Relative Prices, Hysteresis, and the Decline of American Manufacturing

Douglas L. Campbell†
New Economic School§
August, 2017

Abstract

This study uses new measures of real exchange rates (RERs) to study the collapse of US manufacturing employment in the early 2000s in historical and international perspective. To identify a causal impact of RER movements on manufacturing, I compare the US experience in the early 2000s to the 1980s, when large fiscal deficits led to a sharp appreciation of the dollar, and to Canada's experience in the mid-2000s, when high oil prices and a falling US dollar led to an equally sharp appreciation of the Canadian dollar. Using disaggregated sectoral data and a difference-in-difference methodology, I find that a temporary appreciation in relative unit labor costs for the US leads to persistent declines in employment, output, and productivity in relatively more open manufacturing sectors. The appreciation of US relative unit labor costs can plausibly explain the loss of about 1.5 million manufacturing jobs in the early 2000s.

JEL Classification: F10, F16, L60
Keywords: Exchange Rates, American Manufacturing, Hysteresis, Trade

---

†. Special thanks are in order for the comments received from conference attendees at the All-UC Economic History Conference at Berkeley, the Canadian Economic Association annual meeting, the Mid-west International Economics Conference, the iCARE conference at HSE Perm, the Bari International Conference; from seminars at Colby College, Santa Clara, the New Economic School, the University of Illinois, Florida International, and to Steven Durlauf's students at Wisconsin; as well as comments from Penelope Goldberg, Matthew Gentzkow, Matthew Notowidigdo, and Charles Engel in their capacity as editors, and from twelve anonymous referees. I benefited enormously from feedback from my thesis advisor, Chris Meissner, and from Paul Bergin, Gregory Clark, Robert Feenstra, Tadashi Ito, Martha Olney, Monica Roa, Marshall Reinsdorf, Katheryn Russ, Thomas Wu, Deborah Swenson, Alan Taylor, and Noam Yuchtman. This research depends on the new and much improved version 8 of the Penn World Tables, so I am also indebted to Robert Feenstra, Robert Inklaar, and Marcel Timmer, and for Wayne Gray for managing the NBER-CES manufacturing page. I also thank Ilnura Mukhamedzhanova for her excellent research assistance. This research project began while I served on the President's Council of Economic Advisers as a Staff Economist. It benefited immensely from conversations I had with Chad Bown, Michael Klein, and Jay Shambaugh. All errors are my own.

§. New Economic School, 100 Novaya Street, Skolkovo, Moscow, Russia, 143025, Tel.: 7-925-629-6600, e-mail: dolcampb@gmail.com, Homepage: dougcampbell.weebly.com.

American manufacturing employment suddenly collapsed in the early 2000s, falling by three million (17.4%) from 2000 to 2003 (Figure 1) after declining by just 3% from the late 1960s to 2000.[1] As the economy grew from 2003 to 2007, the lost jobs did not return.

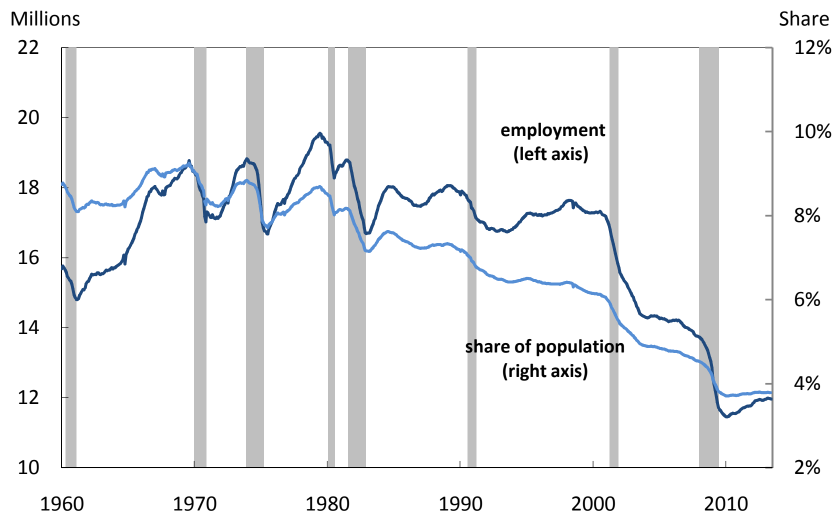


Figure 1: American Manufacturing Employment, 1960-2013.
Source: BEA

What caused the sudden collapse? Economists generally believe that the answer is productivity gains in manufacturing and a sectoral shift toward services. However, aggregate measured labor productivity growth in manufacturing has remained relatively constant over the post-war period, while productivity for the median manufacturing sector *declined* in the 2000s.[2] Additionally, the decline in the services share of consumption from its average in the late 1990s to 2005 was just .5% of GDP (Table 7), while the services share of exports surprisingly has remained constant over the past few decades (Figure 12(b)).

These facts support recent research on trade liberalization and the rise of China as

1. A plot of the manufacturing share of total employment also indicates that manufacturing employment was below trend in the 2000s, although it is less obvious. Yet, this measure could be misleading. If any location, (*e.g.*, Detroit) loses 50% of its tradable-sector jobs then eventually 50% of the non-tradable sector jobs may also be lost. In this case, the (unchanging) share of manufacturing jobs is not informative. Also, if one extrapolates from the trend in manufacturing employment as a share of the population from 1970 to 2000, then manufacturing employment becomes *negative* by 2065. Thus, it is more natural to expect the decline in manufacturing employment as a share of the population to slow over time, as has been the case in agriculture.

2. Houseman et al. (2011) present evidence that perhaps one-fifth to one-half of the measured growth in manufacturing value-added per worker from 1997 to 2007 reflects upward bias caused by the dramatic increase in low-priced imported intermediate inputs. Houseman (2014) notes that, excluding computers, US manufacturing output increased just 7% from 1997 to 2012, an historical anomaly.

explanations for the collapse of US manufacturing. In a seminal contribution, Autor et al. (2013) find that increasing competition with Chinese imports explains one-quarter of the aggregate loss in manufacturing employment through 2007. Pierce and Schott (2016) find that China's accession to the WTO caused a flood of imports and the "surprisingly swift" decline in U.S. manufacturing employment.[3]

However, there was also a large real exchange rate shock during this period, as US unit labor costs in manufacturing appreciated 33% from 1995 to 2001 relative to trading partners. Despite the fact that economists widely believe that relative prices matter, the impact of the RER appreciation in this period has not been studied. Thus, this paper strives to fill the gap by revisiting the question of the impact of RER movements on manufacturing.

To identify a causal effect of real exchange rate (RER) movements on manufacturing, I compare the US experience in the early 2000s to the 1980s, when large US fiscal deficits led to a sharp appreciation in the dollar, and to Canada's experience in the mid-2000s, when high oil prices and a depreciating US dollar led to an equally sharp appreciation of the Canadian dollar. These periods contained large RER movements which I argue were likely to be exogenous from the perspective of the manufacturing sector.

I use a panel difference-in-difference research design exploiting substantial variation in initial exposure to trade across 360 manufacturing sectors and in real exchange rates over time to identify the impact of currency appreciations on manufacturing sectors with differential exposure to international trade. This allows me to make a weaker identifying assumption – that collapses in relatively more tradable manufacturing sectors do not cause RER appreciations. I then control for a long list of other potential third factors, including real interest rates interacted with sectoral capital intensity (and openness), various other factor prices interacted with sectoral factor intensity, trade policy variables, productivity, and estimates of sectoral demand. Defining openness using a weighted average of import penetration and the export share of shipments (also called output) lagged three to six years, I find that when relative unit labor costs in manufacturing are high, initially more open sectors experience a relative decline in employment and

3. Ebenstein et al. (2014) also document a series of facts consistent with the idea that Chinese import competition reduced US manufacturing employment. Autor et al. (2014) look at worker-level evidence of the impact of the rise of China. Charles et al. (2013) argue that temporary housing bubbles in some local labor markets masked the employment declines associated with manufacturing, yet find that 40% of the increase in non-employment in the 2000s was caused by the decline in manufacturing. Boehm et al. (2015) find that US multinational firms accounted for a disproportionate share of the decline in manufacturing employment. Dauth et al. (2014) find that the impact of the rise of China was not as large on Germany, which, incidentally, did not experience the same overvaluation as did the US in the 2000s.

output. The regression results imply that the RER appreciation caused the loss of 1.5 million manufacturing jobs from 1995 to 2005, although I interpret this as a rough estimate suggesting that the magnitude of the shock is large. (Caveats include that this estimate does not include central bank responses, general equilibrium effects, input-output linkages, or local labor market effects.) When relative prices are elevated, I also find evidence of increased job destruction and suppressed job creation, and find relative declines in shipments, production hours worked, productivity and value-added, and a modest decline in production worker hourly wages. I do not find evidence of a significant impact on inventory, sectoral prices, or non-production worker hourly wages.

These findings should not be surprising in light of the central tenet of economics, that prices matter. I also propose a corollary: in a world with sunk costs, historical prices can affect current economic outcomes. Empirically, I find strong evidence that temporary shocks to relative prices have persistent effects on the manufacturing sector. Jobs lost during the previous appreciation do not return even after US relative prices return to fundamentals.

Second, I add an international dimension to the "difference-in-difference" framework, asking whether more open manufacturing sectors in the US lose employment when the dollar is strong relative to the same sectors in other major economies. This is an important test, because if the decline in manufacturing employment in the 2000s was caused solely by the rise of China for reasons unrelated to relative prices, then other major economies, such as Canada, should also have had employment declines in the same sectors at the same time (they did not). In fact, from 1998 to 2003, as US manufacturing employment was collapsing, Canadian manufacturing employment actually increased. Once the Canadian dollar appreciated sharply later in the 2000s, Canadian manufacturing employment then promptly collapsed, with the losses concentrated in more open sectors.

Third, I introduce the anecdote of Japan as a quasi-experiment with a large and plausibly exogenous policy-related movement in real exchange rates in the 1980s. I find that although Japanese industries gained market share in the US when the yen was weak, Japanese industries consolidated their gains but did not make further inroads after the Yen appreciated sharply vs. the dollar. This is further evidence of persistence.

A paper linking real exchange rates to the collapse in US manufacturing employment has not been written, likely because of a subtle, but crucially important, measurement issue: commonly-used measures such as the Federal Reserve's Broad Trade-Weighted RER Index suffer from an index numbers problem. It is computed as an "index-of-indices," which does not reflect compositional changes in trade toward countries, such as China, with systematically lower price levels (Thomas et al. (2008) and Campbell (2016)). The Fed's RER index implies that the appreciation in the dollar from 1996 to 2002 was slightly more modest than the dollar appreciation in the 1980s, and yet (ostensibly a paradox) gave rise to a much larger trade deficit as a share of GDP (plotted ex-oil in Figure 2).[4] By contrast, a simple trade-weighted average of relative prices (WARP) using version 8.1 of the Penn World Tables implies a much larger dollar appreciation in the early 2000s, mirroring the trade balance much more closely. The difference between the two indices is due to the rising share of trade with low-price countries, such as China, and also due to the different underlying data used by the PWT.[5]

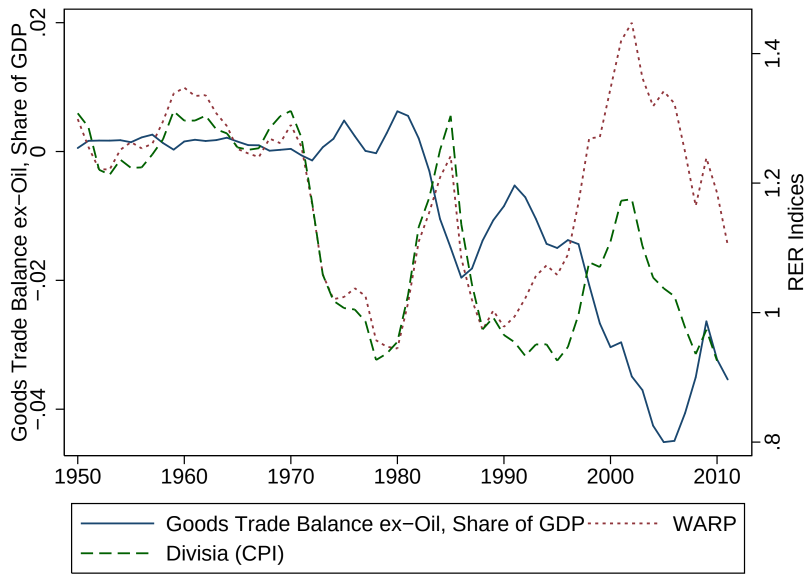


Figure 2: Real Exchange Rate Measures vs. the Current Account
Sources: BEA and Campbell (2016)

Traditionally, economists have thought that real exchange rate indices computed using unit labor costs, which reflect labor costs relative to productivity, are the best price-based measure of international competitiveness (Turner and Van't Dack (1993)). However, relative unit labor cost indices produced by the IMF and OECD have several drawbacks, including that they are computed as indices-of-indices, and thus do not

4. The Fed's real exchange rate index is: $I_t^d = I_{t-1} \times \Pi_{j=1}^{N(t)} (\frac{e_{j,t} p_t / p_{j,t}}{e_{j,t-1} p_{t-1} / p_{j,t-1}})^{w_{j,t}}$, where $e_{j,t}$ is the price of a dollar in terms of the currency of country j at time t, p_t is the US consumer price index at time t, $p_{j,t}$ is the consumer price index of country j at time t, $N(t)$ is the number of trading partners, and $w_{j,t}$ is the trade weight of country j at time t. The base year value of the index is arbitrary.

5. Partly, the difference in the underlying data is that the PWT starting with version 8.0 uses multiple benchmarking, while the Fed's CPI uses country-specific deflators, which may become biased over time. Note that China's rising share of US trade does not affect the Fed's index.

properly account for compositional changes in trade with countries, such as China, that have systematically lower unit labor costs.[6]

In this paper, I address these concerns by using a Weighted Average Relative Unit Labor Cost (WARULC) index computed for the manufacturing sector using data from all six benchmarks from the World Bank's International Comparison Project (ICP), and which includes developing countries such as China. I find that this index accurately predicts manufacturing employment declines. I also find similar results using other RER measures in the class of "weighted average relative" (WAR) exchange rates such as the WARP index created by Thomas et al. (2008) or the Balassa-Samuelson adjusted WARP index created by Campbell (2016).

There is, of course, already a large literature on the impact of RER movements on manufacturing, which tends to find that manufacturing employment is sensitive to currency appreciations. Ekholm et al. (2012) find that oil price appreciations differentially effect more open sectors in Norway.[7] Klein et al. (2003), the seminal paper in this literature and also the closest to this study, finds a large effect of the US RER shock in the 1980s on manufacturing, but has become a bit dated methodologically as it was published in an era when standard errors were not clustered in one direction much less two, and they did not test for the phenomenon of persistence.

One puzzle from the literature is that RER appreciations have led to declines in employment in the US, whereas depreciations do not seem to help. The solution to the puzzle is that what matters for employment is the level of US relative unit labor costs, rather than the change.[8] Conceptually, if unit labor costs were the same in the US

6. Additionally, China and many other developing countries are not even included in the IMF's Relative Unit Labor Cost (RULC) index, which also uses fixed trade weights that have become outdated. These issues are explained in more detail in Campbell (2016). Another important problem with the IMF and OECD series is that manufacturing output is deflated using country-specific deflators (constructed idiosyncratically), which can lead to bias over time without the use of multiple benchmarks. This same problem afflicts older vintages (predating version 8.0) of the Penn World Tables.

7. Klein et al. (2002) contains an overview of this literature to that point. Other key papers in this literature are Branson and Love (1986), (1987), and (1988), who argue for a large impact, and Revenga (1992), Gourinchas (1999) and Campa and Goldberg (2001), who find either a small or non-robust impact using US data. N. Berman et al. (2012) and Moser et al. (2010) generally find small to moderate impacts for Europe, and Dai and Xu (2015) argue for small effects for China (and none for import competition). Rose (1991) and McKinnon and Schnabl (2006), find no impact of RER movements on trade, while Chinn (2004) finds that a low responsiveness of imports to exchange rate changes. Lastly, in a sequel to this paper, Campbell and Lusher (2016) replicate the same identification strategy as in this paper using individual-level data from the CPS MORG, and concludes that these RER shocks lowered employment and raised unemployment and labor market exits.

8. With the exception of the late 1970s, when the dollar was weak and manfucturing was growing, with growth concentrated in more open sectors, the dollar has not had many years where it appears to have been undervalued in the past 50 years. Perhaps this is not surprising for a developed country with advanced financial institutions, an open capital market, and a freely floating hard currency. Thus, the

and in China, then there would be no economic reason to move production, particularly as this could entail substantial fixed costs. On the other hand, when US unit labor costs are 50% higher than for trading partners, there is a clear economic incentive to shift production, and firms already located abroad would have a competitive advantage (assuming all else is equal).

It has been established empirically that history matters for trade patterns (Eichengreen and Irwin (1998), Campbell (2010), Head et al. (2010) and Head and Mayer (2013)). In addition, a large literature on exchange rate hysteresis followed the observation that improvements in the US aggregate trade balance lagged the depreciation of the dollar in the late 1980s, with the original progenitors of increasing returns and New Trade Theory all weighing in (Dixit (1989a), (1989b), (1991), (1992), Krugman (1987), (1988), Baldwin and Krugman (1987) 1989, and Baldwin (1988), (1990)).[9] However, this literature was almost entirely theoretical, while the literature on RERs and manufacturing has not addressed persistence.[10] Given the persistent US trade deficit following the trade shock of the early 2000s (see Figure 2), now would seem an appropriate time to revisit the issue.

1 Data, Theory, and Identification

1.1 Data and Measurement

The main measure of the real exchange rate used in this paper is the Weighted Average Relative Unit Labor Cost (WARULC) index designed by Campbell (2016) to address the shortcomings of the IMF's Relative Unit Labor Cost (RULC) index, which include that the IMF's index is computed as an index-of-indices, and uses fixed trade weights

periods when the dollar falls correspond to periods in which the level of ULCs are the same as those for US trading partners, whereas the periods of appreciation correspond to periods when US RULCs are higher than those for trading partners.

9. Here, hysteresis was often defined to mean persistence, such as by Blanchard and Summers (1986).

10. Belke et al. (2013) and Belke and Kronen (2016) conclude that German and Greek exports exhibit exchange rate hysteresis, while Parsley and Wei (1993), using US data, find hysteresis to be insignificant and inconsequential. In addition, Alessandria and Choi (2007), (2014b) and (2014a), do calibration exercises they argue are consistent with sunk fixed costs of exporting. Campbell (2013) and finds that the slow decay in colonial trade patterns can explain the puzzle over why currency unions appeared to increase trade. A number of other empirical papers have interpreted persistence in export status as evidence for hysteresis (*e.g.*, Roberts and Tybout (1997), Campa (2004), Bernard and Jensen (2004), and Kaiser and Kongsted (2008)). While this is certainly suggestive evidence consistent with hysteresis, one might worry that there are omitted variables driving export status that also happen to be autocorrelated. Blanchard and Summers (1986) and Katz (2010) make strong cases for hysteresis in aggregate employment.

which do not include China. The IMF's index (plotted vs. WARULC in Appendix Figure 15), suggests a steady depreciation of US relative unit labor costs over the period, implying that US manufacturing has become steadily more competitive since the 1970s. WARULC, by contrast, implies that US manufacturing became less competitive in the early 2000s.[11]

Sectoral data on employment, shipments, value-added, wages, hours worked, and capital, and the prices of shipments, materials, and energy are provided by the Census Bureau's Annual Survey of Manufactures, via the NBER-CES Manufacturing Industry Database for the 4-digit SIC data from 1958 to 2009. Data were taken directly from the Census Bureau for the NAICS version of the same variables spanning 1989-2011. Trade data from 1991-2011 are from Comtrade WITS when available, and these data are augmented with trade and the cost of insurance and freight data from Feenstra et al. (2002) from 1972-2005. Sectoral tariff data for 1974-2005 come from Schott (2008) via Feenstra et al. (2002), as does data on the increase in tariffs China would have faced had MFN status been revoked (the key control in Pierce and Schott (2016)). Additional data on the tariffs US industries face for 1990-2009 were taken from UNCTAD. Data on unionization come from unionstats.org, and data on Chinese tariffs came from Brandt et al. (2012). Other China-related variables from Pierce and Schott (2016), such as Chinese production subsidies and export eligibility by sector, are not yet publicly available but were not generally found to be significant predictors of employment changes.

Data on intermediate imports, both broad and narrow measures, were taken from the BEA's Input-Output tables for the benchmark years 1997, 2002, and 2007. Intermediate import estimates were then made using IO data for the benchmark years 1972, 1977, 1982, 1987, and 1992 after employing the standard "proportionality" assumption, tested by Feenstra and Jensen (2012). Data for the intervening years was then estimated based on changes in output and imports.

The classification of broad industrial sectors by markups is borrowed from Campa and Goldberg (2001).[12] International manufacturing data on employment and output at the 3-digit ISIC Rev. 2 and Rev. 3 level for G7 countries comes from UNIDO's INDSTAT database.

11. Fuller explanations on the differences between these two indices are available in Appendix Section 7.3 and in 2016, a companion paper. The four main differences are that WARULC (1) is computed as a simple weighted-average of RULCs, (2) includes China, (3) uses time-varying trade-weights, and also (4) uses multiple-benchmarking of country-specific productivity series using PWT v8.0 methodology.

12. The Campa-Goldberg classification of low markup industries at the 2-digit SIC level includes primary metal products, fabricated metal products, transportation equipment, food and kindred products, textile mill products, apparel and mill products, lumber and wood products, furniture and fixtures, paper and allied products, petroleum and coal products, and leather and leather products.

