results in the last column of Table 4. The export exchange rate has a significant negative effect on employment, while the average exchange rate and the import exchange rate are not significant. The export exchange rate elasticity of employment is -1.12 in column (1) of Table 6, indicating a depreciation of 1% is associated with a 1.12% increase in total employment in tradable industries. This elasticity is similar in magnitude to the coefficient of -0.98 in column (2) of Table 6.

Next, we re-estimate the effects of the export exchange rate on employment in nontradable industries and present the results in column (1) of Table 7. The results are similar to those in the corresponding estimation reported in Table 5. The interaction between the exchange rate and the size of local tradable industries remains statistically significant. The estimated coefficient (-0.02) is larger in magnitude than its counterpart in column (2) of Table 5 (-0.009).

Overall, when we refine the tradable industries to include five service industries, we still find evidence that exchange rates have effects on employment in both tradable and nontradable industries in cities.

4.4 Other Robustness Checks

In this subsection, we report four additional robustness checks. First, we estimate the regressions with two-step GMM estimator, rather than a one-step GMM estimator. From column (2) of Table 6, we can see the estimated effect of export exchange rate on manufacturing employment is smaller in magnitude and significant only at 10%. As for nonmanufacturing employment, the coefficient on the interaction between the exchange rate and lag manufacturing employment share reported in column (2) of Table 7 is also smaller

significant role, all regressions in the robustness check section includes only the export exchange rate. In unreported regressions, when we estimate alternative specifications with the average exchange rate, or both the export and import exchange rates, we obtain similar results.

in magnitude but remains significant at 1

Second, we replace the year fixed effects with a set of variables measuring macroeconomic conditions that are used in Campa and Goldberg (2001): real US GDP growth rate, change in 10-year real interest rate of treasury bills, and change in real oil prices. The first variable captures the strength of domestic demand, while the last two capture the cost of capital and energy.[10] With the year fixed effects, we effectively use only the cross-section variations in exchange rates to identify the employment effect of exchange rates. In this robustness check, we reintroduce the time-series variation of exchange rates. The estimates, reported in column (3) of Table 6 and column (3) of Table 7, are similar to the benchmark regressions.

Third, we decompose the changes in exchange rates into permanent components and transitory components and estimate the effects of the permanent components on employment. As discussed in Campa and Goldberg (2001), changes in employment through hiring and firing are costly. Therefore, firms are more likely to adjust employment in response to permanent or long-term changes in exchange rates compared with the transitory changes. Following previous empirical papers on exchange rates (Campbell and Clarida, 1987; Huizinga, 1987; Clarida and Gali, 1994; Campa and Goldberg, 2001), we apply the decomposition method proposed by Beveridge and Nelson (1981).[11] We re-estimate the direct effects and indirect effects using the permanent components in the exchange rates and report the results in column (4) of Table 6 and column (4) of Table 7. In general, the regression results for manufacturing employment are similar to previous results, but the results for nonmanufacturing employment are not statistically significant.

[10]Because we do not have data to construct these variables at the level of industry or city, the inclusion of year fixed effects excludes them as regressors in our benchmark regressions.

[11]To apply the Beveridge-Nelson decomposition, it is necessary that we assume the log real exchange rate is an $I(1)$ process and the first difference of the log real exchange rate is stationary. We fit an $AR(2)$ model to the first difference of the exchange rate before applying the formula for Beveridge-Nelson decomposition. As discussed in Chen and Rogoff (2003) and Chen and Rogoff (2012), there has been debate whether real exchange rates should be modeled as $I(1)$ a process. Therefore, we recognize it is possible that the Beveridge-Nelson decomposition is not appropriate in this context.