The summary statistics for the most relevant variables in select years are reported in Table 6 in the Appendix. Openness increased from about 7% in 1972 to 24% in 2001 (when China acceded to the WTO) and 27.9% by 2005. It can be seen that labor costs are a large, but declining, share of value-added over the period, declining from 42.6% of value-added to just 32%. The average applied tariff was about 8.2% in 1974, but it fell to just 2.4% by 2005. By contrast, the cost of insurance and freight was 9.6% of customs costs in 1974, and largely unchanged at 9.8% in 2005. The last two entries in Table 6, capital-per-worker and the 5-factor TFP index, also come from the NBER-CES manufacturing data set. The details of their creation are described in Bartlesman and Gray (1996). Finally, panel (a) of Figure 14 shows that there was a large variation in the distribution of openness by sector in 1997, and Panel (b) demonstrates the rise in import penetration relative to export shares when the US WARULC index is elevated.

1.2 Theoretical Motivation

Given that the theoretical motivation is intuitive ("relative prices matter"), the focus of this paper is on identifying a causal relationship for the impact of RER movements on outcomes in manufacturing using reduced-form empirical exercises. Any model in which prices matter is likely to deliver the result that a shift in the RER will have an impact on outcomes. However, only models with sunk costs of some kind will imply that a temporary RER shock will have persistent effects, or, put another way, that current outcomes will be affected by the history of relative prices. In the appendix, Section 7.1, I present a slight variation of the Melitz (2003) model with sunk entry costs, and show that this version of the model implies that historical prices matter. The model also helps motivate some of the controls, including controls for demand, trade policy, trade costs, and producitivity, which are also intuitive. However, in the end, to what extent RERs, and historical prices matter is an empirical question.

1.3 Identification

RER movements are potentially endogenous to manufacturing employment and output. Exchange rates are also influenced by various macroeconomic forces which also may impact manufacturing. I employ a variety of methods, including a repeated difference-in-difference research design using disaggregated data, out-of-sample testing, and falsification tests in order to mitigate these problems and attempt to identify a causal effect of RER movements on manufacturing.

Figures 3 and 4 plot the evolution of employment in the most open sectors vs. less open sectors when the real exchange rate appreciates in the 1980s and early 2000s. In Figure 3, the evolution of employment indices by fixed categories of openness (the most open vs. less open sectors) in 1972 is plotted vs. WARULC (favored measure of the RER) for the manufacturing sector. The employment index for each sector is given a base year value of 100 in 1979, and then updated based on changes in employment not due to changes in demand or productivity, or to general movements in all sectors for each year.[13] The pretreatment trends of the top 25% most open sectors in 1972 are very similar to the least open 50% of sectors. (The results are not sensitive to the choice of cutoffs. For example, in the panel regressions which follow, I use continuous measures of openness.) Yet, when the dollar appreciated in the 1980s, the more open sectors lost more than 10% of their employment relative to the least open sectors. This result makes intuitive sense given that labor costs were more than 40% of value-added for the average sector during this period. Thus a 50% increase in relative unit labor costs should have had a differential impact on more exposed sectors. Interestingly, after the dollar returned to fundamentals in the late 1980s, this differential impact decayed very modestly, if at all.

I would argue that the 1980s episode deserves to be a canonical example of a persistent effect of a temporary exchange rate shock, for several reasons. First, the RER shock (50% appreciation) was large, which increases the signal-to-noise ratio. Second, given that labor costs were 40% of value-added for the typical sector, it would be implausible if profit-maximizing firms did not respond to this large change in relative prices. Third, and perhaps most importantly, the main cause of the appreciation in relative prices in the 1980s was large government deficits, which are arguably exogenous from the perspective of manufacturing employment. This is especially the case since an employment (and output) collapse in the most tradable manufacturing sectors should endogenously lead to a RER *depreciation* rather than an appreciation.[14] Thus, in this case endogene-

13. *I.e.*, first I ran the regression: $ln\Delta L_{ht} = \alpha_t + \beta_2 ln\Delta \hat{D}_{ht} + \beta_2 ln\Delta (VA/P)_{ht} + \epsilon_{ht}, \forall t = 1973, ..., 2009$, where L is employment, D is an IV for demand, and VA/P is value-added over production workers, a measure of productivity. The IV for "demand" was created by regressing sectoral demand (demand=shipments+imports-exports) on RGDP growth for each sector separately. And then using the predicted changes from these equations. Then I updated sectoral indices normalized to 100 in 1979 based on the residuals from this regression. Lastly, I plotted the average of these indices separately for the most open and less open sectors. The goal is to understand how employment evolved in the most open vs. the least open sectors after controlling for demand and productivity.

14. several referees have disagreed with this assessment, arguing that both openness and employment are "endogenous". However, while I agree that endogeneity is "almost always" a problem in empirical trade research, to gauge whether it is a problem in individual cases it is necessary to spell out the mechanisms by which endogeneity could threaten a result. In this instance, it is not clear how an

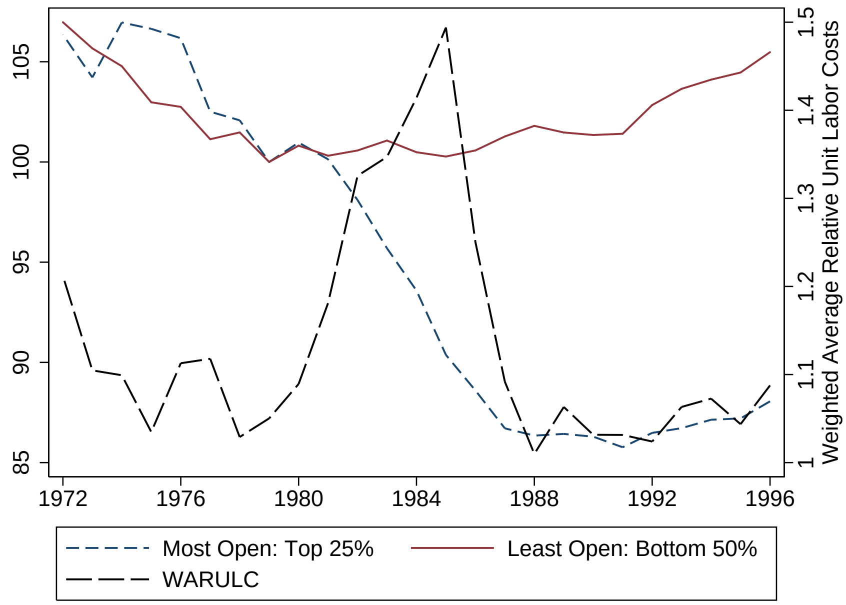


Figure 3: Employment Growth by Degree of Openness in 1972 (SIC)*

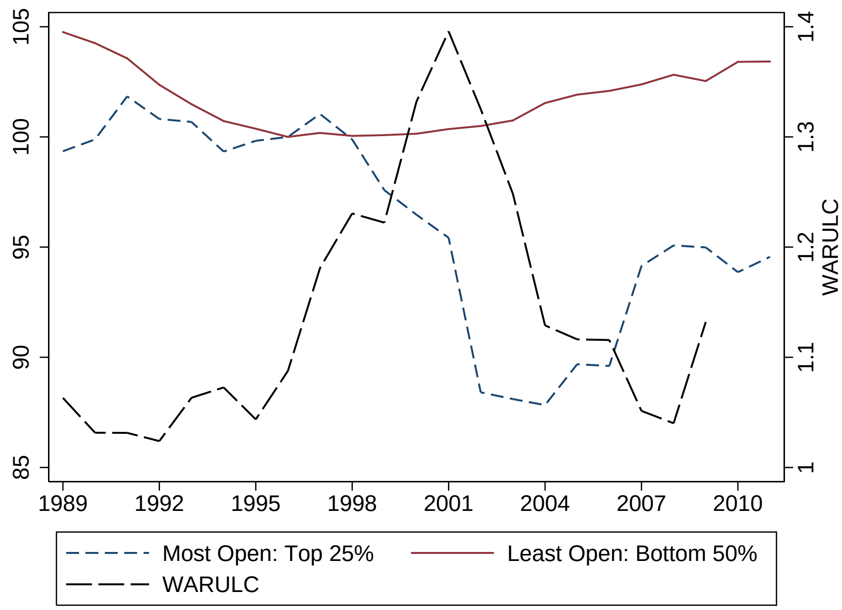


Figure 4: Employment Growth by Degree of Openness in 1989 (NAICs)*

*Notes: Employment is indexed to 1979 in Figure 3, which uses SIC data, and to 1996 in Figure 4, which uses NAICs data, and is updated with residuals from a regression controlling for demand, productivity, and year fixed effects. Thus the blue dashed lines in the figures tell us how employment in initially more open sectors evolved after controlling for other key factors. Openness = m*imports/(imports+shipments-exports)+(1-m)*(exports/shipments), where m = imports/(imports + exports). The cutoff for the non-open sectors was 3.8% in 1972 and 9.7% in 1989, and the lower bound for the open sectors was 8.3% in 1972 and 20.9% in 1989. A version including error bounds in the Additional Appendix (Figure 22) shows that open sectors experienced a significant decrease in employment.

ity should lead to a bias in the direction of not finding anything. If the large estimated negative impact of RER appreciations on manufacturing employment is in fact a floor, the results in this paper would only be more salient. In addition, exchange rates impact trade and manufacturing employment with a lag. Thus, it is not clear why an employment collapse in more tradable sectors in 1986 should cause a dollar appreciation at all, much less in 1985. However, this logic does not necessarily mitigate against third factor causality.

The appreciation in the late 1990s and early 2000s (Figure 4) suggests a similar story – steep losses in the early 2000s which then reverted to previous levels only gradually. While the magnitudes appear smaller, this is partly because even the most closed sectors were much more open in the 2000s than the 1980s. In both periods, the declines in more open sectors occurred at the same time as declines in aggregated "structurally adjusted" manufacturing employment (Figure 12 in the appendix).[15]

This appears to be a case in which the most serious threat to identification is not endogeneity *per se*, but rather that a third factor could cause both an exchange rate appreciation and a decline in manufacturing. The general solution to this problem is to control for obvious third factors in a panel "difference-in-difference" setting using disaggregated data that tests explicitly whether an appreciation in the RER causes a decline in relatively more open manufacturing sectors (where a continuous measure of openness is defined at a several year lag so that it itself is not endogenous). For example, one might be concerned that high real interest rates (RIRs) could cause an appreciation of the RER and a decline in manufacturing employment. In this case, it is straightforward to include the RIR as a control variable, along with the RIR interacted with sectoral capital intensity and openness, as more capital-intensive or open sectors could potentially be more sensitive to movements in the RIR. However, in fact import-competing sectors tend to be less capital intensive and appear to be less sensitive to movements in the RIR than other sectors. In addition, RIRs were at historic lows during the collapse of manufacturing in the early 2000s. Although RIRs were high in the early 1980s, the timing of the peak in RIRs does not match the 1980s collapse in manufacturing as well as relative prices.

---

employment decline in 1985 could have led to the same sectors being more open in 1972, nor is it clear why a decline in employment (and output) of more open sectors would lead to a currency appreciation rather than a depreciation. Note that this argument does not apply to third-factor causality or omitted variables.

15. "Structurally adjusted" employment was computed at quarterly intervals by subtracting implied employment changes based on movements in GDP from a regression of quarterly changes in manufacturing employment on changes in GDP and lagged changes in the Fed's Broad Trade-Weighted RER Index. This index was used because it has data at quarterly intervals.

Another plausible third factor is that perhaps China was simply growing fast in the early 2000s for a variety of reasons unrelated to relative prices, and this alone caused the collapse. Yet, US imports from countries other than China increased by more than Chinese imports in the early 2000s, suggesting that China is unlikely to be the only factor.[16] Even so, it is plausible that China's growth had causes other than relatively low unit labor costs (wages relative to productivity), the chief measure of the RER used in this paper. These factors include China's accession to the WTO and the MFA agreement, both of which I find had significant effects when I control for them separately. Also note that factors which increased the productivity of China's manufacturing sector, such as improvements in infrastructure, the institutional environment, educational attainment, learning-by-doing over time as rural workers become accustomed to factory work, government subsidies, and the suppression of labor unions are all forces that would lower China's relative unit labor costs (RULCs). Even so, RULCs admittedly may not capture the impact of these various factors perfectly.

An alternative way to test the "it's just China" hypothesis is to add a third dimension to the "difference-in-difference" regression, and ask whether more open sectors in the US do worse relative to more open sectors in other major economies when US RULCs are high. If fast export growth from China regardless of relative prices was the cause of the collapse, then other major economies, such as Canada, should have been adversely affected at the same time. I find that they were not. The case of Canada, given that its geographic exposure to Chinese competition is similar to that of the US, provides a particularly illustrative example. When the US dollar was strong in the late 1990s and early 2000s, Canadian manufacturing was increasing even as US manufacturing was collapsing. Then the US dollar began to fall and the Canadian dollar began to rise, strengthened by rising oil prices. Soon after, Canadian manufacturing experienced its own collapse.

Single "difference-in-difference" regressions can fail when researchers omit key variables that happen to coincide with the treatment, resulting in spurious correlation. This problem is prevalent in part because it is often not obvious in advance what factors are really driving a spurious result. While this is a ubiquitous problem, a general mitigating strategy is to use a "repeated difference-in-difference" research design, which repeats the usual "difference-in-difference" method in different time periods and places, effectively testing out of sample. While still not foolproof, repeated difference-in-difference regressions dramatically reduce the number of potential variables that could be perfectly

16. It is also true that Chinese imports were increasing at a faster pace, but Chinese imports started from a much lower base.

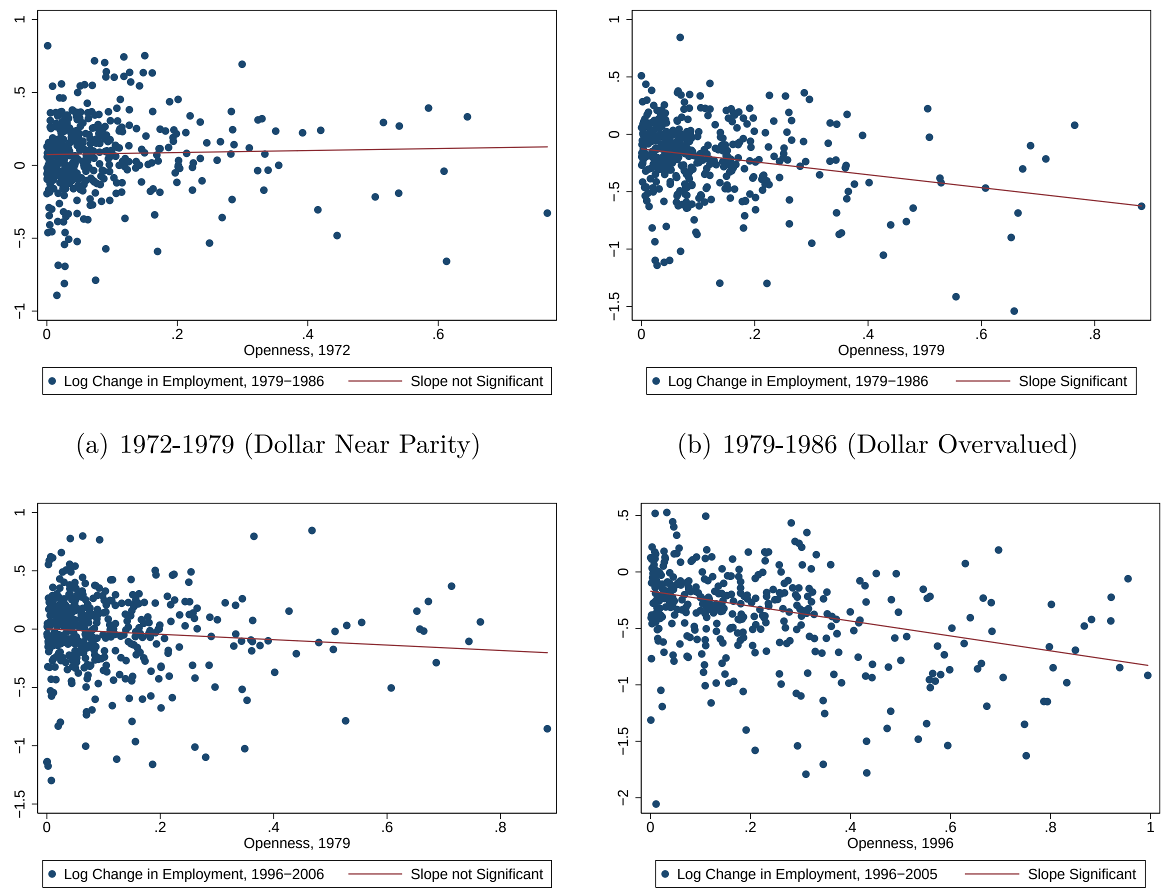
correlated with the treatment. In this case, such a variable would have to be strongly correlated with the US, Canadian, and Japanese RERs over a period of decades. In addition, in each year this omitted variable needs to be strongly correlated with openness by sector. While such a variable may exist, the repeated element of the difference-in-difference methodology make this a high hurdle. Spurious results have a well-known tendency not to hold out of sample.

2 Main Empirical Results

2.1 Cross Sectional Results

In the exercises in Figures 3 and 4, I used fixed categories of openness. What is the appropriate functional form for how openness impacts employment growth by sector in periods when the RER is elevated? Figure 5(a) demonstrates a correlation, between initial sectoral openness in 1979 and subsequent employment declines from 1979 to 1986, a period which is conveniently arranged from one business-cycle peak to the next. The R-squared is .05, and the coefficient on lagged openness is -.74 vs. robust standard errors of .21. The fit gets better when additional controls are added in. However, in the next low RER period, from 1986 to 1996, also measured at similar points in the business cycle, there is no correlation between openness and employment changes by sector. The more open sectors which had experienced fairly sizeable employment declines in the mid-1980s did not experience disproportionate gains in the period when the dollar returned to fundamentals. Similarly, in the 1970s, when US relative prices were near unity, there was no correlation between openness and employment declines, but in the period of dollar appreciation from 1997 to 2005, there was, once again, a fairly strong negative correlation. These conclusions are robust to slight changes in the cutoffs.

This exercise implies a relatively straightforward linear functional form for the relationship between openness and employment declines in periods when the RER is overvalued. However, what is the impact by year, and does this relationship hold up once we include more control variables? One of the most fundamental variables to control for is a measure of sectoral demand. When the economy is doing poorly, consumer durables, which are also highly traded, tend to do relatively worse. Some sectors may experience increasing demand for any number of reasons. However, if we control for demand directly, a measure of domestic consumption (defined as: $demand = shipments + imports - exports$), one might worry that this would be an endogenous control given that it contains shipments. Thus, I create a sector-specific instrumental variable for demand based on



(a) 1972-1979 (Dollar Near Parity)

(b) 1979-1986 (Dollar Overvalued)

(c) 1986-1996 (Dollar Near Parity)

(d) 1996-2005 (Dollar Overvalued)

Figure 5: Manufacturing Employment Growth vs. Openness in 1979

Notes: In panel (a), in the 1970s, with US relative prices close to one, there was no relationship between initial openness and employment changes. In the mid-1980s, however, as the dollar appreciated, a relationship emerged (panel b). However, the more open sectors in 1979 that lost more jobs through 1986 did not regain those jobs after the dollar returned to parity – evidence of persistence. From 1996-2005, as the dollar appreciation, the relationship returned. Data Source: Annual Survey of Manufactures, Census Bureau, and WITS.

changes in US real GDP and sector-specific elasticities. First, for each sector h, I regress:

$$\Delta ln(D_{ht}) = \alpha_h + \beta_h \Delta ln(RGDP_t) + \epsilon_{ht}, \forall h = 1, ..., H. \tag{2.1}$$

Then I use the predictions of demand growth (D) from this equation, $\Delta ln(\hat{D}_{ht})$, as the main measure of sectoral demand to be used as a control variable, but I also try using actual demand, or simply omitting this control as well.

Next, we plot the correlation between openness and employment growth by year, running the following regression on repeated annual cross-sections of the data:

$$\Delta ln(L_{ht}) = \alpha_t + \beta_0 Openness_{h,t-1} + \beta_2 \Delta ln(\hat{D}_{ht}) + \beta_2 \Delta ln(Prod._{ht}) + \tag{2.2}$$

$$\beta_4 (PostPNTR * NTRGap)_{ht} + \beta_5 MFAExposure_{h,t} + \epsilon_{ht}, \forall t = 1973, ..., 2009.$$

This is a regression of log changes in sectoral employment, L_{ht}, on lagged openness, controlling for a measure of productivity (such as shipments per production worker), an IV for sectoral demand growth, $\hat{D}_{ht}$, and two other China-related controls, following Pierce and Schott (2016). The first is the interaction between China's accession to permanent normal trade relations (PNTR) interacted with a control for the NTR gap by sector. The second is a measure of exposure to the expiration of Chinese textile quotas. As many authors, including Brambilla et al. (2010) and Khandelwal et al. (2013) have highlighted, the end of Chinese textile quotas associated with the end of the Agreement on Textile and Clothing (ATC) (the successor to the Multifiber Arrangement, MFA), had a large impact on the sectors in which the quotas were binding. Thus, I have also included a control for the weighted average of the fill rate – the imports divided by the allowable quotas – just before the quotas were lifted (also following Pierce and Schott (2016)).[17] Lastly, openness is defined as a weighted average of import penetration and the export share of shipments:

$$Openness_{it} \equiv \frac{M_{it}}{M_{it} + X_{it}} * \frac{M_{it}}{M_{it} + S_{it} - X_{it}} + \frac{X_{it}}{M_{it} + X_{it}} * \frac{X_{it}}{S_{it}}, \tag{2.3}$$

where S_{it} are shipments in sector i at time t, M_{it} are imports, X_{it} are exports. One could also use trade divided by shipments, and still get similar results, but this specification has the advantage that employment losses should be a linear function of openness, while trade over shipments would likely need to be transformed, particularly in cases in which

17. *I.e.*, the sectors affected by the end of quotas interacted with a post-2005 dummy using data from Brambilla et al. (2010) on the pre-2005 fill rates of the Chinese quotas (converting the HS codes to SIC using the concordance provided by J. R. Pierce and P. K. Schott (2012).

imports are greater than shipments. This specification also indeed fits the data better (see the Additional Appendix for a comparison).