Fourth, we break the sample period into two subperiods, one for the years before the recent recession (2006-2007), and the other for the years of recessions (2008-2010). During the most recent recession, one notable phenomenon in the global economy was the dramatic collapse of international trade in 2009. For instance, in 2009 the real export and import of the US dropped by 14.2% and 16.7%, respectively. Therefore, we want to check whether our results are driven by the effects of the recession or not. In the last two columns of Tables 6 and 7, we report the subperiod regressions of manufacturing and nonmanufacturing employment, respectively. From the last two columns of Tables 6, we can see that in both subperiods, depreciations of the export exchange rates have positive effects on manufacturing employment, which is consistent with the results based on the whole sample period. As for the effects of exchange rates on nonmanufacturing employment, the last two columns of Table 7, exchange rate depreciations are again associated with an increase in employment in both subperiods. Overall, it appears our results are not hinged on the effects of the recession.

5 Discussion

Over the past few decades, the US has increasingly engaged in international trade, whether measured by import penetration or export orientation ratios. With a high degree of participation in trade, the US is more sensitive to the international relative prices caused by exchange rate movements. Over the same period, US employment in manufacturing industries has declined continually. An important question is whether the exchange rates affect employment in the US manufacturing industries and its wider economy. In the empirical literature, the estimated exchange rate elasticity of employment in advanced economies ranges from practically zero (e.g. Campa and Goldberg 2001) to around 1 (e.g. Leung and Yuen 2007). For the US, several recent papers find that the exchange rates have small employment effects. For instance, Campa and Goldberg (2001) report an average employment elasticity of 0.01 associated with the permanent component of the exchange rate; Klein, Schuh and Triest (2003) suggests that if the cyclical component of the exchange rate appreciates by 5.4% in two consecutive years, employment declines by only 0.7%.

Our paper makes three contributions to the literature of employment effects of exchange rates. First, we find that exchange rate depreciations have significant positive effects on employment in tradable industries in US cities. We refer to these as the direct effects of the exchange rates on employment in cities. Second, exchange rate depreciations can have significant positive effects on jobs in nontradable industries. These are what we term indirect effects. As far as we are aware, our paper is the first to estimate such indirect effects of exchange rate. Third, the employment effect of exchange rates is heterogeneous across cities. In cities with higher fractions of employment in tradable industries, employment in nontradable industries is more sensitive to exchange rates. Lastly, our empirical work highlights that the export exchange rates and import exchange rates have different effects. In our regressions, depreciations in the export exchange rates consistently have positive effects on employment. We argue this is because depreciations in export exchange rates directly increase demand for tradable industries and indirectly increase demand for nontradable industries. Meanwhile, the effects of depreciations of import exchange rates can be muted because the pass-through of exchange rate into domestic prices is low in the US, and because depreciations increase prices of imported inputs.

Although our estimates of the export exchange rate elasticities of employment in tradable industries for the whole sample period, ranging from 0.9 to 1.2, are high relative to a few recent papers that focus on the US (Goldberg and Tracy, 2000; Campa and Goldberg, 2001; Klein, Schuh and Triest, 2003), there are a number of differences between our work and earlier papers. First, previous studies use data up to the mid 1990s, while we use data from the last decade, when the level of trade participation was higher. In

Table 8, we use industry-level data from the 2000's to estimate regressions similar to those in Campa and Goldberg (2001). Column (1) has a specification that is identical to the main employment regression in Campa and Goldberg (2001). In column (2), we add import penetration. In the last column, we use year fixed effects to replace real GDP growth rate of the US, change in 10-year real interest rate of treasury bills, and change in real oil prices. In all three regressions, the exchange rate elasticities of employment are between -0.3 and -0.4, considerably larger in magnitude than the -0.01 reported in Campa and Goldberg (2001). These findings suggest that the difference in time period is an important factor, and the effects of exchange rates on employment are larger in the more recent sample period. One possible explanation is the more extensive participation of the US industries in international trade and competition, as documented in Table 1, as well as China's emergence as an important global trading nation and competitor of the US industries (Autor, Dorn and Hanson, 2012). These developments might have led to important structural changes in the global economy that render the US employment more sensitive to exchange rates.

There are two other reasons why our estimates are higher. One is that we differentiate between import and export exchange rates, while previous papers focus on a single trade-weighted exchange rate. As we show in our analysis, the impact of export-weighted exchange rate has a much greater impact on employment than the imported exchange rate. The other reason is that, unlike previous studies that use industrial-level data, we look at city-level data, a different source of variations that allows us to filter out potential contamination in time-series data due to coinciding economic trends in the US or within industries. In fact, by controlling for year fixed effects, we remove all variation along the time dimension and use only variations across cities based on the difference in industrial composition and trade exposure. Overall, our estimates, coming from a more recent time period, with finer distinction between imports and exports exposure, and an alternative identification strategy, add to the debates on the employment impacts of exchange-rate fluctuations for the US. In particular, they indicate that the US employment may be more sensitive to exchange rate changes than previously thought.

Lastly, we should also recognize that limitations on data warrant caution in interpreting our results. We have to make compromises regarding data. First, because there are no data on trade at the city level, we have to assume a firm in each city has the same exposure to trade and exchange rate as the national industry to which the firm belongs. Second, the data on service trade provide very limited information. Hence, when we use the data on service trade to expand the definition of tradable industries to include five service industries, we are exposed to potentially substantial measurement errors.

6 Conclusion

As most economies in the world become more open to trade, changes in international relative prices caused by changes in exchange rates can alter patterns of trade and production across countries. How do these exchange rates affect employment? We answer this question by exploiting the differences in exposure to trade and exchange rates in US cities. Based on the data of 268 major US cities between 2003 and 2010, our analysis suggests that depreciations of the US dollar have positive effects on US employment in manufacturing industries. More importantly, however, the depreciations are also associated with employment increases in the nonmanufacturing sector, a much bigger part of the US economy. The effects of depreciations on nonmanufacturing jobs are stronger in cities that have a higher percentage of manufacturing employment. This is consistent with the hypothesis that the exchange rate movements affect the nonmanufacturing industries indirectly: they have a direct effect on the manufacturing sector (a proxy for the tradable sector), before spilling over to the broader economy through the local demand channel. When manufacturing employment in a city reaches just above a quarter of total employment, the indirect effect becomes statistically significant and its magnitude in terms of the number of jobs is about 60% as large as the direct effect. As a robustness test, we expand our definition of tradable sector to include five service industries, the results are similar; exchange rates affect employment in both tradable and nontradable industries. We also examine wage responses to the exchange-rate movements, and find that the average weekly wages per worker in both the manufacturing and nonmanufacturing sectors react positively to a demand increase from the exchange-rate market, while hourly wage rates in the local economy are unresponsive. We infer from the findings that hours worked is mainly responsible for the changes in weekly wages. The causes behind the lack of wage-rate responses are likely complex and require further research.

Our analysis also indicates that while depreciations in export exchange rates are associated with rises in employment, the effects of depreciations in import exchange rates often have insignificant effects. The insignificant employment effects of a depreciation of the import-weighted exchange rate may arise from the low degree of pass-through of import exchange rates into domestic prices in the US, or from the rising cost of imported inputs.