The annual coefficient on openness is plotted in Figure 6 in blue, along with two standard deviation error bounds. I have also plotted a measure of the RER, weighted average relative unit labor costs (WARULC), and the real interest rate, defined here as the interest rate on 30-year mortgages minus the core CPI (both from FRED).[18] The results suggest a strong correlation between the level of relative unit labor costs and the annual coefficient on lagged openness. The annual coefficient becomes significant in 1998, whereas China was awarded permanent MFN status in the fall of 2000 and joined the WTO in December of 2001. After WARULC returns closer to parity in the latter half of the 2000s, relatively more open sectors stopped hemorrhaging jobs on average, even as imports from China continued to increase.

Figures 3, 4, 5 and 6 suggest a functional form for the relationship between relative unit labor costs and the evolution of sectoral manufacturing employment. When unit labor costs are high in the US relative to trading partners, more open sectors lose employment relative to less open sectors. When the level of WARULC is close to unity, there does not appear to be a differential change in jobs for more open sectors. This makes intuitive sense, as when unit labor costs are roughly the same at home and abroad, there is no large advantage for foreign firms over domestic firms, nor would there be a reason for domestic firms to incur the costs of moving production abroad, and so we should not expect differential employment changes in more open sectors. These findings imply that a temporary overvaluation will have a persistent effect.

2.2 Description of Panel Regressions

Our benchmark panel regression model regresses log changes in sectoral employment on a weighted average of lagged openness, some function of the RER interacted with openness, and some intuitive controls which are also motivated by the theoretical model presented in the appendix (equation 7.6).

$$\Delta ln(L_{ht}) = \alpha + \beta_0 Avg.Openness_{h,t-3,t-6} + \beta_1(\varphi(L)ln(RER_{t-1})) * Avg.Openness_{h,t-3,t-6} + \tag{2.4}$$

18. The real interest rate and the coefficient on openness is only approximately correlated in the early 1980s. For example, from 1985 to 1987, the RIR only declined slightly, yet the coefficient on openness increased from -.2 to 0. Using the Core PCE deflator instead of the Core CPI to calculate the RIR instead would give even more anomalous results, as the RIR measured using the PCE deflator spiked in 1980, a year in which more open sectors did slightly better than non-open sectors.

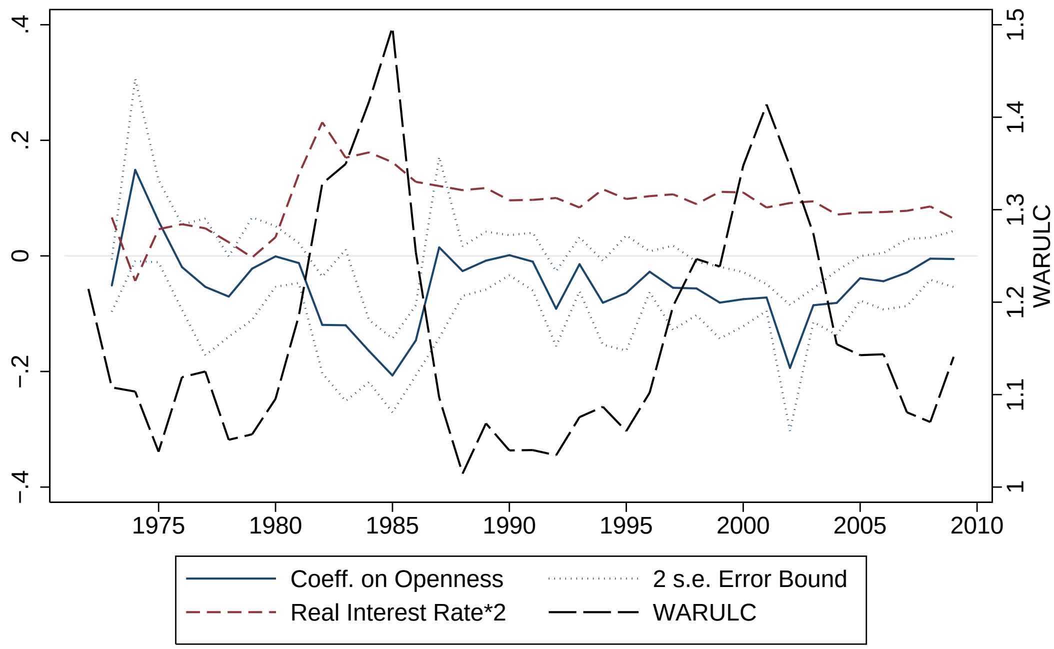


Figure 6: Correlation between Openness and Employment Growth by Year

Notes: Real interest rate data are computed as the 30-year conventional mortgage rate less the Core CPI, from FRED and the BLS (via FRED), WARULC is a measure of the RER from Campbell (2016), and the coefficients came from annual regressions of log changes in employment on changes in demand (using an IV), productivity, the China Post-PNTR*NTR Gap and MFA Exposure (explained in the text), with standard errors conservatively clustered at the 2-digit SIC level.

$$\beta_2 \Delta ln(D_{ht}) + \beta_3 \Delta ln(TFP_{ht}) + \sum_{i=4}^{n} \beta_i C_{i,t} + \alpha_h + \nu_t + \epsilon_{ht},\ \forall h = 1, ..., 359,\ \ t = 1973, ..., 2009,$$

where L_{ht} is employment in sector h at time t, RER is a measure of the real exchange rate, such as WARULC, $D_{h,t}$ is real sectoral domestic demand (defined as shipments plus imports minus exports), $TFP_{h,t}$ is a measure of TFP (I use 4 and 5-factor measures of productivity in addition to value-added and shipments divided by production worker or total employment), and the Cs are various other controls. Note that this setup is similar to Klein et al. (2003) and Bernard et al. (2006).

The function $\varphi(L)$ is a lag polynomial: $\varphi(L) = 1 - \sum_{i=1}^{p} \varphi_i L^i$, which allows for a flexible functional form for the real exchange rate so that we can test between various alternatives. Historically, researchers have controlled for the log change in the RER (equivalent to setting $\varphi_1 = -1$, and $\varphi_i = 0$, $\forall i > 1$). However, the puzzle has been that appreciations tend to harm employment, but that depreciations do not tend to help. I test this as well, interacting log changes in WARULC with openness and a dummy variable for appreciations, and a second control for log changes interacted with openness and a dummy for depreciations. An alternative view is that what matters is the level of

RER (equivalent to setting $\varphi_i = 0$, $\forall i$), so that a depreciation back to parity should not, in fact, be expected to cause an increase in employment, although a depreciation which leaves a currency undervalued would. Asymmetry, and the level version would imply that a temporary shock has persistent effects.

$Avg.Openness_{h,t-3,t-6}$ is an average of openness (defined as in equation 2.3) at 3, 4, 5, and 6 year lags:

$$Avg.Openness_{h,t-3,t-6} \equiv (1/4) \sum_{k=3}^{6} Openness_{t-k}. \tag{2.5}$$

This is done precisely to eliminate any potential feedback from the exchange rate to openness. This ensures that the time series changes in the interaction term will be driven primarily by movements in the exchange rate. The rationale for using a (slowly) evolving measure of openness instead of a fixed measure is that, given the long panel covering four decades, of course the world changed and trade increased substantially. Any sector's exposure to RER movements should depend on its current exposure to trade rather than whatever its trade exposure happened to be at the end of the Bretton Woods period. In addition, while openness could theoretically be endogenous, in practice more open manufacturing sectors do not lose jobs when WARULC is close to unity (see Figure 6). Thus it is not surprising that the results are robust to using either shorter or longer lags of openness. Lastly, the results are also robust to using initial period openness for the entire sample (see Online Appendix Table 12, in addition to Figure 3 and Figure 4).

Each regression also includes sectoral fixed effects α_h, year fixed effects ν_t, and two-way clustered errors (Cameron et al. (2011)), by both industry and by year. In addition, all sectors are weighted by initial period value-added.

2.3 Panel Regression Results

Table 1, column (1) shows that appreciations in relative unit labor costs are associated with a decline in employment for more open sectors (at 10%), but that depreciations have no significant impact. Column (2) uses the log of the level of WARULC instead as a control, and this time the interaction is significant at 1% (indeed, even at .5%), and has a slightly higher R-squared than column (1) despite one fewer control (.283 vs. .280). Column (3) includes controls for productivity, demand (using the IV), capital-per-worker and capital-per-worker interacted with the real interest rate, defined as the interest rate on 30-year mortgages less the Core CPI, and lagged log changes in wages and the price of shipments. Once again, appreciations are associated with employment declines for more open sectors, but depreciations are not significantly correlated with job gains. In column (4), I also include the log of the level of WARULC interacted with openness, and find that the RER appreciation and depreciation variables lose significance, while the level of WARULC continues to have a significant impact. Thus, I use the level of WARULC for the remainder of the paper. Since the level of WARULC impacts the log change in employment, this specification by itself implies persistence.

The coefficient of -.37 in column (4) suggests that in 2001, when US ULCs were 38% (or 1.38, for a log value of .32) above a weighted average of ULCs of US trading partners, an industry in the 90th percentile of lagged average openness (openness of .58) would have lost an additional 6% of employment from 2001 to 2002 (=exp(-.37*0.32*.58)-1), as compared with a completely closed industry, and 4% more than an industry with median openness (which was .16 in 2001). Over the entire 1997-2005 period, this industry would have lost a cumulative 30% of employment relative to a closed industry, and 19% more than an industry with average openness.

Column (5) adds additional controls, including controls for sectoral input prices (materials, energy, and investment) and sectoral input prices interacted with sectoral input shares lagged one period. I also add in the two China-related controls from Pierce and Schott (2016), the Post-PNTR*NTR gap variable, and a second control for MFA exposure (both described previously), and find that both had significant adverse impacts on employment (the NTR gaps are all negative). I also control for the share of intermediate inputs over shipments, and an interaction of this term with the level of the log of WARULC. Neither are significant in column (5). If we ran a quantile regression instead (which we do in the robustness), we would actually find significance, but with a negative sign. This could be seen as a caveat to the main results, as one might expect that as the dollar appreciates, sectors with substantial imported inputs would not be hurt as badly, as the cost of these inputs would become cheaper. On the other hand, it could be that sectors with more imported intermediates are also sectors in which offshoring is more feasible, and thus may be more likely to take place when domestic production costs rise. In this case we might expect the negative coefficient we only see with a quantile regression. Also, it is worth repeating that the sectoral imported input data are simply estimates made using a proportionality assumption which assumes that a sector's imports of each input, relative to its total demand of that input, are the same as the economy-wide imports relative to total demand. Thus, our lack of a clear result on the impact of intermediate inputs could simply be an artifact of the data.

Table 1: Exchange Rates, Openness, and US Manufacturing

	(1)	(2)	(3)	(4)	(5)	(6)
	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln5yr.\Delta$ L
L.3-6yr.Openness	-0.061***	-0.023	-0.061***	-0.014	-0.0042	-0.28**
	(0.022)	(0.020)	(0.022)	(0.020)	(0.022)	(0.13)
L.3-6yr.Openness*Δ ln(WARULC)*Pos.	-0.62*		-0.77**	-0.11		
	(0.33)		(0.37)	(0.34)		
L.3-6yr.Openness*Δ ln(WARULC)*Neg.	0.11		0.24	0.13		
	(0.31)		(0.33)	(0.27)		
L.3-6yr.Openness*ln(WARULC)		-0.31***		-0.37***	-0.29***	-0.41***
		(0.081)		(0.074)	(0.084)	(0.16)
Δ ln(Demand, IV))			0.44***	0.45***	0.37***	
			(0.092)	(0.090)	(0.084)	
L.(K/L)			0.078**	0.078**	0.048*	
			(0.031)	(0.031)	(0.029)	
L.(K/L)*Real Interest Rate			-1.06*	-1.12**	-1.44**	
			(0.57)	(0.56)	(0.62)	
ln Δ VA-per-Prod. Worker			-0.066***	-0.066***		
			(0.022)	(0.022)		
Δ ln(TFP, 5-factor)					0.30***	
					(0.044)	
Post-PNTR x NTR *Gap_i*					0.050***	
					(0.017)	
MFA Exposure					-0.059***	
					(0.016)	
L.avg.MPInputs.*L.ln(WARULC)					-0.014	
					(0.012)	
L.3-6yr.Openness*Real Interest Rate					-0.073	
					(0.063)	
L.Δ ln(PM*M/S)					-0.18	
					(0.12)	
L.Δ ln(PI*I/S)					0.54	
					(0.71)	
L.6-9yr.Openness*ln(L.2-5yr.WARULC)						-1.33***
						(0.24)
Δ(5*yr*) ln(VA-per-Production Worker)						-0.034
						(0.034)
Δ(5*yr*) ln(Demand, IV)						0.52***
						(0.063)
Observations	12469	12469	12469	12469	11863	11395
r2	0.28	0.28	0.34	0.34	0.38	0.48

$*p < 0.1$, $** p < 0.05$, $*** p < 0.01$. Two-way clustered standard errors in parentheses, clustered by year and by 4-digit SIC industry. $*p < 0.1$, $** p < 0.05$, $*** p < 0.01$. All regressions are weighted by initial sectoral value-added, and include 359 SIC industry and year fixed effects over the period 1975-2009. The dependent variable is the log change in sectoral manufacturing employment in the first five columns, and the 5 year log change in the last column. Sectoral changes in the cost of investment, energy, and materials are omitted for space. L.3-6yr.Openness equals average openness lagged 3, 4, 5, and 6 years, and is interacted with the logged lag of WARULC, a measure of the RER. The variable "3-6yr.Avg.MPInp/Ship." is the moving average of imported inputs divided by shipments lagged 3, 4, 5, and 6 years.

Lastly, to control for the possibility that more open sectors also may be more sensitive to movements in real interest rates, I include an interaction between openness and the real interest rate, defined as the yield on 30-year mortgages minus the Core CPI. I find that employment in more open sectors is not generally more sensitive to movements in interest rates.

Column (6) runs the regression in five year lags, and includes two separate RER controls. One is the normal interaction between lagged WARULC and the three to six year weighted average of openness, and the second is an interaction between the average of ln(WARULC) lagged two to five years and the average of openness lagged six to nine years. The idea is to directly test the idea that employment today is a function of lagged relative prices. And, indeed, we see that the coefficient on lagged WARULC is only a bit more than half of the coefficient on the average of WARULC the previous four years. Historical prices matter.

2.4 Accounting for Employment Changes

The results so far indicate that RER movements seem to have a statistically significant and large impact on the sectors most exposed, but if the sectors that trade the most are small, then the overall impact on employment might not be very large. To estimate the number of jobs lost due to trade and RER movements over the 1995-2008 period, I used the panel regression results from Column 5 of Table 1 from regression equation 2.4. The approach is to multiply the coefficient on the interaction term, by the interaction term itself and the lagged level of employment (L), and then to sum across all 395 industries with data in this period.

$$Total\ Jobs\ Lost_t = \sum_{h}^{395} \beta_1 * Openness_{ht} * ln(WARULC)_t * L_{h,t-1} \tag{2.6}$$

Certainly, this method relies on a number of assumptions. First, I assume that sectors with little trade exposure are not adversely hurt during years when the RER is appreciated – an assumption which appears to be true in the data. Secondly, this method will only pick up the direct effects of the RER shocks, and not indirect effects, such as via local labor market effects or input-output linkages. Third, the Federal Reserve would likely respond to job losses in manufacturing by keeping interest rates lower than it otherwise would have, thus raising overall manufacturing employment, and there also could be other general equilibrium effects as workers move from tradable to non-tradable sectors. I would also stress that any estimates coming from regression results are likely to be approximate, and suggestive rather than conclusive. In any case, the results suggest that the trade shock was quantitatively large, and directly responsible for nearly 2.2 million jobs lost from 1995 to 2005, with about 1.5 million jobs stemming directly from the appreciation of US relative prices over this period, and the balance mostly due to China's WTO accession (727,000). By 2008, the total number of jobs lost due to all trade shocks rises to close to 3 million, but this increase is mostly due to China's WTO accession and the MFA agreement's impact on textile employment.[19] Another caveat is that the ASM data used in the regressions implies a total manufacturing job loss of 4.1 million vs. just 3 million for the BEA's numbers. Nevertheless, this complete estimate of the toll from trade is more than five times larger than the direct estimate of 560,000 provided by Acemoglu *et al.* (2015). Yet, note that this figure is still substantially lower than the 3.9 million jobs lost implied from using a straightforward, back-of-the-envelope accounting approach (Table 7), which suggests that 3 million jobs lost directly due to trade is plausible.[20]

Panel (a) of Figure 7 plots a "counterfactual", where I add back the jobs lost due to the dollar appreciation, and then also add back the jobs lost due to China's accession to the WTO and the MFA agreement. However, what is clear is that this counterfactual exercise still implies a substantial fall in manufacturing employment after 2000. What accounts for this decline?

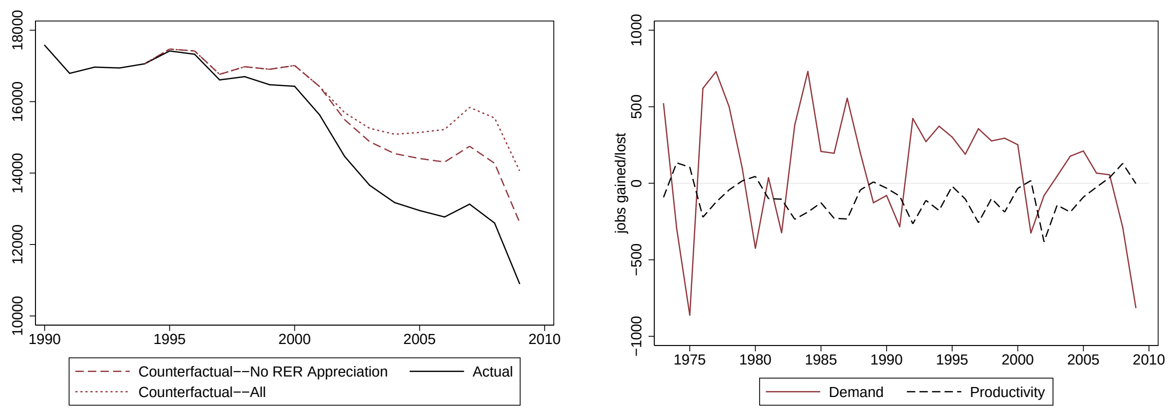
To understand what may be driving this, Figure 7(b) details the impact of changes in demand and productivity on changes in manufacturing employment (using the regression coefficients from Column 5 of Table 1 from regression equation 2.4, only we use actual demand rather than an IV). We then compute the change in employment due to changes in demand as:

$$TotalJobsGained_t^{Demand} = \sum_h \beta_2 \Delta ln(D_{ht}) * L_{h,t-1}. \tag{2.7}$$

Where D is actual domestic demand, equal to shipments plus imports minus exports. We make the same calculation for productivity, multiplying the coefficient on log changes in productivity, by the log change in productivity itself, and then by the lagged level of employment. While the jobs lost due to productivity gains after 2000 look unimpres-

19. If one uses actual demand rather than the demand IV, one gets an estimate of 2.1 million jobs lost from the RER appreciation. If one uses the annual cross sectional estimates such as those using the regressions displayed in Figure 6, and sums up the excess jobs lost in more open and China-competing sectors, one gets total estimates of job losses through 2008 of about 3.2 million.

20. This table "accounts" for manufacturing jobs lost due to trade by dividing the increase in the manufacturing trade deficit after 1995 by observed labor productivity as a crude estimate of jobs lost due to increases in the deficit.



(a) Manufacturing Employment Counterfactuals (b) Impact of Demand and Productivity

Figure 7: Accounting for Labor Lost

Notes: In Panel (a), the "Counterfactual–All" is computed from all three trade-related coefficients in the panel regression in Column (5) of Table 1.

sive, demand growth stands out as being particularly sluggish in this period. While this may have been the result of an exogenous sectoral shift in consumption patterns toward services, another possibility is that the decline in demand was itself caused by trade via input-output linkages. For example, every dollar of output of apparel manufacturing requires 30 cents of output from textile mills. Overall, every dollar of aggregate manufacturing output generally requires about 60 cents worth of additional output from other manufacturing industries (I get a similar estimate using detailed IO data). This would suggest that the direct and indirect impact of trade might be as high as 5 million manufacturing jobs, which admittedly sounds implausibly large. Acemoglu *et al.* (2015) estimate the total input-output linkages from all sectors, including services, and get a full multiplier close to four (which includes local labor market effects, which they find to be close to zero). If correct, this would imply a stunning toll of 12 million jobs, easily large enough to lend credibility to the Bernanke hypothesis that trade and the savings glut are the fundamental cause of the low nominal interest rates, the US's slide into a liquidity trap, and the apparent "secular stagnation" experienced in the US since 2000.[21] Of course, these are micro estimates, and do not factor in general equilibrium effects, the jobs gained from the Fed's low interest rates in the mid-2000s, which helped feed the housing bubble, which no doubt increased employment. Yet, neither do they count the employment impact of the collapse of the housing bubble or the slide into a liquidity

21. Bernanke (2005) first raised this idea in a speech while Fed Chair, and followed this up with a series of blog posts in 2015, including here: http://www.brookings.edu/blogs/ben-bernanke/posts/2015/04/01-why-interest-rates-low-global-savings-glut.

trap in 2008. Despite the emphasis that these are rough estimates, they suggest three important conclusions: (1) the RER shock, and trade shocks in general, appear to have been large enough to have had an impact on the macroeconomy, (2) productivity growth does not appear to have been a more significant cause of job loss than it had been in previous decades when manufacturing employment was steady, and (3) slower demand growth also appears to be a significant factor in the decline of the level of manufacturing employment, although the causes of this decline are beyond the scope of this paper.