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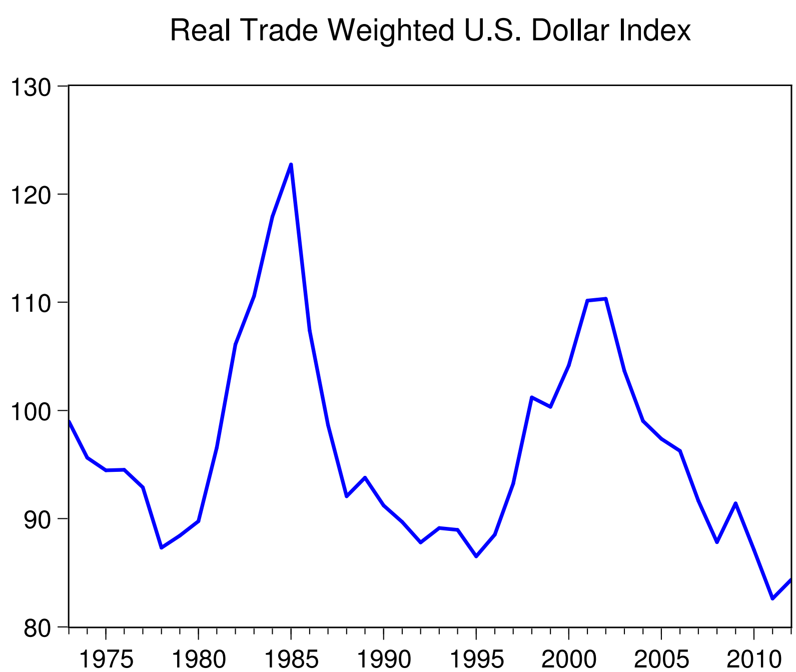

Figure 1: The real trade weighted U.S. dollar index

Source: Federal Reserve Bank of St. Louis and authors' calculation.

Table 1: Means and standard deviations of selected variables for 82 four-digit NAICS manufacturing industries and the tradable service industries

industries variables	manu Δ imp ER	manu Δ exp ER	manu import penetration	manu export orientation	manu Δ empl	service Δ imp ER	service Δ exp ER	service Δ empl
2003	-2.13	-3.09	23.74	14.00	-5.26	-5.42	-5.01	-0.74
Std. Dev.	(2.19)	(2.81)	(19.82)	(11.34)	(3.61)	-	-	-
2004	-2.79	-2.64	25.79	14.87	-2.06	-4.04	-3.82	0.86
Std. Dev.	(1.00)	(1.59)	(20.76)	(12.31)	(3.56)	-	-	-
2005	0.60	1.26	26.58	15.22	-1.34	2.75	2.32	2.29
Std. Dev.	(1.05)	(1.60)	(21.32)	(12.28)	(4.02)	-	-	-
2006	-1.54	-1.05	27.69	16.49	-1.52	0.05	0.05	2.46
Std. Dev.	(0.92)	(1.55)	(22.15)	(13.76)	(3.66)	-	-	-
2007	-2.54	-3.43			-2.58	-3.54	-3.27	2.57
Std. Dev.	(0.82)	(1.26)			(4.30)	-	-	-
2008	1.54	-0.49			-3.82	1.37	1.10	0.17
Std. Dev.	(1.26)	(1.81)			(4.58)	-	-	-
2009	0.22	-2.02			-12.37	-.14	-0.59	-4.70
Std. Dev.	(0.92)	(2.38)			(6.79)	-	-	-
2010	-1.75	-0.43			-3.18	1.33	0.59	-1.37
Std. Dev.	(1.28)	(1.85)			(3.46)	-	-	-

Notes: [1] The abbreviation "manu", "Δ imp ER", "Δ exp ER", and "Δ empl" stand for manufacturing, percentage change in import real exchange rate, percentage change in export real exchange rate, and percentage change in employment, respectively. [2] The term "service" in the top row refers to the group of five tradable service industries (two-digit NAICS codes in parenthesis): transportation (48); information (51); finance and insurance (52); professional, scientific, and technical services (54); and management of companies and enterprises (55).
Source: authors' calculation.