3 Robustness

3.1 Main Robustness Exercises

In Table 2, I include 30 different robustness checks (each column within a panel is a separate regression). First, in Panel A, I show that the results are robust to various combinations of year and industry fixed effects, and to excluding the full controls included in Table 1. In column (6), this includes a control for 2-digit SIC*year interactive fixed effects (that is 740 FEs), in addition to 4-digit SIC FEs. In Panel B, I show the results are robust to using quantile regressions, which are less sensitive to outliers than OLS. In Panel C, I show that the key results are insensitive to different choices of weights: initial value-added, no weights, initial employment or shipments, average value-added, or value-added lagged one period. In Panel D, I add and subtract industries which one might want to exclude for various reasons. In the baseline regressions in Table 1, I excluded unbalanced sectors and publishing, as this sector was eventually re-classified out of manufacturing. In the second and third columns of Panel D, I add these sectors back in, and find that the results are little changed. In column (4), I subtract defense-related sectors (as government spending in these sectors boomed in the 1980s and 2000s), and in column (5), I deduct computer-related sectors (given the questions about the official productivity numbers in these sectors), and then add all the sectors back in column (6). The results appear to be robust.

In Panel E, I do an additional functional form test for WARULC. I create 5 separate indicator bins for the level of WARULC, for every .1 increase between 1 and 1.5. In the preferred specification in Column A, I find that, for example, when the RER is less than 1.1, there is no correlation between openness and employment changes. Yet, when WARULC is between 1.1 and 1.2, the coefficient is -.048, and borderline significant. This coefficient rises all the way to -.098 when WARULC is between 1.2 and 1.3. While the absolute value of the coefficient increases monotonically, it doesn't necessarily increase

Table 2: Robustness Exercises

	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L
A. Altering FEs, Controls						
L.3-6yr.Openness*ln(WARULC)	-0.30***	-0.33***	-0.40***	-0.33***	-0.58***	-0.17**
	(0.085)	(0.094)	(0.095)	(0.072)	(0.11)	(0.084)
FEs	SIC, Year	Year	SIC	Year, SIC	None	SIC2D*Year
Full Controls	Yes	Yes	Yes	No	No	Yes
B. Quantile Regressions						
L.3-6yr.Openness*ln(WARULC)	-0.25***	-0.32***	-0.31**	-0.29***	-0.58***	-0.15***
	(0.090)	(0.073)	(0.12)	(0.087)	(0.13)	(0.040)
FEs	SIC, Year	Year	SIC	Year, SIC	None	SIC2D*Year
Full Controls	Yes	Yes	Yes	No	No	Yes
C. Altering Weights						
L.3-6yr.Openness*ln(WARULC)	-0.30***	-0.31***	-0.31***	-0.32***	-0.27***	-0.37***
	(0.085)	(0.10)	(0.094)	(0.10)	(0.083)	(0.13)
Weights	VA, 1972	None	ln(VA,1972)	Emp., 1972	Ship., 1972	L.VA
D. Adding and Subtracting Sectors						
L.3-6yr.Openness*ln(WARULC)	-0.30***	-0.30***	-0.30***	-0.30***	-0.27***	-0.30***
	(0.085)	(0.085)	(0.084)	(0.087)	(0.079)	(0.084)
Unbalanced Sectors	No	Yes	No	No	No	Yes
Defense Related Sectors	Yes	Yes	Yes	No	No	Yes
Publishing	No	No	Yes	No	No	Yes
Computers	Yes	Yes	Yes	Yes	No	Yes
Number of Sectors	359	437	363	352	347	448
E. Alternative Functional Form for RER						
L.3-6yr.Open.*I.{WARULC<1.1}	-0.020	-0.016	-0.031	-0.028*	-0.040*	-0.028*
	(0.020)	(0.011)	(0.031)	(0.015)	(0.022)	(0.017)
L.3-6yr.Open.*I.{1.1<WARULC<1.2}	-0.026*	-0.027**	-0.0019	-0.040***	-0.040	-0.029
	(0.016)	(0.011)	(0.026)	(0.016)	(0.025)	(0.018)
L.3-6yr.Open.*I.{1.2<WARULC<1.3}	-0.11***	-0.13***	-0.12***	-0.13***	-0.15***	-0.076***
	(0.026)	(0.015)	(0.033)	(0.022)	(0.031)	(0.027)
L.3-6yr.Open.*I.{1.3<WARULC<1.4}	-0.078**	-0.087***	-0.12***	-0.094***	-0.16***	-0.057***
	(0.034)	(0.019)	(0.038)	(0.031)	(0.025)	(0.018)
L.3-6yr.Open.*I.{1.4<WARULC}	-0.11***	-0.11***	-0.17***	-0.14***	-0.23***	-0.12***
	(0.031)	(0.034)	(0.034)	(0.033)	(0.038)	(0.030)
Reg Type	OLS	OLS	OLS	OLS	OLS	Quantile
FEs	SIC, Year	Year	SIC	Year, SIC	None	Year, SIC
Controls	Yes	Yes	Yes	No	No	Yes

Errors clustered by year and 4-digit SIC sectors. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. There are five sets of six regressions, with the same controls as in column (5) of Table I, the baseline regression, with other controls suppressed for space. Panel A varies the fixed effects (SIC industry effects, and year effects) and the inclusion of other controls. L.3-6yr. Openness is again defined as the average of openness lagged 3, 4, 5, and 6 years. Column (6) includes 2-digit SIC*year interactive fixed effects or 20*37= 740 FEs, in addition to SIC FEs. Panel B repeats Panel A using quantile regressions. Panel C varies the weighting scheme used in the paper, between using initial Value-Added (VA), vs. no weights, log initial value-added, initial employment or shipments, or VA lagged one period. Panel D adds and subtracts industries which are either unbalanced, or for which there are logical reasons why they should be excluded. In Panel E, I interact openness with dummy variables for WARULC in different bins.

proportionally. However, there are not many observations of WARULC greater than 1.4, and in some of the other specifications the decline in more open sectors becomes significantly steeper. It might also be the case that more jobs are lost in the first years of an appreciation episode than in the later years, but we do not really have enough appreciation episodes to test this. On the whole, the log-linear specification looks to be approximately correct.

3.2 Additional Robustness Exercises

There is not space to list all the myriad robustness exercises I have implemented, so I summarize briefly in this section, and will refer interested parties to the online Appendix.

The results are robust to using various measures of openness. For example, the results do not change significantly using a geometric rather than an arithmetic average of export share and import penetration as a measure of openness, when one uses a simple average of import penetration and the export share of shipments, or if one uses trade/shipments instead. Earlier versions of this paper used "relative openness" instead of openness, which yielded very similar results. One could also use openness lagged one period instead, or, in fact, simply use openness in 1972, the first year we have data for, and the results are still robust.

The results are also robust to using various measures of RERs. One could also use the Fed's RER index (and control for Chinese penetration separately), or various other Weighted Average Relative RERs such as WARP introduced by Thomas et al. (2008) or the Penn-Adjusted version introduced by Campbell (2016). One could also use a WARP index computed not using trade shares, but computed with GDP. This shows that endogeneity in the trade weights are not somehow driving the results. One can also use a sectoral version of WARULC, although sectoral RULC data is not available for US trading partners and thus the only thing sector-specific about it is the trade weights. It turns out that sectors that experienced larger than average depreciations also lost more employment and output. Lastly, one could proxy the US RER using changes in the defense share of GDP, defense spending over shipments, or changes in the US structural budget. In each case, these measures will also predict employment declines.

One could also separate import penetration and the export share of shipments, and interact these with import and export-weighted versions of WARULC (iWARULC and eWARULC). The coefficient on both happens to be roughly the same for the full period, although the interaction between eWARULC and the export share of shipments is not significant in the early 2000s. Changes in import penetration and export share are also generally highly correlated with changes in employment—a necessary condition for the lagged relative openness interaction with the real exchange rate to predict innovations in employment.

The results are also unchanged when including controls for tariffs or the cost of insurance and freight, for which I did not have complete coverage for all years and so omitted from the main regressions. US tariffs and freight costs did not exhibit sharp changes during this period, and perhaps as a result neither variable was significant in any specification or with alternative dependent variables. Tariffs faced by US industries abroad, tariffs faced by US industries exporting to China, and tariffs faced by US industries interacted with the share of shipments bound for China all do not predict changes in employment. Even as of 2008, on average industries only sent 1.4% of shipments to China, so it is not surprising to find no effect of Chinese tariff policy on employment or output.

I also tested whether the decline in the 2000s was more pronounced in unionized sectors, and whether RER movements have a bigger impact on unionized sectors, but found no relationship (as expected). Unionization has been steadily declining in the manufacturing sector over this period, and had already declined from 38.9% in 1973 to 16.3% in 1997. There is a positive raw correlation between unionization in the 1990s and job growth in the early 2000s, but this correlation does not survive the inclusion of controls and is unlikely to be causal.

3.3 Impact on Output, TFP, and Other Variables

Movements in relative prices impact manufacturing employment, but if they were to only affect manufacturing employment and not other variables such as output and productivity, this might suggest that the apparent impact on employment may be spurious, or perhaps even beneficial. In addition, if appreciations in the dollar also happened to be correlated with movements in other variables in more open sectors which should not theoretically be affected, such as the price of energy inputs, then this could imply that the estimation method used in this paper is prone to yielding spurious results.[22] In this section, I test the impact of relative price movements on several other variables, and provide several falsification tests.

First, for exchange rate movements to impact manufacturing employment, a necessary condition is that exchange rates affect trade. Figure 11 shows that when the dollar

22. Note that while energy prices are affected by RER movements, the energy prices faced by sectors which compete internationally should not be impacted relative to sectors who compete domestically.

fell from 1972 to 1979, the entire distribution of log changes in US exports disaggregated by both sector and destination country is centered around a higher percentage change than the distribution of changes in imports. When the dollar spiked in the mid-1980s, the distribution of log changes in imports then shifted far to the right of the distribution of exports, with the median log change in imports close to one vs. slightly greater than zero for exports, corresponding to a 72% increase in imports relative to exports. The same pattern holds up over the period of dollar weakness from 1986 to 1996, and dollar strength from 1996 to 2005.

In Table 3, I find a modest decline in production worker hourly wages in more open sectors when relative prices are elevated, although a caveat is that lagged openness itself has the opposite sign, making an interpretation of this result less than straightforward. Nevertheless, this result is new, as Ebenstein et al. (2014) did not find an effect of globalization on industry wages using the Current Population Survey (although, they did find an impact on the occupations most exposed). In a subsequent follow-up to this paper, Campbell and Lusher (2016) did not find an impact generally of RER shocks on wages using CPS data, although some sub-groups, such as those without college education, did experience a reduction. I separately found no significant impact on non-production worker wages, but that value-added, TFP, and production worker hours all declined. Note that while the theoretical impact on TFP may be ambiguous, one intuitive reason why you might have a negative sign here is that if sectors have substantial overhead costs, then a decline in sales will lead to a decline in measured productivity. There was no significant impact on the log change in prices or on inventory. Since theory does not necessarily provide a strong rationale why inventory should be affected by movements in real exchange rates, this is arguably a falsification exercise. Predicting the changes in the sectoral deflators for investment, materials, and energy are perhaps even stronger candidates for falsification exercises, since any finding that real exchange rate movements lead to disproportionate changes in the costs of more open sectors would likely be spurious, raising doubts as to whether the estimation method in this paper has a tendency to find false positives. However, I find that the interaction term on WARULC and relative openness does not significantly predict the growth of any of these deflators, even for various leads and lags.[23] In addition, multi-year leads and lags of the RER interacted with openness are not significant predictors of differential changes in any of the dependent variables.

In addition, I find an impact of exchange rate movements on job creation, job de-

23. These results are also in the Additional Appendix, Table 11. I thank Scott Carrell for suggesting this as a robustness check.

Table 3: Impact of RER Movements on Output and Other Variables

	(1) $ln\Delta$ PW Wages	(2) $ln\Delta$ VA	(3) $ln\Delta$ TFP	(4) $ln\Delta$ Hours	(5) $ln\Delta$ Inventory	(6) $ln\Delta$ Prices
L.3-6yr.Open.*ln(WARULC)	-0.092**	-0.28***	-0.13***	-0.40***	-0.11	-0.0039
	(0.037)	(0.086)	(0.036)	(0.057)	(0.17)	(0.051)
Observations	12469	12469	12469	12469	12469	14039

Two-way clustered standard errors in parentheses, clustered by year and industry. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regressions weighted by initial sectoral value-added, and include 4-digit SIC industry and year fixed effects over the period 1973-2009. The dependent variables are 1) log changes in production worker hourly wages, 2) investment, 3) value-added, 4) 5-Factor TFP (from NBER-CES), 5) production worker hours, and 6) prices of shipments. Other significant controls from Table 1 are suppressed for space.

struction, and shipments.[24] When unit labor costs in the US rise relative to trading partners, there is suppressed job creation, but the impact on job destruction is much larger. Since job creation varies much less than job destruction overall, this asymmetry is an indication of persistence.

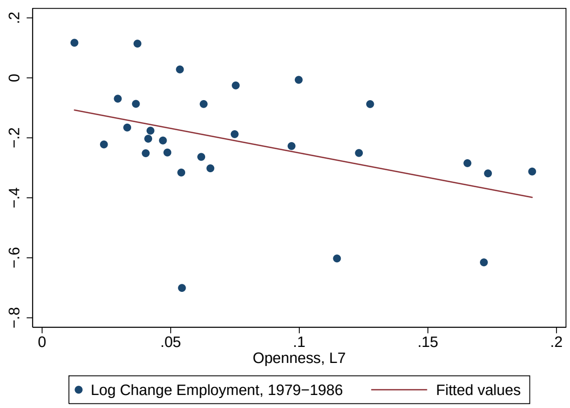
4 International Evidence

4.1 Difference-in-Difference-in-Difference

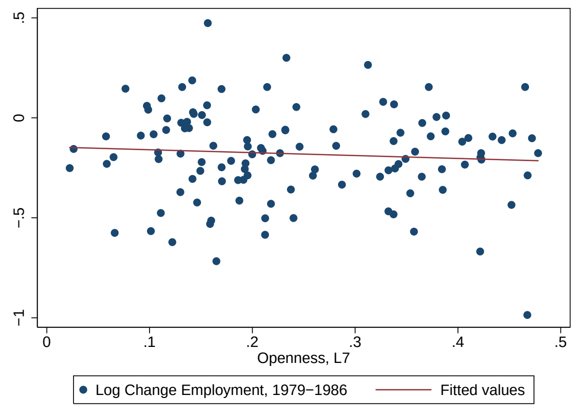
An additional empirical approach is to use international data to create a third dimension to the difference-in-difference estimation, and ask whether more open manufacturing sectors in the US tend to lose more jobs when the currency appreciates relative to the same sectors in other large manufacturing countries. Figure 8 displays the idea graphically. From 1979 to 1986 and from 1995 to 2002, the 3-digit ISIC sectors which were more open tended to experience larger declines in employment in the US, but there was no such relation in other major economies. (In the Additional Appendix, Figure 17, I also show that there is no correlation between openness and employment for years when the dollar was weak.) This indicates that the job losses in the US in the early 2000s were not simply due to a general flood of Chinese exports, which also went to other major economies, but rather must be something specific to the US in that period. From the perspective of economic geography, Canada should have been just as exposed to Chinese import competition as the US. But from the mid-1990s to 2003, a period when the Canadian dollar was weak relative to its American counterpart, Canadian manufacturing employment actually *increased* even as American manufacturing employment collapsed

24. The regression results for these variables are also reported in Additional Appendix Table 14. The job creation and destruction variables (provided by Davis et al. (1998)) end in 1998, unfortunately.

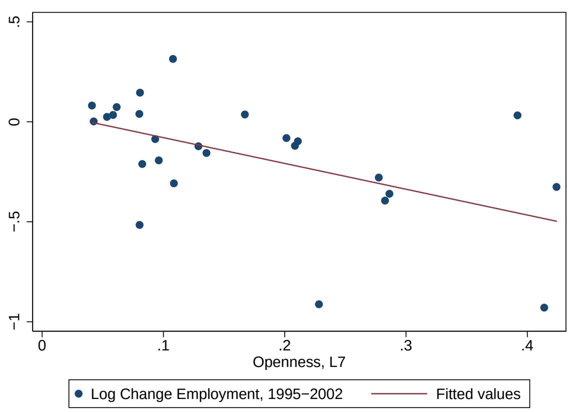
(Panel (a) of Figure 9). As Canadian unit labor costs have increased sharply relative to trading partners (including the US) since 2003, Canadian manufacturing has lost more than twice as many manufacturing jobs as the US as a share of 2003 employment, with the losses concentrated in the more open Canadian manufacturing sectors (Figure 9, Panel (b)).



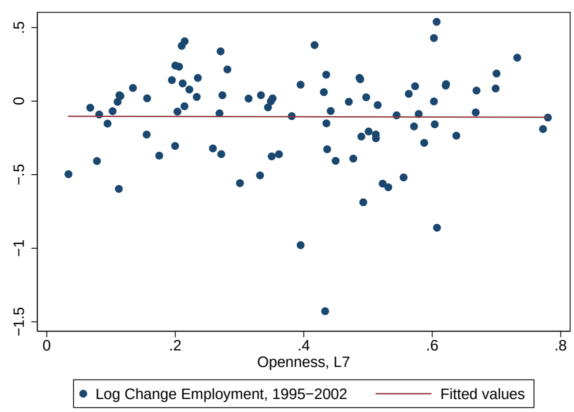
(a) US, 1979-86



(b) Other Major Economies, 1979-86



(c) US, 1995-2002



(d) Other Major Economies, 1995-2002

Figure 8: Employment Growth vs. Lagged Openness

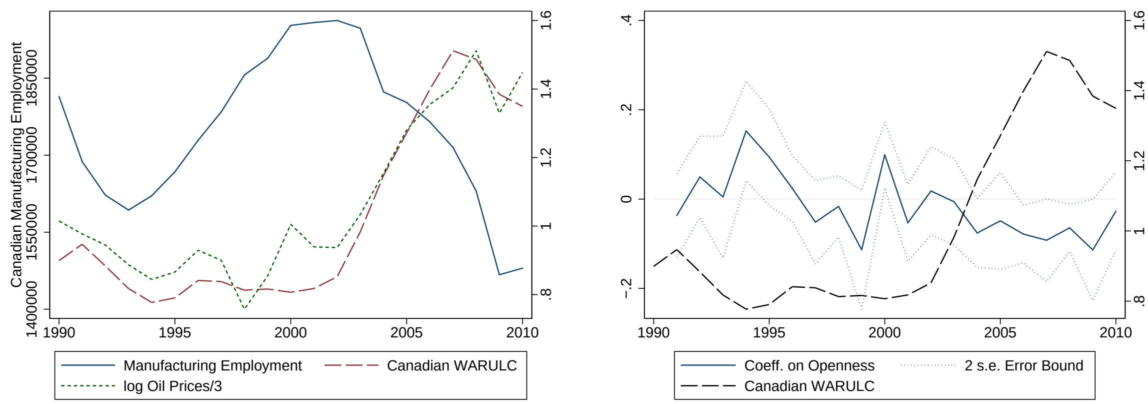
Source: UNIDOs (3-digit ISIC manufacturing sectors). Other major economies include Canada, France, Germany, Italy, and the UK.

Thus, we now estimate:

$$ln\Delta L_{US,h,t} - ln\Delta L_{G5,h,t} = \alpha_t + \beta_1 ln(WARULC) * Openness_{h,t-1} + \tag{4.1}$$

$$\beta_2(ln\Delta\hat{D}_{US,h,t} - ln\Delta\hat{D}_{G5,h,t}) + \beta_3(ln\Delta(S/L)_{US,h,t} - (ln\Delta(S/L)_{G5,h,t}) + \alpha_h + \nu_t + \epsilon_{ht},$$

$$\forall h = 1, ..., 29, \;\; t = 1978, ...1995, 1998, ..., 2003,$$



(a) Total Employment vs. WARULC

(b) Impact of Openness on Employment Growth vs. WARULC

Figure 9: Canadian Manufacturing Employment, WARULC

Sources: UNIDOs, Comtrade, Campbell (2016). Notes: Panel (b) shows the results of an annual regression of demand growth, productivity growth, and openness by sector on employment growth. The negative correlation between openness and employment growth begins once WARULC appreciates.

$$G5 = (Canada, France, Germany, Italy, UK).$$

The dependent variable is now the log change in sectoral US employment minus the average log change in employment in Canada, France, Germany, Italy and the UK. The manufacturing data are 3-digit ISIC Rev. 2 data from UNIDOs, which does not report data for the US for the year 1996. I include only a single lag instead of the four year moving average lagged three years because there is missing data, and since I have found that using a one year lag instead makes little qualitative difference with the ASM data.

The first column in Table 4 runs the difference-in-difference regression using US data as in previous tables (*e.g.*, regression 2.4) in a quantile regression with errors clustered at the ISIC 3 industry level and includes industry and year dummies. Here, we can add in a control for foreign demand as well since we have this data. The controls for both US demand and foreign demand are computed using the IV strategy as before based on country GDP and sector-specific elasticities. Foreign demand is then computed as a US export-weighted average of demand in the other five economies. The key interaction term between openness and WARULC is large and highly significant, indicating that more open sectors tend to lose employment when unit labor costs are high relative to less open sectors compared with when WARULC is close to unity.[25] The magnitude

25. I subtract one in the US case rather than taking the log (which is approximately the same), because each country may need a slightly different normalizations, and Canada appears to lose employment in manufacturing as its WARULC goes above .85. Since the WARULC measures here exclude factors such

suggests that as a sector goes from no openness to 50% openness, employment will decline by an additional 13.5% in a year when WARULC is 1.5 (=exp(-.72*.5*ln(1.5))-1). In the second column, the dependent variable is now the log change in sectoral output, and the key interaction term is once again large and significant.[26] In column 3, the coefficient of -.76 tells us that for a sector with an additional 50% openness, it will lose (=exp(-1*.5*ln(1.5))-1) = 18% of its total employment when WARULC is 1.5 relative to the employment change of the same sector in other major economies. These numbers are larger than those implied by running a directly comparable regression using the ASM data (a quantile regression on with otherwise the same setup as in Column 6, Panel B of Table 2), as the coefficient of -.76 can be compared with a coefficient of -.37. A caveat is that there are only 31 sectors with the ISIC data, and thus is more likely to provide a noisy estimate.