Table 2: Means and standard deviations of selected variables for 268 MSAs

industries variables	manu Δ imp ER	manu Δ exp ER	manu Δ empl	manu empl share	service Δ imp ER	service Δ exp ER	service Δ empl	service empl share	nontradable Δ empl	nontradable empl share
2003	-3.31	-2.54	-4.32	13.08	-5.42	-5.01	3.15	9.41	0.72	77.60
Std. Dev.	(1.42)	(1.16)	(4.98)	(7.24)	-	-	(20.36)	(4.12)	(2.66)	(7.38)
2004	-2.82	-3.03	-1.21	12.65	-4.04	-3.82	4.79	9.59	1.50	77.79
Std. Dev.	(0.79)	(0.49)	(4.22)	(7.06)	-	-	(20.16)	(4.08)	(3.13)	(7.13)
2005	1.22	0.63	-0.39	12.45	2.75	2.32	2.49	9.61	2.00	78.00
Std. Dev.	(0.97)	(0.57)	(4.68)	(6.94)	-	-	(15.46)	(4.09)	(2.55)	(7.03)
2006	-1.20	-1.65	-0.24	12.30	0.05	0.05	5.95	9.70	1.89	78.02
Std. Dev.	(0.83)	(0.56)	(4.86)	(6.82)	-	-	(42.43)	(4.10)	(2.64)	(6.88)
2007	-3.49	-2.58	-2.03	11.95	-3.54	-3.27	2.78	9.75	1.39	78.33
Std. Dev.	(0.77)	(0.46)	(5.09)	(6.61)	-	-	(16.76)	(4.11)	(2.26)	(6.70)
2008	-0.23	1.93	-3.39	11.65	1.37	1.10	1.02	9.81	-0.14	78.55
Std. Dev.	(0.92)	(0.74)	(4.88)	(6.39)	-	-	(14.60)	(4.06)	(2.15)	(6.55)
2009	-1.60	0.35	-13.58	10.79	-.14	-0.59	-4.71	9.70	-3.59	79.54
Std. Dev.	(1.17)	(0.55)	(7.24)	(5.91)	-	-	(14.35)	(4.12)	(2.69)	(6.28)
2010	-0.49	-1.83	-2.96	10.60	1.33	0.59	3.23	9.72	-0.37	79.66
Std. Dev.	(1.13)	(0.73)	(4.25)	(5.92)	-	-	(45.81)	(4.09)	(2.28)	(6.27)

Notes: [1] The abbreviation "manu", "Δ imp ER", "Δ exp ER", and "Δ empl" stand for manufacturing, percentage change in import real exchange rate, percentage change in export real exchange rate, percentage change in employment, and the share in total employment, respectively. [2] The term "service" in the top row refers to the group of five tradable service industries (two-digit NAICS codes in parenthesis): transportation (48); information (51); finance and insurance (52); professional, scientific, and technical services (54); and management of companies and enterprises (55). [3] The term "nontradable" refer to all industries are that neither manufacturing nor the five tradable service industries.
Source: authors' calculation.

Table 3: Bilateral exchange rates between the US and its key trade partners

economies economies	weight in trade-weighted dollar exchange rate	R^2 in bivariate regression	change in real USD/national currency exchange rates between 2003 and 2010
Euro zone	18.80%	0.75	15.22%
Canada	16.43%	0.57	36.73%
China	11.35%	0.05	23.79%
Japan	10.58%	0.10	15.07%
Mexico	10.04%	0.39	-7.18%
UK	5.17%	0.45	-6.13%
Korea	3.86%	0.56	6.64%
Taiwan	2.87%	0.36	5.07%
Hong Kong	2.33%	0.02	-10.08%
Malaysia	2.24%	0.37	18.11%

Notes: [1] In the second column, the R^2 are obtain from bivariate regressions of the real trade-weighted US dollar index on individual bilateral real exchange rates. [2] In the last column, a positive (negative) number indicates that the national currency experienced a real appreciation (depreciation) against the USD.
Source: the Federal Reserve and authors' calculation.

Table 4: Dependent variable: Δ total employment and Δ wage in manufacturing industries

	Emp	Emp	Emp	Emp	Weekly wage
Variables	(1)	(2)	(3)	(4)	(5)
Δ avg ER, de-meaned	-.41 (0.41)				
Δ avg ER × exp orientation	-.03 (0.02)				
Δ avg ER × imp penetration	0.02 (0.01)*				
Δ avg ER × sh of imp inputs	-.01 (0.05)				
Δ exp ER, de-meaned, de-meaned		-.98 (0.34)***		-1.22 (0.38)***	-.15 (0.09)*
Δ exp ER × exp orientation		-.02 (0.01)		-.04 (0.02)**	-.005 (0.004)
Δ imp ER, de-meaned, de-meaned			0.15 (0.25)	0.12 (0.25)	
Δ imp ER × imp penetration			0.02 (0.01)	0.02 (0.01)**	
Δ imp ER × sh of imp inputs			-.04 (0.04)	0.03 (0.05)	
GDP growth in ROW, exp weighted	-2.00 (1.18)*	-2.01 (1.14)*	-1.49 (1.13)	-2.07 (1.15)*	0.61 (0.32)*
1st lag of dependent variable	0.39 (0.08)***	0.40 (0.08)***	0.40 (0.08)***	0.40 (0.08)***	0.20 (0.04)***
2nd lag of dependent variable	-.04 (0.06)	-.04 (0.06)	-.04 (0.06)	-.04 (0.06)	0.04 (0.05)
city fixed effects	yes	yes	yes	yes	yes
year fixed effects	yes	yes	yes	yes	yes
Obs.	1372	1372	1372	1372	1743
model χ^2	1509.32	1538.31	1481.03	1542.22	1185.86
p-value for AR(2) test	0.66	0.57	0.62	0.50	0.59
p-value for Sargan-Hansen statistic	0.39	0.62	0.45	0.58	0.72

Notes: [1] The abbreviations "imp ER" and "exp ER" refer to import exchange rate and export exchange rate. "avg ER" is the average of import and export exchange rates. [2] All equations are estimated with the Arellano-Bond GMM estimator for dynamic panel regressions (Arellano and Bond, 1991). [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5% and 1% levels, respectively. [4] We demean the independent variables before interacting them; therefore, the coefficient on the export exchange rate is the marginal effect of the export exchange rate evaluated at the sample mean, and so on. [5] The "model χ^2" is the Wald statistic that measures overall significance of the model. [6] The "p-value for AR(2) test" is the p-value for testing the H0 that the errors are not auto-correlated, a condition under which the Arellano-Bond GMM estimator is consistent.
Source: authors' calculation.

Table 5: Dependent variable: Δ total employment and Δ wage in nonmanufacturing industries

	Emp	Emp	Emp	Emp	Weekly wage	Hourly wage	Hours
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Δ avg ER, de-meaned	-.05 (0.1)						
Δ avg ER × lag manu empl share	-.01 (0.004)***						
Δ exp ER, de-meaned, de-meaned		-.08 (0.1)		-.09 (0.1)	-.05 (0.25)	0.02 (0.08)	-.04 (0.32)
Δ exp ER × lag manu empl share		-.009 (0.004)**		-.01 (0.009)	-.02 (0.009)***	0.006 (0.003)*	-.03 (0.01)***
Δ imp ER, de-meaned, de-meaned			0.003 (0.08)	0.0004 (0.08)			
Δ imp ER × lag manu empl share			-.009 (0.006)	-.001 (0.01)			
lag manu empl share	0.46 (0.18)**	0.47 (0.19)**	0.44 (0.19)**	0.5 (0.19)***	0.46 (0.35)	-.05 (0.15)	0.38 (0.49)
1st lag of dependent variable	0.41 (0.13)***	0.41 (0.14)***	0.41 (0.13)***	0.41 (0.14)***	-.19 (0.04)***	-.03 (0.05)	-.14 (0.05)***
2nd lag of dependent variable	0.003 (0.03)	0.002 (0.03)	0.004 (0.04)	0.004 (0.04)	-.11 (0.05)**	0.14 (0.05)***	-.07 (0.5)
city fixed effects	yes	yes	yes	yes	yes	yes	yes
year fixed effects	yes	yes	yes	yes	yes	yes	yes
Obs.	1372	1372	1372	1372	1372	1242	1218
model χ^2	1995.79	1950.09	2021.08	1922.53	165.17	256.01	138.76
p-value for AR(2) test	0.77	0.76	0.68	0.78	0.52	0.08	0.25
p-value for Sargan-Hansen Statistic	0.16	0.17	0.18	0.19	0.65	0.61	0.76