In the third column of Table 4, I estimate the relative difference-in-difference regression in equation (4.1), and find that the magnitude of the results increases compared to column (1), although the estimate also becomes less precise. Given that the previous literature has found heterogeneous effects of exchange rate movements by country dependent on labor market institutions (see, for example, E. Berman et al. (1998), Nucci and Pozzolo (2010), and Belke et al. (2013)), it is important to show in column (4) that the relative difference-in-difference results hold for output as well as employment, although the results are a bit weaker here when the relative demand IV is used. In column (5), I estimate the difference-in-difference estimation as in column (1) for Canada instead of the US, and also find that when Canadian Weighted Average Relative Unit Labor Costs are high, the more open Canadian manufacturing sectors lose employment relative to less open sectors. This is also true for Canadian output. Note that the coefficient for Canada is much smaller than for the US. This could be seen as a caveat to the main results, but keep in mind that the typical Canadian sector is about five times more open than the average US sector, which means that while the elasticity is lower, the impact on employment could actually be roughly the same. A second factor is that other RER indices for Canada, such as WARP and BSWARP, do not show as sharp of an appreciation in the 2000s as WARULC, so estimating with these alternative (yet also appropriate) RER indices would yield a higher elasticity for Canada.

as tariffs, fiscal policy, and various other factors, the break-even point for competitiveness need not be exactly one.

26. In this paper, I do not focus on Europe, in part because it has been done, and in part because it would be deserving of a separate paper. Chen et al. (2013) finds that Euro zone countries with relative price appreciations after the formation of the Euro also experienced worsening trade balances. Ekholm et al. (2012) adopt a similar methodology and finds that oil price appreciations adversely affected the Norwegian manufacturing sector.

Table 4: Impact of RER Movements on Output and Other Variables

	(1) $\Delta ln(L)$	(2) $\Delta ln(Y)$	(3) $\Delta ln(L, Rel.)$	(4) $\Delta ln(Y, Rel.)$	(5) $\Delta ln(L) Can.$	(6) $\Delta ln(L) Can.$
L.Openness	0.043	0.066	0.060	0.21***	0.048	0.030
	(0.062)	(0.073)	(0.078)	(0.051)	(0.038)	(0.033)
L.Openness*ln(WARULC)	-0.72***	-1.16***	-1.00***	-0.69***		
	(0.21)	(0.23)	(0.28)	(0.24)		
Δ ln(Y/L)	-0.048***				-0.83***	-0.82***
	(0.013)				(0.040)	(0.043)
Δ ln(Demand, IV)	0.45***	0.68***				
	(0.11)	(0.16)				
Δ ln(Foreign Demand, IV)	0.20	0.22				
	(0.12)	(0.18)				
Δ ln(Y/L) (Relative)			-0.088			
			(0.067)			
Δ ln(Demand) (IV, Relative)			0.50***	0.72***		
			(0.14)	(0.13)		
L.Openness*ln(WARULC Canada)					-0.15***	
					(0.042)	
Δ ln(Demand)					0.82***	0.82***
					(0.060)	(0.068)
L.Openness*Oil Prices (norm.)						-0.050***
						(0.017)
Observations	606	606	606	606	1720	1720

Standard errors clustered by sector in parentheses. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Each column is a quantile regression including year and 3-digit ISIC industry fixed effects. Data for the first four regressions span from 1977 to 1995 and 1998-2003 for 31 sectors, and the last two regressions span 1991-2010 for 104 sectors. The dependent variables in the first two columns are the log change in sectoral manufacturing employment and output. In the 3rd and 4th columns, the dependent variables are the log change in manufacturing employment (and output) relative to the average log change in employment (and output) in the same sectors in other major economies. Data in the last two columns are for Canada. In the 5th column, I normalized WARULC by adding .15. In the last column, oil prices are used as a proxy for Canada's RER. To normalize oil prices, I took the log and of the price of a barrel of crude oil and subtracted three.

For Canada, it appears that the dividing line between faster vs. slower growth for more open sectors is when WARULC is around .85 instead of 1, so I have normalized the Canadian index by adding .15 instead of one for Canada (the results are little changed if one adds .1 instead). This could be due to a country-specific bias in the data collection, tariff policy, or any number of other factors. Finally, in the last column, I proxy movements in Canadian relative unit labor costs using the log of oil prices minus three,[27] and again find that when oil prices are high, the more open sectors in Canada tend to lose ground relative to less open sectors.

27. Any measure of the RER or proxy for it have to be transformed somehow so that they vary between zero and positive or negative numbers, otherwise the interaction with openness will be collinear with openness itself.

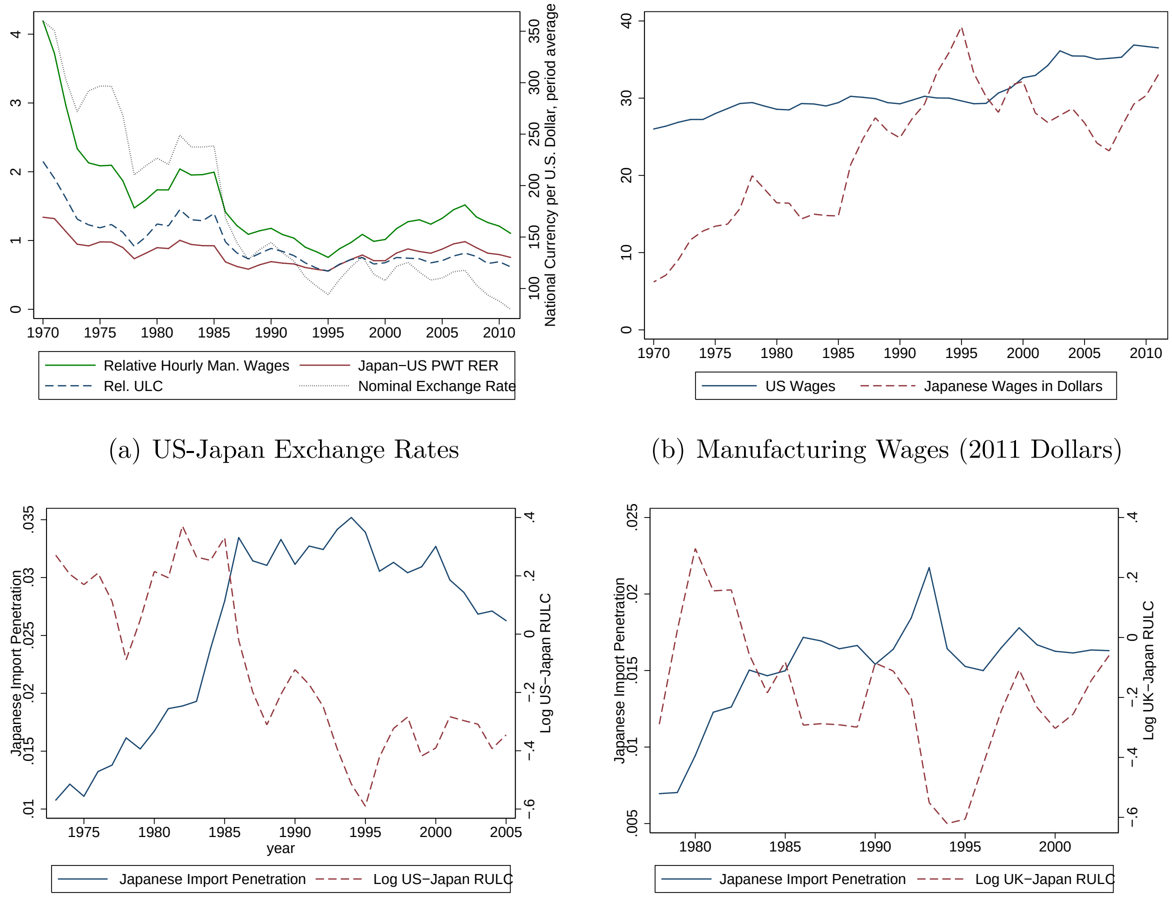
4.2 Japan

Just as China has become the center of focus for those wishing to explain the decline of US manufacturing today, similarly, in the 1980s many Americans blamed manufacturing job losses on Japan's rise. During this period it was widely thought that Japan's dominance owed to superior Japanese business practices such as *Kaizen* costing and *Kanban* scheduling, support from MITI, and innate features of Japanese culture. While these and other factors may have been important, it turns out that relative prices alone can largely explain Japan's ascent and then stagnation in the US market.

Japan is a particularly good case study since the yen was heavily managed and then appreciated substantially shortly after the full liberalization of Japanese capital markets. The yen was fixed after World War II until the early 1970s, when President Nixon, worried about what were very small trade deficits by recent standards, imposed a 10% tariff to force other countries, namely Japan and Germany, to revalue their currencies (Irwin (2013)). In the 1970s, the yen continued to be managed in a dirty float, with most controls on capital lifted in 1980. At that point the dollar began its appreciation for reasons unrelated to Japan. In 1984 Japan, under intense pressure from the US Treasury, added substantial additional liberalization measures in the Yen-Dollar Agreement Frankel (1990). As the dollar continued to soar in 1985, the Reagan Administration responded with the Plaza Accord, an agreement among major nations to reduce fiscal imbalances and intervene in the currency markets to weaken the dollar, and the 1985 Gramm-Rudman-Hollings Deficit Control Act.

Figure 10, panel (a) and (b) demonstrate that the combination of the end of capital controls, the move toward fiscal balance in the US in late 1985, and the Plaza Accord had a major impact on relative prices between the US and Japan. US manufacturing workers went from enjoying hourly wages twice that of their Japanese counterparts in 1985 to earning wages that were close to parity three years later. US unit labor costs relative to Japan fell 47% and the real exchange rate using PPP from the Penn World Tables, v8.1, implies an appreciation of Japanese relative prices of 37%. Thus the case of Japan yields a relatively clean quasi-natural experiment for the impact of currency undervaluation and large exchange rate adjustments.

The result of this real appreciation was that as wages in the Japanese manufacturing sector suddenly increased relative to their American counterparts, the meteoric Japanese export growth from 1946 to 1986 suddenly ground to a halt (Figure 10(c)). However, Japan kept the gains in market share it had made even though it did not make further inroads—another indication of persistence. Japan's gains through 1986 were also not



(a) US-Japan Exchange Rates

(b) Manufacturing Wages (2011 Dollars)

(c) US

(d) UK

Figure 10: RULCs and Japanese Import Penetration

Sources: PWTs, CP 2013, UNIDOs, Comtrade. Notes: RULCs = Relative Unit Labor Costs. Import penetration = imports/(imports + shipments - exports).

purely due to domestic factors in Japan, such as government encouragement to increase market share in export markets, since the same trends are not evident in other markets. In the UK case, Japanese exports grew very quickly in the early 1980s, when the yen was weak relative to the pound, but Japanese import penetration into the UK market did not grow at all from 1983 to 1985, when Japanese unit labor costs were higher than UK unit labor costs. Hence, on balance Krugman (1986) appears to have been correct in guessing that the yen's appreciation in that year meant that "the Japan problem was over."

The first column of Table 5 regresses the log change in Japanese import penetration (imports divided by domestic demand) in the US on the lagged log of bilateral relative unit labor costs for the manufacturing sector between the US and Japan, while controlling for changes in overall US import penetration. The coefficient indicates that when

ULCs were relatively higher in the US, Japanese sectors gained market share in the US, and when US ULCs were relatively lower, the growth in Japanese import penetration decreased (in fact it became stagnant). In column (2), I include a dummy variable for the period after the Plaza Accord – after the end of capital controls and the strong dollar – and find that after 1985, Japanese import penetration fell relative to the period when the Yen was weaker. In column (3), I use UK data, and find that when unit labor costs in the UK are high relative to Japan, Japanese industries increased their market share in the UK. In column (4), I rerun the regression in column (1), and control for Japanese changes in import penetration in the UK. In column (5), I stack data for each of the G6 countries, and find a similar elasticity as to the US initially.

Thus, the example of Japan would appear to provide another confirmation that relative prices matter and that persistence is a quantitatively important aspect of the economic landscape, using quasi-experimental evidence which is effectively out-of-sample.

Table 5: Japanese Exports and the Yen

	(1) US	(2) US	(3) UK	(4) US	(5) G6
ln Δ Import Pen.	0.82*** (0.18)	0.80*** (0.22)	0.74*** (0.16)	0.76*** (0.081)	0.87*** (0.050)
L.ln(RULC)	0.13*** (0.027)		0.25*** (0.050)	0.11*** (0.022)	0.13*** (0.017)
Post-Plaza Accord Dummy		-0.076*** (0.015)			
ln Δ Japan. MP Pen. in UK				0.18*** (0.026)	
Observations	606	606	669	606	3544

The dependent variable is the log change in sectoral Japanese import penetration. Errors clustered for 29 ISIC industries in parentheses. $*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
All regressions include 3-digit ISIC Rev.2 industry fixed effects over the period 1978-2003.
Columns (1), (2), and (4) use US data, column (3) uses UK data, and column (5) includes stacked observations from the US, the UK, Canada, Germany, Japan, France, and Italy.
The data come from Comtrade, UNIDOs, and Campbell (2016).

5 Conclusion

When nominal exchange rates move, the nominal rigidity of wages leads to large changes in Weighted Average Relative Unit Labor Costs (WARULC), a new measure of competitiveness for the manufacturing sector. I examine periods, such as the 1980s for the US and Japan, and the 2000s for the US and Canada, when identifiable exogenous factors were likely to have driven large movements in relative price levels. These exogenous shocks (from the perspective of manufacturing employment) which led to overvalued relative unit labor costs are correlated with periods of increased imports and decreased manufacturing exports, and to declines in employment, hours worked, TFP, and output concentrated in relatively more open manufacturing industries. The impact of a temporary shock to relative prices is persistent, indicating that current economic relationships are historically dependent, an insight of obvious importance to the field of development economics. The shock to trade in the early 2000s, and the measured elasticity of RER changes on more open manufacturing sectors was large enough for this shock to have played a significant role in the "surprisingly sudden" collapse of US manufacturing employment in this period. As the "Lesser Depression" continues, and as the Federal Reserve lowers its long-run growth forecasts while the debate over "secular stagnation" rages, understanding the fundamental cause of the slow growth performance in the 2000s is more important than ever. The thesis here is that one would do well to start by studying the recent history of relative prices, and by dusting off the 1980s literature on hysteresis.[28]

References

Alessandria, G., and H. Choi. 2007. "Do Sunk Costs of Exporting Matter for Net Export Dynamics?" *The Quarterly Journal of Economics:* 289–336.

Alessandria, G., and H. Choi. 2014. "Do falling iceberg costs explain recent US export growth?" *Journal of International Economics* 94 (2): 311–325.

Alessandria, G., and H. Choi. 2014. "Establishment Heterogeneity, Exporter Dynamics, and the Effects of Trade Liberalization." *Journal of International Economics* 94 (2): 207–223.

Autor, D., D. Dorn, and G. H. Hanson. 2013. "The China Syndrome: The Local Labor Market Effects of Import Competition in the US." *American Economic Review* 103 (6): 2121–68.

Autor, D., D. Dorn, G. H. Hanson, and J. Song. 2014. "Trade Adjustment: Worker-Level Evidence." *The Quarterly Journal of Economics* 129 (4): 1799–1860.

Baldwin. 1988. "Hysteresis in Import Prices: The Beachhead Effect." *American Economic Review* 78, no. 4 (): 773–85.

Baldwin. 1990. "Hysteresis in Trade." *Empirical Economics* 15 (2): 127–42.

28. Note that this is in line with the Bernanke (2005) thesis, which he has written more about recently on his blog, including here: http://www.brookings.edu/blogs/ben-bernanke/posts/2015/04/01-why-interest-rates-low-global-savings-glut. Dooley et al. (2009), (2007), (2004), and (2005) are also relevant.

Baldwin and Krugman. 1987. "The Persistence of the U.S. Trade Deficit." *Brookings Papers on Economic Activity* 18 (1): 1–56.

Baldwin and Krugman. 1989. "Persistent Trade Effects of Large Exchange Rate Shocks." *The Quarterly Journal of Economics* 104, no. 4 (): 635–54.

Bartlesman, E., and W. B. Gray. 1996. *The NBER Manufacturing Productivity Database.* Technical report.

Belke, A., M. Göcke, and M. Günther. 2013. "Exchange Rate Bands of Inaction and Play – Hysteresis in German Exports – Sectoral Evidence for Some OECD Destinations." *Metroeconomica* 64 (1): 152–179.

Belke, A., and D. Kronen. 2016. "Exchange Rate Bands of Inaction and Play-Hysteresis in Greek Exports to the Euro Area, the US and Turkey: Sectoral Evidence." *Empirica* 43 (2): 349–390.

Bergin, P. R., and C. Y. Lin. 2012. "The Dynamic Effects of Currency Union on Trade." *Journal of International Economics,* no. 11.

Berman, E., J. Bound, and S. Machin. 1998. "Implications of Skill-Biased Technological Change: International Evidence*." *The Quarterly journal of economics* 113 (4): 1245–1279.

Berman, N., P. Martin, and T. Mayer. 2012. "How do Different Exporters React to Exchange Rate Changes?" *The Quarterly Journal of Economics* 127 (1): 437–492.

Bernanke, B. S. 2005. *The Global Saving Glut and the US Current Account Deficit.* Technical report.

Bernard, A. B., and J. B. Jensen. 2004. "Why Some Firms Export." *Review of Economics and Statistics* 86 (2): 561–569.

Bernard, A. B., J. B. Jensen, and P. K. Schott. 2006. "Survival of the Best Fit: Exposure to Low-Wage Countries and the (Uneven) Growth of U.S. Manufacturing Plants." *Journal of International Economics* 68, no. 1 (): 219–237.

Blanchard, O. J., and L. H. Summers. 1986. *Hysteresis and the European Unemployment Problem.* Technical report.

Boehm, C. E., A. Flaaen, and N. Pandalai-Nayar. 2015. "Multinationals, Offshoring, and the Decline of US Manufacturing."

Brambilla, I., A. K. Khandelwal, and P. K. Schott. 2010. *China's Experience Under the Multi-fiber Arrangement (MFA) and the Agreement on Textiles and Clothing (ATC).* Technical report.

Brandt, L., J. Van Biesebroeck, L. Wang, and Y. Zhang. 2012. *WTO Accession and Performance of Chinese Manufacturing Firms.* Technical report.

Branson, W. H., and J. P. Love. 1986. *Dollar Appreciation and Manufacturing Employment and Output.* NBER Working Papers 1986. National Bureau of Economic Research, Inc.

Branson, W. H., and J. P. Love. 1987. *The Real Exchange Rate and Employment in U.S. Manufacturing: State and Regional Results.* NBER Working Papers 2435. National Bureau of Economic Research, Inc.

Branson, W. H., and J. P. Love. 1988. *The Real Exchange Rate, Employment, and Output in Manufacturing in the U.S. and Japan.* NBER Working Papers 2491. National Bureau of Economic Research, Inc.

Burstein, A., and M. I. Melitz. 2013. *Trade Liberalization and Firm Dynamics.* Technical report.

Cameron, A. C., J. B. Gelbach, and D. L. Miller. 2011. "Robust Inference with Multiway Clustering." *Journal of Business & Economic Statistics* 29 (2).

Campa, J. M. 2004. "Exchange Rates and Trade: How Important is Hysteresis in Trade?" *European Economic Review* 48 (3): 527–548.

Campa, J. M., and L. S. Goldberg. 2001. "Employment Versus Wage Adjustment and the US Dollar." *Review of Economics and Statistics* 83 (3): 477–489.

Campbell, D. L. 2010. *History, Culture, and Trade: A Dynamic Gravity Approach.* MPRA Paper 24014. University Library of Munich, Germany.

Campbell, D. L. 2013. "Estimating the Impact of Currency Unions on Trade: Solving the Glick and Rose Puzzle." *The World Economy.*

Campbell, D. L. 2016. "Measurement Matters: Productivity-Adjusted Weighted Average Relative Price Indices." *Journal of International Money and Finance* 61 (C): 45–81.

Campbell, D. L., and L. Lusher. 2016. "Trade Shocks, Taxes, and Inequality."

Chaney, T. 2008. "Distorted Gravity: The Intensive and Extensive Margins of International Trade." *American Economic Review* 98, no. 4 (): 1707–21.

Charles, K. K., E. Hurst, and M. J. Notowidigdo. 2013. *Manufacturing Decline, Housing Booms, and Non-Employment.* Working Paper, Working Paper Series 18949. National Bureau of Economic Research.

Chen, R., G. M. Milesi-Ferretti, and T. Tressel. 2013. "External Imbalances in the Eurozone." *Economic Policy* 28 (73): 101–142.

Chinn, M. D. 2004. "Incomes, Exchange Rates and the US Trade Deficit, Once Again." *International Finance* 7 (3): 451–469.

Dai, M., and J. Xu. 2015. "Firm-specific Exchange Rate Shocks and Employment Adjustment: Theory and Evidence."

Dauth, W., S. Findeisen, and J. Suedekum. 2014. "The Rise of the East and the Far East: German Labor Markets and Trade Integration." *Journal of the European Economic Association* 12 (6): 1643–1675.