Notes: [1] The abbreviations "imp ER" and "exp ER" refer to import exchange rate and export exchange rate. "avg ER" is the average of import and export exchange rates. [2] All equations are estimated with the Arellano-Bond GMM estimator for dynamic panel regressions (Arellano and Bond, 1991). [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5% and 1% levels, respectively. [4] We demean the independent variables before interacting them; therefore, the coefficient on the export exchange rate is the marginal effect of the export exchange rate evaluated at the sample mean, and so on. [5] The "model χ^2" is the Wald statistic that measures overall significance of the model. [6] The "p-value for AR(2) test" is the p-value for testing the H0 that the errors are not auto-correlated, a condition under which the Arellano-Bond GMM estimator is consistent.
Source: authors' calculation.

Table 6: Robustness checks: Δ total employment in manufacturing/tradable industries

	+service	two-step GMM	no yr FEs	PermER	2006-07	2008-10
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Δ exp ER, de-meaned, de-meaned	-1.10	-.52	-.74	-.73	-1.63	-.97
	(0.49)**	(0.28)*	(0.33)**	(0.24)***	(0.62)***	(0.37)***
Δ exp ER × avg exp orientation		-.006	-.01	-.006	0.02	-.03
		(0.01)	(0.01)	(0.008)	(0.02)	(0.02)*
GDP growth in ROW, exp weighted	-5.33	-2.73	-1.52	-3.06	-3.37	-1.60
	(2.15)**	(0.97)***	(1.10)	(1.20)**	(2.51)	(0.71)**
1st lag of dependent variable	-.02	0.36	0.40	0.44	0.25	0.41
	(0.04)	(0.06)***	(0.08)***	(0.06)***	(0.15)*	(0.09)***
2nd lag of dependent variable	0.06	-.02	-.05	-.10	-.01	-.08
	(0.03)*	(0.04)	(0.06)	(0.05)*	(0.08)	(0.09)
city fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects	yes	yes		yes	yes	yes
Obs.	1356	1372	1372	1147	555	817
model χ^2	400.94	1802.62	1510.53	1596.98	53.01	1076.52
p-value for AR(2) test	0.43	0.98	0.47	0.57	NA	0.49
p-value for Sargan-Hansen statistic	0.39	0.62	0.62	0.03	0.84	0.28

Notes: [1] The abbreviation "exp ER" refers to the export exchange rate. [2] All equations are estimated with the Arellano-Bond GMM estimator for dynamic panel regressions (Arellano and Bond, 1991). [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5% and 1% levels, respectively. [4] We demean the independent variables before interacting them; therefore, the coefficient on the export exchange rate is the marginal effect of the export exchange rate evaluated at the sample mean. [5] The "model χ^2" is the Wald statistic that measures overall significance of the model. [6] The "p-value for AR(2) test" is the p-value for testing the H0 that the errors are not auto-correlated, a condition under which the Arellano-Bond GMM estimator is consistent. Source: authors' calculation.

Table 7: Robustness checks: Δ total employment in nonmanufacturing/nontradable industries

	+service	two-step GMM	no yr FEs	PermER	2006-07	2008-10
Variables	(1)	(2)	(3)	(4)	(5)	(6)
Δ exp ER, de-meaned, de-meaned	-.07	0.01	-.11	-.003	-.03	-.26
	(0.19)	(0.12)	(0.1)	(0.07)	(0.15)	(0.04)***
Δ exp ER × lag manu empl share	-.02	-.01	-.01	-.006	-.03	-.007
	(0.006)***	(0.004)***	(0.004)**	(0.002)***	(0.007)***	(0.004)
lag manu empl share	0.34	0.48	0.48	0.59	0.92	0.29
	(0.18)*	(0.25)*	(0.18)***	(0.21)***	(0.27)***	(0.19)
1st lag of dependent variable	0.20	0.45	0.40	0.68	0.01	0.39
	(0.06)***	(0.15)***	(0.13)***	(0.04)***	(0.19)	(0.12)***
2nd lag of dependent variable	0.06	-.0001	0.003	-.04	-.18	-.11
	(0.04)	(0.06)	(0.03)	(0.05)	(0.08)**	(0.05)**
city fixed effects	yes	yes	yes	yes	yes	yes
year fixed effects	yes	yes		yes	yes	yes
Obs.	1356	1372	1372	1147	555	817
model χ^2	851.76	1174.22	1892.52	2683.30	82.81	1742.01
p-value for AR(2) test	0.40	0.80	0.76	0.55	NA	0.99
p-value for Sargan-Hansen statistic	0.45	0.17	0.17	0.36	0.62	0.17

Notes: [1] The abbreviation "exp ER" refers to the export exchange rate. [2] All equations are estimated with the Arellano-Bond GMM estimator for dynamic panel regressions (Arellano and Bond, 1991). [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5% and 1% levels, respectively. [4] We demean the independent variables before interacting them; therefore, the coefficient on the export exchange rate is the marginal effect of the export exchange rate evaluated at the sample mean. [5] The "model χ^2" is the Wald statistic that measures overall significance of the model. [6] The "p-value for AR(2) test" is the p-value for testing the H0 that the errors are not auto-correlated, a condition under which the Arellano-Bond GMM estimator is consistent. [7] In column (1), "lag tradable empl share" is the lagged share of manufacturing industries and the five tradable service industries combined in local employment. In the other columns, it refers to the share of manufacturing industries in local employment.
Source: authors' calculation.

Table 8: Dependent variable: Δ employment in 82 four-digit NAICS manufacturing industries

Variables	(1)	(2)	(3)
Δ avg ER	-.38	-.38	-.32
	(0.14)***	(0.14)***	(0.17)*
Δ avg ER × lag exp orientation	0.008	0.01	0.008
	(0.007)	(0.007)*	(0.007)
Δ avg ER × lag imp input share	-.01	-.0007	-.01
	(0.02)	(0.02)	(0.02)
Δ avg ER × lag imp penetration		-.006	
		(0.004)	
foreign GDP growth, exp weighted	-.58	-.58	-.70
	(0.47)	(0.47)	(0.81)
US GDP growth	1.80	1.81	
	(0.61)***	(0.61)***	
10-year real interest rate	-1.13	-1.11	
	(0.56)**	(0.55)**	
Δ real oil price	0.03	0.03	
	(0.04)	(0.04)	
linear time trend	0.52	0.51	
	(0.16)***	(0.15)***	
lag employment growth	0.38	0.37	0.39
	(0.05)***	(0.05)***	(0.07)***
industry fixed effects	yes	yes	yes
year fixed effects			yes
Obs.	574	574	574
model χ^2	404.74	395.67	490.74
p-value for AR(2) test	0.48	0.46	0.40
p-value for Sargan-Hansen statistic	0.75	0.75	0.75

Notes: [1] The abbreviations "imp ER" and "exp ER" refer to import exchange rate and export exchange rate. "avg ER" is the average of import and export exchange rates. [2] All equations are estimated with the Arellano-Bond GMM estimator for dynamic panel regressions (Arellano and Bond, 1991). [3] The symbols "*", "**", and "***" indicate statistical significance at the 10%, 5% and 1% levels, respectively. [4] We demean the independent variables before interacting them; therefore, the coefficient on the export exchange rate is the marginal effect of the export exchange rate evaluated at the sample mean, and so on. [5] The "model χ^2" is the Wald statistic that measures overall significance of the model. [6] The "p-value for AR(2) test" is the p-value for testing the H0 that the errors are not auto-correlated, a condition under which the Arellano-Bond GMM estimator is consistent.
Source: authors' calculation.