Davis, S. J., J. C. Haltiwanger, and S. Schuh. 1998. "Job Creation and Destruction." *MIT Press Books* 1.

Dixit, A. 1989. "Entry and Exit Decisions Under Uncertainty." *Journal of Political Economy* 97, no. 3 (): 620–38.

Dixit, A. 1989. "Hysteresis, Import Penetration, and Exchange Rate Pass-Through." *The Quarterly Journal of Economics* 104, no. 2 (): 205–28.

Dixit, A. 1991. "Analytical Approximations in Models of Hysteresis." *Review of Economic Studies* 58, no. 1 (): 141–51.

Dixit, A. 1992. "Investment and Hysteresis." *Journal of Economic Perspectives* 6, no. 1 (): 107–32.

Dooley, M., D. Folkerts-Landau, and P. Garber. 2004. *The Revived Bretton Woods System: The Effects of Periphery Intervention and Reserve Management on Interest Rates & Exchange Rates in Center Countries.* NBER Working Papers 10332. National Bureau of Economic Research, Inc.

Dooley, M., D. Folkerts-Landau, and P. Garber. 2005. "An Essay on the Revived Bretton Woods System." *Proceedings, Federal Reserve Bank of San Francisco,* no. Feb.

Dooley, M., D. Folkerts-Landau, and P. Garber. 2007. *Direct Investment, Rising Real Wages and the Absorption of Excess Labor in the Periphery.* Technical report, NBER Chapters.

Dooley, M., D. Folkerts-Landau, and P. Garber. 2009. "Bretton Woods II Still Defines The International Monetary System." *Pacific Economic Review* 14, no. 3 (): 297–311.

Ebenstein, A., A. Harrison, M. McMillan, and S. Phillips. 2014. "Estimating the Impact of Trade and Offshoring on American Workers Using the Current Population Surveys." *Review of Economics and Statistics* 96 (4): 581–595.

Edwards, T. H. 2015. "The Search for Partners and the Path-Dependency of Trade."

Eichengreen, B., and D. A. Irwin. 1998. *The Role of History in Bilateral Trade Flows.* Technical report.

Ekholm, K., A. Moxnes, and K. H. Ulltveit-Moe. 2012. "Manufacturing Restructuring and the Role of Real Exchange Rate Shocks." *Journal of International Economics* 86 (1): 101–117.

Feenstra, R. C., and J. B. Jensen. 2012. "Evaluating estimates of materials offshoring from US manufacturing." *Economics Letters* 117 (1): 170–173.

Feenstra, R. C., J. Romalis, and P. K. Schott. 2002. *US Imports, Exports, and Tariff Data, 1989-2001.* Technical report. National Bureau of Economic Research.

Frankel, J. A. 1990. "And Now Won/Dollar Negotiations? Lessons from the Yen/Dollar Agreement of 1984." *Department of Economics, UCB.*

Gourinchas, P.-O. 1999. *Exchange Rates and Jobs: What Do We Learn From Job Flows?* Technical report.

Guajardo, J., D. Leigh, and A. Pescatori. 2014. "Expansionary Austerity? International Evidence." *Journal of the European Economic Association.*

Head, K., and T. Mayer. 2013. "What Separates Us? Sources of Resistance to Globalization." *Canadian Journal of Economics/Revue canadienne d'économique* 46 (4): 1196–1231.

Head, K., T. Mayer, and J. Ries. 2010. "The Erosion of Colonial Trade Linkages after Independence." *Journal of International Economics* 81, no. 1 (): 1–14.

Houseman, S. 2014. "The Role of Manufacturing in a Jobs Recovery." *Center on Budget and Policy Priorities.*

Houseman, S., C. Kurz, P. Lengermann, and B. Mandel. 2011. "Offshoring Bias in U.S. Manufacturing." *Journal of Economic Perspectives* 25, no. 2 (): 111–32.

Im, K. S., M. H. Pesaran, and Y. Shin. 2003. "Testing for Unit Roots in Heterogeneous Panels." *Journal of Econometrics* 115 (1): 53–74.

Irwin, D. A. 2013. "The Nixon Shock After Forty Years: The Import Surcharge Revisited." *World Trade Review* 12 (1): 29–56.

Kaiser, U., and H. C. Kongsted. 2008. "True Versus Spurious State Dependence in Firm Performance." *Empirical Economics* 35 (2): 207–228.

Katz, L. F. 2010. "Long Term Unemployment in the Great Recession." *Testimony for the Joint Economic Committee U.S. Congress Hearing on "Long-Term Unemployment: Causes, Consequences and Solutions".*

Khandelwal, A. K., P. K. Schott, and S.-J. Wei. 2013. "Trade Liberalization and Embedded Institutional Reform: Evidence from Chinese Exporters." *American Economic Review* 103 (6): 2169–2195.

Klein, S. Schuh, and R. K. Triest. 2003. "Job Creation, Job Destruction, and the Real Exchange Rate." *Journal of International Economics* 59, no. 2 (): 239–265.

Klein, Schuh, and Triest. 2002. "Job Creation, Job Destruction, and International Competition: A Literature Review," nos. 02-7.

Krugman, P. 1980. "Scale Economies, Product Differentiation, and the Pattern of Trade." *American Economic Review* 70, no. 5 (): 950–59.

Krugman, P. 1986. *Is the Japan Problem Over?* NBER Working Papers 1962. National Bureau of Economic Research, Inc.

Krugman, P. 1987. "The Narrow Moving Band, the Dutch Disease, and the Competitive Consequences of Mrs. Thatcher: Notes on Trade in the Presence of Dynamic Scale Economies." *Journal of Development Economics* 27, nos. 1-2 (): 41–55.

Krugman, P. 1988. *Deindustrialization, Reindustrialization, and the Real Exchange Rate.* NBER Working Papers 2586. National Bureau of Economic Research, Inc.

Krugman, P. 1992. *Geography and Trade.* Vol. 1. MIT Press Books 0262610868. The MIT Press.

Levin, A., C.-F. Lin, and C.-S. J. Chu. 2002. "Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties." *Journal of Econometrics* 108 (1): 1–24.

Liu, D., and C. M. Meissner. 2015. "Market Potential and the Rise of US Productivity Leadership." *Journal of International Economics* 96 (1): 72–87.

McKinnon, R., and G. Schnabl. 2006. "China's Exchange Rate and International Adjustment in Wages, Prices and Interest Rates: Japan deja vu?" *CESifo Economic Studies* 52 (2): 276–303.

Melitz, M. J. 2003. "The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity." *Econometrica* 71, no. 6 (): 1695–1725.

Moser, C., D. Urban, and B. W. di Mauro. 2010. "International Competitiveness, Job Creation and Job Destruction–An Establishment-Level Study of German Job Flows." *Journal of International Economics* 80, no. 2 (): 302–317.

Nino, V. D., B. Eichengreen, and M. Sbracia. 2011. *Real Exchange Rates, Trade, and Growth: Italy 1861-2011.* Quaderni di Storia Economica (Economic History Working Papers) 10. Bank of Italy, Economic Research and International Relations Area.

Nucci, F., and A. F. Pozzolo. 2010. "The Exchange Rate, Employment and Hours: What Firm-Level Data Say." *Journal of International Economics* 82 (2): 112–123.

Parsley, D. C., and S.-J. Wei. 1993. "Insignificant and Inconsequential Hysteresis: The Case of US Bilateral Trade." *The Review of Economics and Statistics:* 606–613.

Pierce, J. R., and P. K. Schott. 2012. "Concording US Harmonized System Codes over Time." *Journal of Official Statistics* 28 (1): 53–68.

Pierce and Schott. 2016. "The Surprisingly Swift Decline of US Manufacturing Employment." *American Economic Review* 106, no. 7 (): 1632–62.

Redding, S., and A. J. Venables. 2004. "Economic Geography and International Inequality." *Journal of international Economics* 62 (1): 53–82.

Revenga, A. L. 1992. "Exporting Jobs?: The Impact of Import Competition on Employment and Wages in US Manufacturing." *The Quarterly Journal of Economics:* 255–284.

Roberts, M. J., and J. R. Tybout. 1997. "The Decision to Export in Colombia: An Empirical Model of Entry with Sunk Costs." *The American Economic Review:* 545–564.

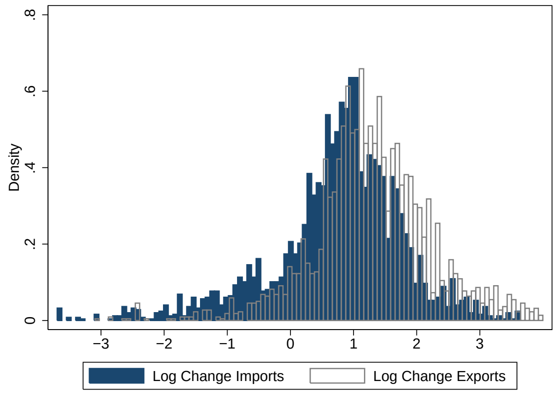
Rose, A. K. 1991. "The Role of Exchange Rates in a Popular Model of International Trade: Does the 'Marshall–Lerner' Condition Hold?" *Journal of International Economics* 30 (3): 301–316.

Schott, P. K. 2008. "The Relative Sophistication of Chinese Exports." *Economic policy* 23 (53): 6–49.

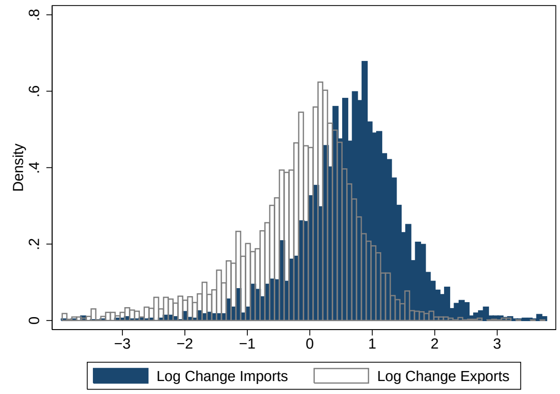
Thomas, C., S. Fahle, and J. Marquez. 2008. "Measuring US International Relative Prices: A WARP View of the World." *FRB International Finance Discussion Paper,* no. 917.

Turner, P., and J. Van't Dack. 1993. "Measuring International Price and Cost Competitiveness," no. 39.

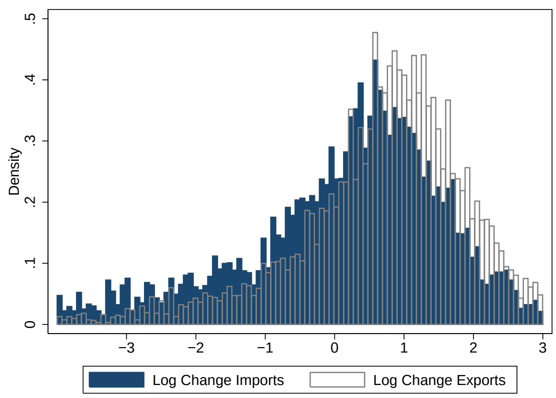
6 Appendix



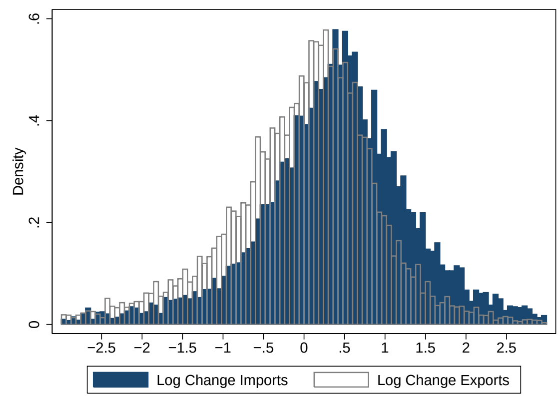
(a) Dollar Depreciation: 1972-1979



(b) Dollar Appreciation: 1979-1986



(c) Dollar Depreciation: 1986-1996



(d) Dollar Appreciation: 1996-2005

Figure 11: Distribution of Changes in Trade, by Sector and Country

Source: Trade data for 452 SIC sectors and roughly 200 countries are from Comtrade

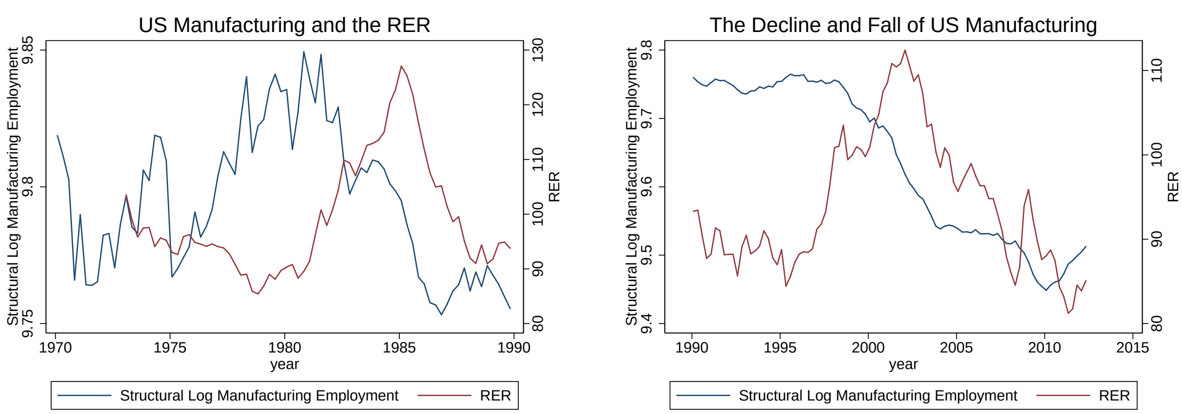
Table 6: Data Summary for Select Years

	(1) 1974	(2) 1979	(3) 1985	(4) 1993	(5) 2001	(6) 2005
Openness	0.0857	0.0973	0.113	0.173	0.235	0.276
	(0.111)	(0.104)	(0.118)	(0.173)	(0.240)	(0.265)
Value Added, Millions	1095.9	1806.4	2258.8	3467.9	4551.0	5450.7
	(1678.6)	(2893.1)	(3405.8)	(5470.4)	(7972.2)	(10903.5)
Hourly Wages, Prod. Workers	4.366	6.462	9.571	12.00	15.11	17.50
	(1.003)	(1.781)	(2.762)	(3.337)	(4.115)	(4.705)
Payroll/Value-Added	0.425	0.412	0.412	0.373	0.364	0.319
	(0.116)	(0.110)	(0.112)	(0.119)	(0.121)	(0.116)
Investment/Value-Added	0.0670	0.0692	0.0755	0.0623	0.0649	0.0502
	(0.0426)	(0.0455)	(0.0749)	(0.0651)	(0.0429)	(0.0297)
Energy Costs/Value-Added	0.0405	0.0581	0.0733	0.0490	0.0492	0.0467
	(0.0593)	(0.0863)	(0.128)	(0.0853)	(0.0686)	(0.0659)
Materials Costs/Value-Added	1.263	1.315	1.362	1.134	1.153	1.121
	(1.064)	(1.098)	(1.503)	(0.769)	(0.709)	(0.682)
Shipments per Worker, (1000s)	63.45	99.47	146.2	201.2	270.7	379.8
	(70.48)	(113.8)	(161.4)	(179.8)	(286.0)	(486.9)
Duties %	0.0839	0.0751	0.0566	0.0510	0.0306	0.0242
	(0.0712)	(0.0650)	(0.0576)	(0.108)	(0.0421)	(0.0321)
Ins., Freight Costs %	0.0748	0.0688	0.0746	0.0971	0.0916	0.0958
	(0.0665)	(0.0576)	(0.0767)	(0.0472)	(0.0493)	(0.0551)
K/L, (1000s)	51.18	59.44	78.43	84.87	115.4	145.0
	(56.88)	(69.46)	(89.41)	(91.02)	(130.5)	(160.1)
5-factor TFP index 1987=1.000	0.973	0.974	0.973	1.018	1.078	1.216
	(0.213)	(0.151)	(0.0814)	(0.131)	(1.432)	(2.564)
Prod. Workers/Total Emp	0.763	0.757	0.730	0.714	0.714	0.700
	(0.0961)	(0.0952)	(0.105)	(0.118)	(0.119)	(0.114)
Chinese Import Penetration	0.000179	0.000461	0.00281	0.0254	0.0795	0.122
	(0.00142)	(0.00205)	(0.00887)	(0.115)	(0.541)	(0.623)
Japanese Import Penetration	0.0128	0.0136	0.0229	0.0289	0.0254	0.0257
	(0.0354)	(0.0322)	(0.0463)	(0.0518)	(0.0500)	(0.0530)
Shipments Deflator	0.544	0.765	0.977	1.160	1.284	1.402
	(0.186)	(0.131)	(0.0580)	(0.120)	(0.245)	(0.315)
Materials Deflator	0.531	0.775	1.001	1.122	1.159	1.326
	(0.130)	(0.0733)	(0.0653)	(0.0793)	(0.195)	(0.270)
Investment Deflator	0.479	0.734	0.938	1.137	1.117	1.163
	(0.0401)	(0.0394)	(0.0174)	(0.0550)	(0.126)	(0.148)
Energy Deflator	0.375	0.761	1.123	1.126	1.386	1.560
	(0.119)	(0.0761)	(0.0525)	(0.0205)	(0.0720)	(0.146)

Mean coefficients; sd in parentheses. All variables have 357 observations for each year, except for duties and freight costs, which have just 308 observations in the 1970s and 1980s.

Table 7: Manufacturing Employment Accounting

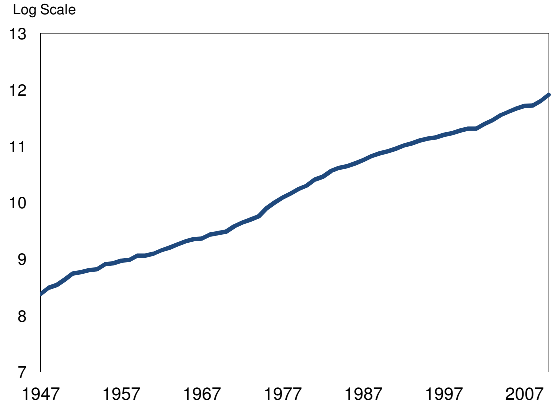
Year	Manufacturing Consumption (billions)	Manufacturing Consumption (Share of GDP)	Manufacturing Trade Deficit (billions)	Productivity (thousands per worker)	Deficit Δ from 1995 over Productivity	Lost in Man. Since 1995
1995	1340	18.1%	159	68	0.00	0
1996	1361	17.4%	152	70	-0.09	-0.01
1997	1432	17.2%	155	73	-0.05	0.17
1998	1542	17.5%	215	76	0.75	0.32
1999	1661	17.8%	293	79	1.70	0.08
2000	1780	17.9%	364	82	2.50	0.02
2001	1688	16.4%	344	82	2.26	-0.80
2002	1760	16.5%	404	89	2.76	-1.99
2003	1822	16.4%	448	95	3.05	-2.74
2004	2023	17.0%	540	104	3.68	-2.93
2005	2158	17.1%	590	110	3.92	-3.02



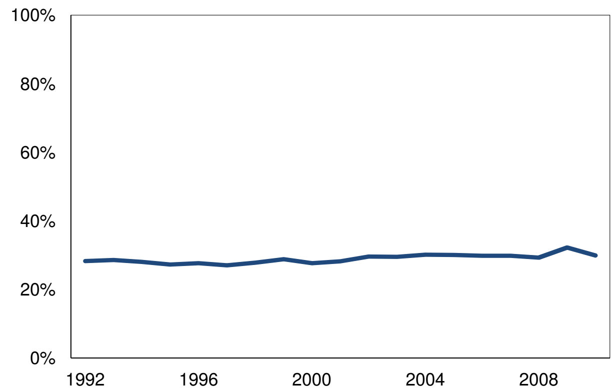
(a) 1970s and 1980s

(b) 1990s and 2000s

Figure 12: Structural Manufacturing Employment vs. the RER
Source: The quarterly RER series used here is the Federal Reserve's Broad Trade-Weighted RER index.



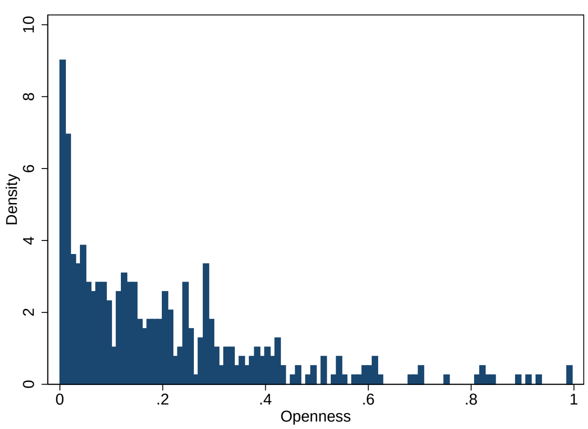
(a) Value-Added per Worker



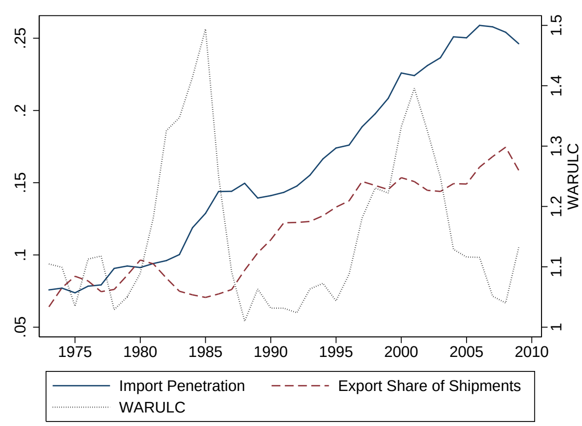
(b) Services Share of Exports

Figure 13: The Usual Suspects: Explanations for the Decline of Manufacturing

Source: BEA, Census



(a) Openness



(b) Trade Growth vs. WARULC

Figure 14: Trade Growth and the Distribution of Openness in 1997

Sources: Census, Comtrade, and Campbell (2016)

7 Online Appendix

7.1 Theoretical Model

In this section, I motivate the empirics using a slight variation of the Chaney (2008) model with sunk costs as in Melitz (2003). I use this approach because I can show analytically that sectoral labor demand depends on the past history of prices (and I can derive an analytical solution for a dynamic gravity equation), and also partly due to the popularity of the Melitz model.

In this model, households in the home country consume from a continuum of goods, ω, from a set of goods in H+1 sectors, Ω_h, determined in equilibrium. There is a freely traded homogeneous numeraire good q_0 as in Chaney (2008), with one unit of labor producing w units of the good.

$$U_t = q_{0t}^{\mu_0} \prod_{h=1}^{H} \Big(\int_{\Omega_h} q_h(\omega)_t^{\frac{(\sigma_h - 1)}{\sigma_h}} d\omega \Big)^{\frac{\sigma_h \mu_h}{(\sigma_h - 1)}} , \ \sigma_h > 1 \forall h \, . \tag{7.1}$$

Each period this leads to the solution for variety ω, with total income in the home country, Y_t, and the CES price index $P_{ht} = (\int_{\omega \in \Omega_h} p_h(\omega)_t^{(1-\sigma_h)} d\omega)^{\frac{1}{(\sigma_h - 1)}}$:

$$q_h(\omega)_t = \frac{\mu_h Y_t p_h(\omega)_t^{-\sigma_h}}{P_{ht}^{1-\sigma_h}} . \tag{7.2}$$

Firms maximize profits each period after paying a sunk fixed cost to receive a productivity draw (output per unit of labor φ) and begin producing for the home market, and then choose whether to pay a sunk entry cost to enter the foreign market (for simplicity I assume there are only two countries). Profits per period for an existing firm from sales at home are thus[29]

$$\Pi_h(\omega)_t = q_h(\omega)_t p_h(\omega)_t - \frac{q_h(\omega)_t w_t}{\varphi_h(\omega)} - f_{ht} w_t , \tag{7.3}$$

where p is price, q is output sold at home, w is the wage, τ is an iceberg trade cost, f is the per-period overhead cost and $\varphi_h(\omega)$ is the output per unit of labor, supplied inelastically by households. Firms have an exogenous probability of death δ, yet otherwise will always choose to stay in a market they have previously entered, as expected profits are strictly

29. And similarly for exports: $\Pi_h(\omega)_t^* = q_h(\omega)_t^* p_h(\omega)_t^* - \frac{q_h(\omega)_t^* w_t \tau_t}{\varphi_h(\omega)}$, where q^* and p^* denote quantities and prices of goods produced at home and sold abroad.

positive going forward. Maximizing profits, firms choose prices marked up over marginal cost $p_h(\omega)^*_t$ (denotes the price of exports)

$$p_h(\omega)_t = \frac{\sigma_h}{\sigma_h - 1}\frac{w_t}{\varphi_h(\omega)}, \quad p_h(\omega)^*_t = \frac{\sigma_h}{\sigma_h - 1}\frac{w_t \tau_t}{\varphi_h(\omega)}. \tag{7.4}$$

A home firm which has previously paid to receive a productivity draw will pay a sunk fixed cost to export, f^x, if it is less than the expected discounted present value of future profits.[30]

$$Foreign\, Entry : E_t \Pi(\omega)^*_{PV,t} = E_t \sum_{s=0}^{\infty} (1-\delta)^s \Pi(\omega)^*_{t+s} - f^x_{ht} w_t \geq 0. \tag{7.5}$$

The baseline empirical approach in the next section will be to use relative price indices to explain the behavior of sectoral manufacturing employment. Thus, we can write sectoral labor demand as:

$$L_{ht} = \underbrace{\int_{\omega \in \Omega} \frac{q_h(\omega)_t}{\varphi_h(\omega)_t}}_{\text{Home Production}} + \underbrace{\int_{\omega \in \Omega^*} \frac{q^*_h(\omega)_t}{\varphi_h(\omega)_t}}_{\text{Export Production}} + \underbrace{M^e_{ht}(f^e_{ht} + f^x_{ht} p^x_{ht})}_{\text{Entry}} + \underbrace{\sum_{s=0}^{\infty} M^e_{h,t-s}(1-\delta)^s f_{ht} \varrho_{h,t,s}}_{\text{Overhead}}. \tag{7.6}$$

Here M^e_{ht} is the mass of potential entrants at time t, $\varrho^x_{ht} = 1 - G(\bar{\varphi}_x)$ is the share of new firms in sector h with productivity greater than the cutoff productivity for exporting, $\bar{\varphi}_x$, and $\varrho_{h,t,s} = 1 - G(\bar{\varphi}_{f,t,s})$ is the share of continuing firms with productivity greater than the maximum cutoff for continuing to produce for the home market, $\bar{\varphi}_{f,t,s}$, in between years t-s and t. The mass of entrants in Chaney (2008) is assumed to be exogenous, and based on country factors (proportional to output).

The cutoff productivity for entering into the export market at time t can be derived from equation (7.5) assuming that firms know the productivity distribution when they decide to invest to receive a productivity draw, and then have perfect foresight of market conditions for the upcoming period when they decide to invest. However, firms make their investment decisions using rules-of-thumb, taking the form of simple expectations about a future they believe will be like today, conditioned on not receiving a "death"

30. Firms will pay a fixed cost to receive a productivity draw and enter the domestic market if the expected profits, home and abroad, are greater than the fixed cost of entry: $E_t \Pi(\omega)_{tot,PV,t} = E_t[\sum_{s=0}^{\infty}(1-\delta)^s \Pi(\omega)_{t+s} + \Pi(\omega)^*_{PV,t}] - f_{e,ht} w_t \geq 0$.

draw with probability δ. Thus the cutoff productivity for exporting is

$$\bar{\varphi}_{xht} = \left(\frac{P_{ht}^{*(1-\sigma_h)} w_t^{\sigma_h}}{\mu_h Y_t^*} \lambda_0 \delta f_{h,t}^x \right)^{\frac{1}{\sigma_h - 1}} \tau_t, \tag{7.7}$$

where $\lambda_0 = \frac{\sigma_h^{\sigma_h}}{(\sigma_h - 1)^{\sigma_h - 1}}$.

When wages, trade costs, or the sunk fixed costs of exporting rise, or the foreign market either becomes more competitive or experiences an exogenous reduction in demand in sector h, the cutoff productivity for exporting will rise, meaning that fewer firms will enter.

Additionally, existing firms will exit and stop producing if revenue fails to cover per-period fixed costs. The cutoff productivity for staying in business for purely domestic firms is[31]

$$\bar{\varphi}_{fht} = \left(\frac{P_{ht}^{(1-\sigma_h)} w_t^{\sigma_h}}{\mu_h Y_t} \lambda_0 f_{ht} \right)^{\frac{1}{\sigma_h - 1}}. \tag{7.8}$$

This equation tells us that when labor costs or fixed costs rise, or when the domestic market becomes more competitive or domestic demand in sector h shrinks, fewer firms will be around to employ labor in overhead activities. To the extent that it is the case that more productive firms export (as it is in this model), relative price appreciations, denoted by a rise in wages, or a rise in domestic vs. foreign GDP, would imply that import-competing industries might be more adversely affected than relatively export-intensive industries along the extensive margin, since industries with many firms that do not export may have a more difficult time covering the fixed overhead costs.

The first term in the sectoral labor demand equation (7.6) is the total labor requirement for home production. Plugging in the solutions from above and integrating assuming Pareto-distributed productivity with parameter γ_h (the Pareto distribution is $G(\varphi) = 1 - \varphi^{-\gamma_h}$, where I assume $\gamma_h > \sigma_h - 1$), the first term becomes

$$\frac{\sum_{s=0}^{\infty} \mu_{h,t} Y_t M_{h,t-s}^e \rho^s w_t^{-\sigma_h} \lambda_1 \bar{\varphi}_{mh,t,s}^{(\sigma_h - 1 - \gamma_h)}}{\sum_{s=0}^{\infty} \rho^s (M_{h,t-s}^e w_t^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t,s}^{\sigma_h - 1 - \gamma_h} + M_{h,t,s}^{*e} (w_t^* \tau_{ht}^*)^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mxh,t,s}^{*(\sigma_h - 1 - \gamma_h)})}, \tag{7.9}$$

31. The constraint for staying in business for firms which also export is $\bar{\varphi}_{fxt} = \left(\frac{\mu_h Y_t}{P_{ht}^{(1-\sigma_h)}} + \frac{\mu_h^* Y_t^* \tau_t}{P_{ht}^{*(1-\sigma_h)}} \right)^{\frac{-1}{\sigma_h - 1}} (\lambda_0 w_t^{\sigma_h} f_{ht})^{\frac{1}{\sigma_h - 1}}$.

where λ_1 and λ_2 are parameters[32], $\rho = 1 - \delta$ for brevity, $\bar{\varphi}_{mh,t,s}$ is the maximum cutoff productivity to remain in the market for a firm that entered s periods previously in the intervening years, and variables with an asterisk denote foreign variables. Thus $\bar{\varphi}^{*}_{mxh,t,s}$ is the maximum cutoff productivity for a foreign firm that entered s periods previously to export and remain producing during the intervening years, and variables with an asterisk denote foreign variables. The denominator of this equation is the solution to $P_{ht}^{1-\sigma_h}$. Thus, along the intensive margin, labor demand for domestic production depends positively on domestic sectoral demand ($\mu_{ht} Y_t$), negatively on domestic wages, and positively on importing trade costs, τ^{*}_{ht}. The extensive margin operates via current and lagged cutoff productivities, which negatively impact home sectoral labor demand. Higher home wages, a more competitive home market, higher fixed costs or smaller domestic demand will all potentially trigger firm exits (via equation 7.8), which will not necessarily be reversed immediately when these variables return to previous levels. The sole discordant note is that, due to the CES preferences, which serve as a modeling convenience rather than as a statement about the way the world operates, growing productivity in a sector will not imply decreased labor demand as both intuition and data would suggest.

The second term on the right-hand side of equation (7.6) is analogous, as labor devoted to production for exports will be a positive function of foreign demand along the intensive margin, and a negative function of home wages and trade costs for exporting. Additionally, there can be movements along the extensive margin, which will depend on the cutoff productivity for existing firms, equation (7.8). If wages, fixed overhead costs (f_{ht}), iceberg trade costs, or more foreign firms enter, the cutoff productivity for making a profit will rise, and some existing firms will be forced out of the market:

$$\frac{\sum_{s=0}^{\infty} \mu^{*}_{h,t} Y^{*}_{t} M^{*e}_{h,t-s} \rho^{s} w_t^{*(-\sigma_h)} \tau_t^{1-\sigma_h} \lambda_1 \bar{\varphi}_{mh,t,s}^{\sigma_h - 1 - \gamma_h}}{\sum_{s=0}^{\infty} \rho^{s} M^{e}_{h,t-s} (w_t \tau_{ht})^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t-s}^{\sigma_h - 1 - \gamma_h} + \sum_{s=0}^{\infty} \rho^{s} M^{*e}_{h,t-s} w_t^{*(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t-s}^{*(\sigma_h - 1 - \gamma_h)}}. \tag{7.10}$$

While there is no explicit "exchange rate" in this model, one could proxy it in several ways. One is to stipulate that both wages and output are denominated in local dollars, and to then treat an exchange rate appreciation as local wages and output rising relative to foreign. A second approach, used by Nino et al. (2011), is to proxy exchange rate movements using the iceberg trade costs. Either would yield the needed result, although a referee correctly notes that this model, with CES preferences and no relocation decision

32. $\lambda_1 = \frac{(\sigma_h/(\sigma_h - 1))^{-\sigma_h}}{\gamma_h - (\sigma_h - 1)}$ and $\lambda_2 = \frac{1}{\gamma_h - (\sigma_h - 1)}$

by firms, should not be expected to yield a realistic elasticity. Also note that since either of these methods imply a constant elasticity of changes in employment in exporting or given movements in wages or iceberg trade costs, that sectors with higher shares of either imports or exports in production will theoretically be impacted more by movements in exchange rates. This intuitive theoretical result will be used to identify the impact of relative price movements on manufacturing employment.

7.2 Implications (Online Appendix, continued)

Proposition: Trade is a Function of History

To simplify matters, the fixed overhead costs will now be set to 0. Total exports in industry h at time t are the sum of exports of each cohort of past entrants, where I borrow Chaney's assumption that the mass of entrants in industry h at time t is $\alpha_{ht} Y_t$:

$$X_{ht} = \sum_{s=0}^{\infty} (1-\delta)^s \alpha_h Y_{t-s} \int_{\bar{\varphi}_{t-s}}^{\infty} x_{h,t}(\varphi)\mu(\varphi)d\varphi. \tag{7.11}$$

Substituting in the solutions for x = pq, plugging in the pricing rules, assuming Pareto-distributed productivity and integrating, I arrive at a dynamic gravity equation:

$$X_{ht} = \frac{\mu_h^* Y_t^* (w_t \tau_t)^{1-\sigma_h}}{P_t^{*(1-\sigma_h)}} \lambda_3 \sum_{s=0}^{t} (1-\delta)^s (\alpha_h Y_{t-s}) \left(\frac{P_{h,t-s}^{*(1-\sigma)} w_{t-s}^{\sigma_h}}{\mu_{h,t-s} Y_{t-s}^*} \lambda_0 \delta f_{h,t-s}^x \tau_{t-s}^{\sigma_h - 1} \right)^{\frac{-\gamma_h + \sigma_h - 1}{\sigma_h - 1}}, \tag{7.12}$$

where $\lambda_3 = \frac{\gamma_h}{\gamma_h - \sigma_h + 1} \frac{\sigma_h^{1-\sigma_h}}{(\sigma_h - 1)^{1-\sigma_h}}$, and where $P_t^{1-\sigma}$ is the denominator of equation (7.10).

The key underlying insight of this equation is that trade today depends on the history of trade costs, both entry and iceberg, in addition to market sizes and contemporaneous variables. Even with the simplifying assumptions, this equation is still fairly complex, so for purposes of clarity, I have summarized the sign of the impact of key variables on exports (foreign variables denoted by an *) at time t:

$$X_t = f(\underbrace{Y_t}_{+}, \underbrace{Y_{t-s}}_{+}, \underbrace{Y_t^*}_{+}, \underbrace{Y_{t-s}^*}_{+}, \underbrace{w_t}_{-}, \underbrace{w_{t-s}}_{-}, \underbrace{\tau_t}_{-}, \underbrace{\tau_{t-s}}_{-}, \underbrace{f_{ht}^x}_{-}, \underbrace{f_{h,t-s}^x}_{-}), s > 0. \tag{7.13}$$

Note that if we were in a one-period world, then, as in Chaney (2008), the elasticity of substitution would not magnify the impact of iceberg trade costs, but that with multiple periods of firm entry, this result would no longer follow. How general is this dynamic gravity formulation? In the Additional Appendix, I prove that similar transition dynamics arise when moving from autarky to free trade for assumptions similar to those for key models in the new trade theory canon, including Krugman (1980) and Melitz (2003). Recent related research includes Burstein and Melitz (2013), who provide impulse response functions for shocks to trade costs, and Bergin and Lin (2012), who focus on the dynamic impact of future shocks. The large aforementioned literature on hysteresis from the 1980s carried the same core insight, that trade shocks can have persistent effects, as in equation (7.12). This paper is the first to show that the logic of sunk entry costs naturally leads to a "dynamic gravity" equation which can be derived explicitly.

Empirically, incumbent firms dominate most sectors in terms of market share, which means that the current trade relationship could be determined, in part, by historical factors as emphasized by Campbell (2010), 2013, Eichengreen and Irwin (1998), and Head et al. (2010).[33]

Corollary: The Real Wage is a Function of Historical Market Access

A key insight from New Trade Theory is that the real wage is a function of market access. Krugman (1992) argues that new trade theory can help explain higher wages in the northern manufacturing belt of the US, Redding and Venables (2004) argue that market access can explain cross-country variation in per capita income, and Liu and Meissner (2015) show that market access can help explain high living standards in northwest Europe in the early 20th century. An important corollary is that sunk costs imply that the real wage is also a function of historical market access. This follows from the dynamic gravity equation, as utility is increasing in the number of varieties and the extensive margin increases over time after a decline in trade costs. Figure 19 in the Appendix is a chloropleth map of per capita income by county, which can be compared to the distribution of import-competing manufacturing in Figure 20. It is immediately obvious that both are highly correlated with access to sea-navigable waterways – and that the US north was still much richer than the south in 1979. I posit that this owes more to the past history of trade costs than it does to low shipping costs on Lake Erie today.

7.3 Additional Notes on RER Indices (Online Appendix, Cont.)

The main measure of the real exchange rate used in this paper is the Weighted Average Relative Unit Labor Cost (WARULC) index designed by Campbell (2016) to address

33. Edwards (2015) makes a similar argument based on a search model of trade.

the shortcomings of the IMF's Relative Unit Labor Cost (RULC) index. The four key problems with the IMF's index are that it (1) is computed as an index-of-indices, and thus does not reflect compositional changes in trade toward countries that have lower unit labor costs, (2) does not include China, (3) uses fixed trade weights, which have become outdated (Japan still held a 20% weight in the 2000s while China was excluded), and (4) uses country-specific deflators, which can become biased over time without the benefit of multiple benchmarks. (This last point is the same problem that afflicted older versions of the Penn World Tables predating version 8.0).

Note that most real exchange rate indices, such as those produces by the Federal Reserve, the OECD, the BIS, and many other central banks, also use time-varying trade weights, and that time-varying trade weight indices are often used in studies on the impact of RER movements on manufacturing, such as in Klein et al. (2003).

Campbell (2016) introduced WARULC, a simple weighted-average of RULCs which includes China, uses time-varying trade-weights, and also uses multiple-benchmarking of country-specific productivity series using PWT v8.0 methodology. This last point will be subtle for general readers, and so I would refer interested parties to Campbell 2016.

The WARULC index is computed as

$$I_{US,t}^{WARULC} = \prod_{i=1} \Big(\frac{ULC_{US,t}}{ULC_{i,t}}\Big)^{\Omega_{i,t}}, \tag{7.14}$$

where

$$ULC_{i,t} = \frac{w_{i,t}}{e_{i,t}} / \frac{Y_{i,t}}{PPP_{i,t}}, \tag{7.15}$$

and where $\Omega_{i,t}$ are time-varying trade weights (a weighted average of import, export, and third-country competition weights, the same as used by the BIS and very similar to the Fed's weights), and where $w_{i,t}$ are manufacturing wages of country i at time t, $e_{i,t}$ is the local currency price of a dollar, and $Y_{i,t}$ is manufacturing production, converted to dollars at PPP (equal to one for the US). One of the key differences with the IMF's index is that for this index the ULCs are actual unit labor costs rather than indices of unit labor costs. Manufacturing PPP data were computed using ICP data for benchmark years, and then interpolated in between using manufacturing deflators from the OECD, or country-specific sources in the case of China.

Both measures are plotted in Figure 15 vs. the IMF's RULC index. The IMF's index suggests a steady depreciation of US relative unit labor costs over the period, implying that US manufacturing has become steadily more competitive since the 1970s.

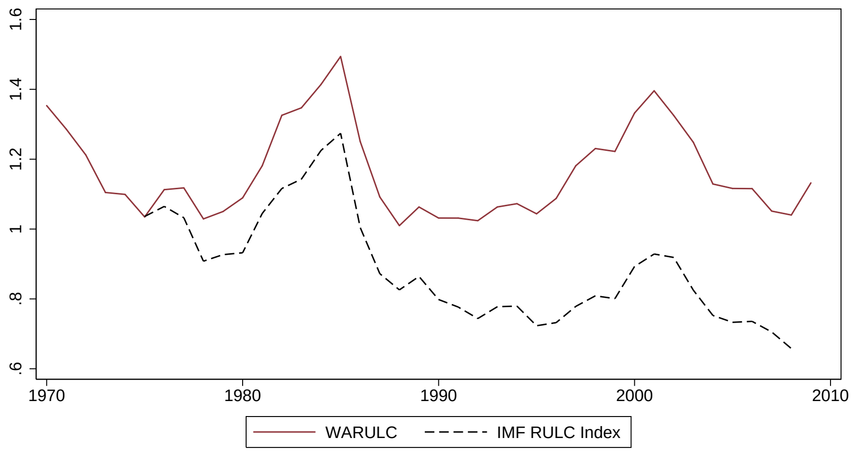


Figure 15: WARULC vs. IMF RULC Index

Sources: Campbell (2016) and the IMF

WARULC, by contrast, implies that US manufacturing became less competitive in the early 2000s.

It turns out that all four of the adjustments from the IMF's RULC to WARULC are important. For example, changing the indexing method while using fixed trade-weights would yield an index almost identical to the IMF's index, even if China is included. Without the multiple benchmarking, WARULC would still have a more negative slope. I refer readers interested in the differences in these indices when some of these adjustments are left out to 2016.

I also consider alternative measures of relative prices. Figure 16 compares several state-of-the-art measures of relative prices which use PWT v8.0 data and methodology to more commonly used measures provided by the Federal Reserve Board and IMF. Indexing the IMF's RULC series to begin at the same level as the WARULC index in 1975, the IMF's index implies that US ULCs were nearly 40% lower than trading partners by the 2000s, which is implausible. I have also plotted an updated version of Weighted Average Relative Prices (WARP) (from Thomas et al. (2008)) using PWT v8.1, and Penn-Adjusted Weighted Average Relative Prices (PWARP), introduced in Campbell (2016). The Federal Reserve's CPI-based Broad Trade-Weighted Real Exchange Index, plotted in yellow, also implies that the dollar tended to depreciate over the period. The three "Weighted Average Relative" (WAR) indices all yield broadly similar results, although there are certainly differences in the details and in the implied degree of overvaluation. One of the differences is that the other WAR measures show a slower dollar depreciation in the mid-2000s, which is consistent with the finding that

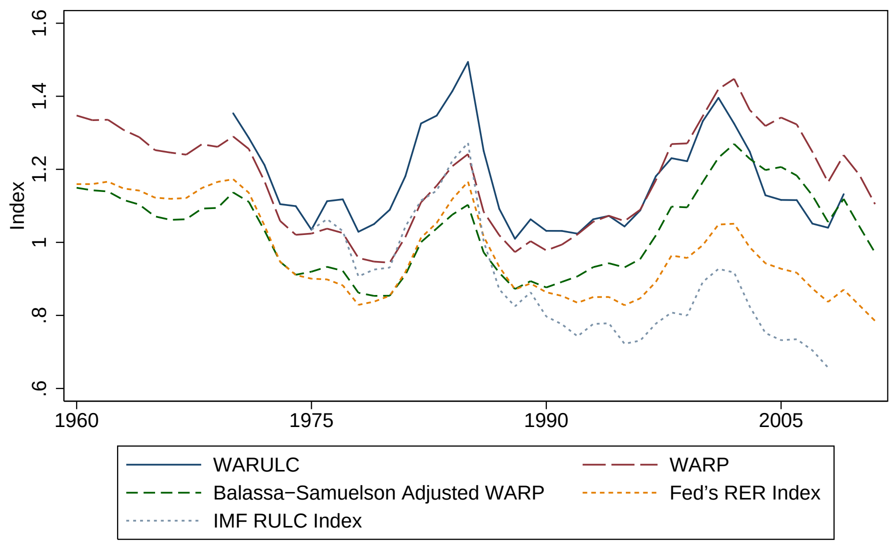


Figure 16: Comparing Various Exchange Rate Measures

Source: Campbell (2016) and the IMF

relatively open manufacturing sectors continued to fair poorly in this period (Figure 6). Another difference is the slightly more negative overall slope of WARULC, which is due to the declining share of labor income in manufacturing in the US relative to many other developed countries, which appears to be a broad-based phenomenon in manufacturing not caused by outsized changes in a small number of sectors.

7.4 Panel Unit Root Test

The existence of a unit root for sectoral manufacturing employment, *i.e.*, if one regressess log employment on a lag of itself, whether the coefficient is one, is evidence consistent even with hysteresis/path dependence. This would also justify a simple functional form for a panel regression, of the log difference in employment on the left-hand side, and it would also be an indication that temporary shocks to employment in general tend to have a long-lasting impact.

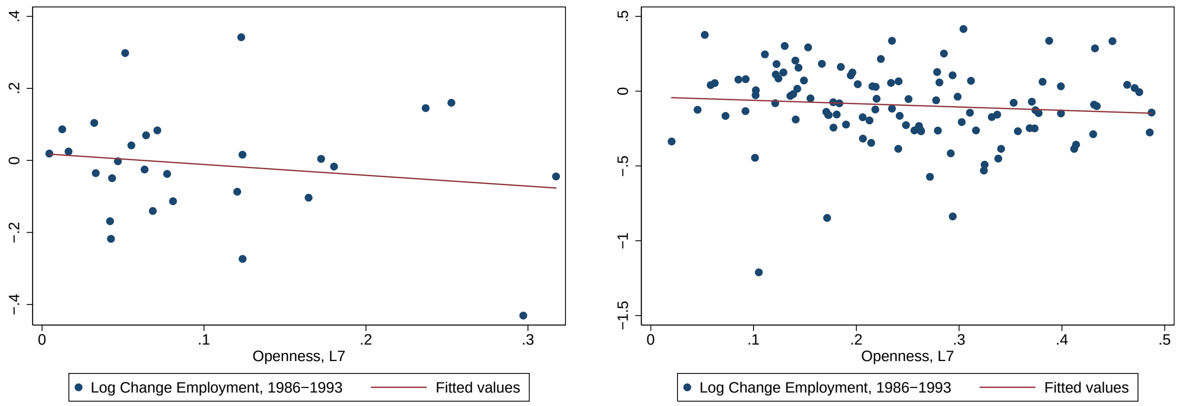
In Table 8, I present several different commonly-used panel unit root tests. The first is a test developed by Levin et al. (2002). It assumes that all panels share a common autoregressive parameter, and works best with N larger than T, which is the case we have. The null hypothesis is that the panel contains a unit root. The p-value on the test of one indicates that we cannot reject the null at any level of confidence. Next we perform a related series of tests by Im et al. (2003), which appealingly allows the autoregressive parameter to differ by sector. These tests have the null hypothesis that all panels contain unit roots. In Column (2), using the Im-Pesarin-Shin (IPS) test, we again can not reject the null hypothesis that all sectors contain a unit root. In column (3), we now add in lags, using the Akaike information criterion (AIC) to choose the appropriate number of lags for each panel (up to 4). In column (4), we choose the appropriate number of lags for each panel using the Bayesian information criterion (BIC) is used instead. In Column (5), we allow for each panel to have its own mean, in column (6) we allow for time trends, and in column (7), we allow for lags, means, and trends. In no case can we reject the null hypothesis even at 10%, although in column (6) there is some uncertainty. However, in practice, it is also worth noting that, for practical purposes, a lagged dependent variable close to one, implying that a temporary shock would take a long time to fade out, would not be much different in terms of economic significance.

Table 8: Panel Unit Root Tests

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Test Statistic	16.4	23.6	21.8	22.4	11.0	-.38	13.5
P-Value	1.000	1.000	1.000	1.000	1.000	.352	.998
Test	LLC	IPS	IPS	IPS	IPS	IPS	IPS
Test Statistic Name	Adjusted t*	Z-t-tilde-bar	W-t-bar	W-t-bar	W-t-bar	Z-t-tilde-bar	W-t-bar
Lags	No	No	AIC 4	BIC 4	AIC 4	None	AIC 4
Panel Means	No	No	No	No	Yes	No	Yes
Time Trend	No	No	No	No	No	Yes	Yes

The first column runs the Levin-Lin-Chu (LLC) test, the others run different versions of the Im-Pesaran-Shin (IPS) test. The Null hypothesis of the LLC test is that the panels contain unit roots. For the IPS tests, the null is that *all* panels contain unit roots. A P-value near zero indicates that one can reject the null. In none of these cases can the null hypothesis of a unit root be rejected at 10%.

7.5 Additional International Evidence (Online Appendix, Cont.)



(a) US, 1986-93 (slope not significant)

(b) Other Major Economies, 1986-93

Figure 17: International Evidence: Employment Growth vs. Openness

Source: UNIDOs (3-digit ISIC manufacturing sectors). Other major economies include Canada, France, Germany, Italy, and the UK.

Table 9: Additional International Evidence

	(1) DEU	(2) FRA	(3) ITA	(4) GBR	(5) JPN	(6) All	(7) All
L.Openness	0.063	0.052	0.031***	0.0056	-0.099	0.0020	0.0014
	(0.040)	(0.035)	(0.010)	(0.016)	(0.082)	(0.0063)	(0.0022)
L.Openness*ln(WARULC)	-0.27***	-0.25*	0.39***	-0.13***	-0.067*	-0.054**	-0.11***
	(0.056)	(0.14)	(0.095)	(0.027)	(0.039)	(0.022)	(0.015)
ln $\Delta(Y/L)$	-0.47***	-0.87***	-0.49***	-0.74***	-0.85***	-0.62***	-0.70***
	(0.17)	(0.071)	(0.096)	(0.17)	(0.044)	(0.069)	(0.031)
ln Δ Demand	0.44**	0.80***	0.60***	0.66***	0.85***	0.64***	0.67***
	(0.16)	(0.087)	(0.060)	(0.17)	(0.035)	(0.041)	(0.030)
Observations	328	647	695	668	719	3608	3608

Standard errors clustered by sector in parenthesis. $^*p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. The first five columns include year and 3-digit ISIC industry fixed effects using data from 1979 to 2003 for 29 sectors (West German data here is only through 1990). Columns (6) and (7) are stacked regressions with data from all 7 countries (including the US and Canada), with country*ISIC interactive FEs. Column (7) is a quantile regression.

7.6 Tables, Figures and Graphs (Online Appendix, Cont.)

Table 10: More on Imported Intermediate Inputs

	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L
A. OLS				
L.3-6yr.Openness*ln(WARULC)	-0.45***	-0.45***	-0.40***	-0.47***
	(0.086)	(0.090)	(0.085)	(0.088)
Imported Inputs*L.ln(WARULC)	-0.052			
	(0.19)			
L.3-6yr.Avg.Imported Inputs/Shipments		-0.00094		
		(0.0038)		
L.3-6yr.Avg.MPInp.*L.ln(WARULC)		-0.0054		
		(0.015)		
L.3-6yr.Avg.Narrow.Imported Inputs/Shipments			0.0023	
			(0.0017)	
L.3-6yr.Avg.NarrowMPInp.*L.ln(WARULC)			-0.013*	
			(0.0072)	
L.3-6yr.Avg.Non-Narrow.Imported Inputs/Shipments				-0.00021
				(0.0041)
L.3-6yr.Avg.NotNarrowMPInp.*L.ln(WARULC)				0.0060
				(0.012)
Observations	12469	11975	11885	11960
B. Quantile Regressions				
L.3-6yr.Openness*ln(WARULC)	-0.40***	-0.40***	-0.40***	-0.37***
	(0.073)	(0.066)	(0.069)	(0.076)
Imported Inputs*L.ln(WARULC)	-0.22*			
	(0.11)			
L.3-6yr.Avg.Imported Inputs/Shipments		0.00044		
		(0.0028)		
L.3-6yr.Avg.MPInp.*L.ln(WARULC)		-0.013		
		(0.0072)		
L.3-6yr.Avg.Narrow.Imported Inputs/Shipments			0.00036	
			(0.0014)	
L.3-6yr.Avg.NarrowMPInp.*L.ln(WARULC)			-0.0067*	
			(0.0030)	
L.3-6yr.Avg.Non-Narrow.Imported Inputs/Shipments				-0.000073
				(0.0027)
L.3-6yr.Avg.NotNarrowMPInp.*L.ln(WARULC)				-0.015**
				(0.0056)
Observations				

$^{*}p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. SEs in parentheses, clustered by year and by 4-digit SIC industry, and include year and SIC FEs. The Dep. var. is the log change in employment. Panel A is run with OLS; Panel B are quantile regressions. Other controls from Table 1 omitted for space. “Imported Inputs” is for 1997. “L.avg.MPInputs” is the average of imported inputs lagged 3, 4, 5, and 6 years. “L.avg.NarrowMPinputs” is an average of lagged intermediate inputs within the same 2 digit sectoral classification. “L.avg.NotNarrowMPInputs” is the average of lagged intermediate inputs which are not within the same 2-digit SIC classification.

Table 11: Falsification Exercises: Input Prices and Employment at Various Lags

	$ln\Delta$ L	$ln\Delta MaterialsPrices$	$ln\Delta EnergyPrices$	$ln\Delta InvestmentPrices$
L3.ln(WARULC)*Rel. Openness	-0.0077	-0.0044	-0.0057	0.0013
	(0.018)	(0.0085)	(0.0053)	(0.0022)
L2.ln(WARULC)*Rel. Openness	-0.043***	-0.0077	-0.0048	-0.00059
	(0.016)	(0.011)	(0.0047)	(0.0025)
L.ln(WARULC)*Rel. Openness	-0.061***	0.019*	0.018	0.0032
	(0.022)	(0.010)	(0.011)	(0.0034)
ln(WARULC)*Rel. Openness	-0.068**	0.0022	-0.0077	0.0015
	(0.027)	(0.0085)	(0.0065)	(0.0026)
F.ln(WARULC)*Rel. Openness	-0.038*	0.000042	-0.00094	0.0022
	(0.021)	(0.011)	(0.0039)	(0.0027)
F2.ln(WARULC)*Rel. Openness	-0.014	-0.010	-0.0036	0.0014
	(0.025)	(0.012)	(0.0043)	(0.0026)
F3.ln(WARULC)*Rel. Openness	0.0039	-0.0093	-0.00045	0.0023
	(0.022)	(0.0095)	(0.0049)	(0.0017)

Two-way Clustered standard errors in parenthesis, clustered by year and 4-digit SIC sectors. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. Each cell is a separate regression, with 28 regressions total, and with other controls from the benchmark regression suppressed. In addition, each regression controls for relative openess at the same number of leads and lags as the reported interaction term. The dependent variable in the first column is the log change in sectoral manufacturing employment. These results demonstrate that this estimation strategy is not generally prone to yielding spurious results.

Table 12: Appendix Robustness: Dynamics and Other Controls

	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L
A. Adding Dynamics and Other Controls						
L.ln(WARULC)*L.Rel.Openness	-0.087***	-0.087***	-0.089***			-0.094***
	(0.020)	(0.020)	(0.027)			(0.021)
L.$ln\Delta$ L	0.062***	0.063***				
	(0.020)	(0.021)				
L2.$ln\Delta$ L		-0.0087				
		(0.027)				
L.ln(WARULC)*L.Openness				-0.48***		
				(0.12)		
L.(WARULC-1)*L.Openness					-0.40***	
					(0.096)	
Duties						0.025*
						(0.014)
Ins., Freight Costs						-0.0038
						(0.0082)
B. Longer Lags of Rel. Openness						
L1.ln(WARULC)*L1.RO	-0.090***					
	(0.021)					
L1.ln(WARULC)*L2.RO		-0.075***				
		(0.021)				
L1.ln(WARULC)*L3.RO			-0.074***			
			(0.021)			
L1.ln(WARULC)*L4.RO				-0.070***		
				(0.018)		
L1.ln(WARULC)*L5.RO					-0.070***	
					(0.020)	
L1.ln(WARULC)*(RO in 1972)						-0.019***
						(0.0059)

Two-way clustered standard errors in parentheses, clustered by year and by 4-digit SIC industry. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regressions are weighted by initial sectoral value-added, and include 359 SIC industry and year fixed effects over the period 1973-2009. The dependent variable is the log change in sectoral manufacturing employment. In Panel A the first two columns add lagged dependent variables. Note that given T=37, Nickell Bias will be relatively small. The third column includes sector trends, which control for second-derivative trends in employment. The fourth column uses openess interacted with ln(WARULC) instead of relative openness as the regressor of interest, and the fifth column uses WARULC-1 in place of ln(WARULC), and the last column includes controls for the cost of insurance and freight. In Panel B, the key regressor is the lagged log of WARULC interacted with longer and longer lags of relative openness (RO). The last column interacts the lag of log WARULC Value-Added in 1972. The other controls from the baseline regression in Table I are suppressed.

Table 13: Exchange Rates, Openness, and US Manufacturing: with LDV

	(1) ln(L)	(2) ln(L)	(3) ln(L)	(4) ln(L)	(5) ln(L)	(6) ln(L)
L.ln(L)	0.97***	0.97***	0.99***	0.99***	0.97***	0.98***
	(0.0097)	(0.0097)	(0.0069)	(0.0070)	(0.0068)	(0.0063)
L.3-6yr.Openness	-0.11***	-0.071***	-0.065**	-0.018	-0.0089	-0.015
	(0.026)	(0.023)	(0.027)	(0.029)	(0.025)	(0.016)
L.3-6yr.Openness*ln Δ WARULC*Pos.	-0.49		-1.24*	-0.56		
	(0.33)		(0.72)	(0.76)		
L.3-6yr.Openness*ln Δ WARULC*Neg.	0.12		0.11	-0.011		
	(0.29)		(0.35)	(0.32)		
L.3-6yr.Openness*ln(WARULC)		-0.31***		-0.39***	-0.46***	-0.37***
		(0.085)		(0.091)	(0.10)	(0.077)
$ln\,\Delta$ Demand			0.43***	0.44***	0.37***	0.52***
			(0.064)	(0.063)	(0.067)	(0.047)
L.(K/L)			0.035	0.033	-0.012	0.033
			(0.030)	(0.030)	(0.031)	(0.037)
L.(K/L)*Real Interest Rate			-0.34	-0.41	-1.34***	-1.13
			(0.27)	(0.27)	(0.46)	(0.86)
$ln\Delta$ VA-per-Production Worker			-0.21***	-0.21***		
			(0.036)	(0.036)		
$ln\Delta$ TFP					-0.064	-0.25***
					(0.075)	(0.051)
Post-PNTR x NTR *Gap_i*					0.044***	0.045***
					(0.014)	(0.015)
MFA Exposure					-0.081***	-0.054***
					(0.020)	(0.014)
Imported Inputs*L.ln(WARULC)					0.11	-0.18*
					(0.17)	(0.10)
L.3-6yr.Openness*Real Interest Rate					-0.024	-0.021
					(0.078)	(0.042)
L.$ln\,\Delta$ PM*(M/S)					-0.15*	-0.17***
					(0.080)	(0.065)
L.$ln\,\Delta$ PI*(I/S)					-1.70***	-0.59
					(0.56)	(0.80)
Observations	12469	12469	12469	12469	12357	

*$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-way clustered standard errors in parentheses, clustered by year and by 4-digit SIC industry. All regressions are weighted by initial sectoral value-added, and include 359 SIC industry and year fixed effects over the period 1975-2009. The dependent variable is log sectoral employment, and includes a lagged dependent variable. Note that in a 35 year panel, the resulting Nickell Bias will be small, and should also shrink the coefficient on the lagged dependent variable itself. Without FEs, it will be closer to one. The last column is a quantile regression minimizing the sum of absolute deviations, the other regressions are OLS. Sectoral changes in the cost of investment, energy, and materials are omitted for space. L.3-6yr.Openness equals average openness lagged 3, 4, 5, and 6 years as elsewhere.

Table 14: Impact of Job Creation, Destruction, and Shipments

	(1) Job Creation	(2) Job Destruction	(3) $ln\Delta$ Ship
L.3-6yr.Openness	2.513*	-1.469	0.0000838
	(1.280)	(1.822)	(0.0291)
L.3-6yr.Openness*ln(WARULC)	-9.590***	33.06***	-0.542***
	(2.860)	(7.639)	(0.0967)
Industries	448	437	437
Observations	10076	9842	13975
Within R-squared	0.251	0.322	0.649
Between R-squared	0.00556	0.0509	0.412
Overall R-squared	0.112	0.112	0.599

*$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-way clustered standard errors in parentheses, clustered by year and by 4-digit SIC industry. Regressions weighted by initial sectoral value-added, and include 359 SIC industry and year fixed effects over the period 1975-1998 for the first two columns, and 1975-2009 for the third. The dependent variables are job creation, job destruction, and the log change in shipments. Job creation and destruction data are from Davis *et al.* (1998). L.3-6yr.Openness equals average openness lagged 3, 4, 5, and 6 years as elsewhere.

Table 15: Previous Robustness Table (March, 2016 version)

	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L
A. Altering FEs, Controls						
L.ln(WARULC)*L.Avg.Openness	-0.48***	-0.48***	-0.50***	-0.45***	-0.60***	-0.45***
	(0.10)	(0.10)	(0.10)	(0.086)	(0.12)	(0.095)
Year FE	No	Yes	No	Yes	No	Yes
Industry FE	No	No	Yes	Yes	No	Yes
Full Controls	Yes	Yes	Yes	No	No	Yes
B. Using Openness (one lag)						
L.ln(WARULC)*L.Openness	-0.39***	-0.39***	-0.44***	-0.38***	-0.55***	-0.36***
	(0.12)	(0.12)	(0.14)	(0.12)	(0.14)	(0.12)
Year FE	No	Yes	No	Yes	No	Yes
Industry FE	No	No	Yes	Yes	No	Yes
Full Controls	Yes	Yes	Yes	No	No	Yes
C. Altering Weights						
L.ln(WARULC)*L.Avg.Openness	-0.45***	-0.44***	-0.48***	-0.43***	-0.41***	-0.41***
	(0.095)	(0.095)	(0.10)	(0.090)	(0.12)	(0.13)
Weights	VA, 1972	None	Emp., 1972	Ship., 1972	Avg. VA	L.VA
D. Adding and Subtracting Sectors						
L.ln(WARULC)*L.Avg.Openness	-0.45***	-0.45***	-0.45***	-0.45***	-0.42***	-0.45***
	(0.095)	(0.095)	(0.094)	(0.095)	(0.094)	(0.094)
Unbalanced Sectors	No	Yes	No	No	No	Yes
Defense Related Sectors	Yes	Yes	Yes	No	Yes	Yes
Publishing	No	No	Yes	No	No	Yes
Computers	Yes	Yes	Yes	Yes	No	Yes
Number of Sectors	359	437	363	352	354	448
E. Imports, Exports, and China						
L.Avg.Import Pen.*ln(iWARULC)	-0.58*	-0.31***	-0.34**			
	(0.31)	(0.11)	(0.16)			
L.Avg.Export Share.*ln(eWARULC)	-0.46*	0.026	-0.21			
	(0.24)	(0.13)	(0.19)			
L.Avg.MPPen.(ex-China)*FedRER				-0.43***	-0.40***	-0.46***
				(0.11)	(0.11)	(0.12)
L.Avg.Chinese Pen.*ln(RULC)				-0.044	-0.061	-0.095***
				(0.034)	(0.038)	(0.025)
Industry FE	Yes	Yes	Yes	Yes	Yes	No
Time Period	1973-1989	1990-2009	1973-2009	1973-2009	1990-2009	1990-2009

Two-way clustered standard errors in parenthesis, clustered by year and 4-digit SIC sectors. *$p < 0.1$, **$p < 0.05$, ***$p < 0.01$. There are five sets of six regressions, for 30 regressions total, with the same controls as in column (5) of Table I, the baseline regression in the paper, with the other controls suppressed for space. Panel A varies the fixed effects (SIC industry effects, and year effects) and whether or not the full list of controls are included. L.Avg. Openness is again defined as the average of openness lagged 3, 4, 5, and 6 years. Panel B uses the interaction between ln(WARULC) and openness lagged just one year as the key variable of interest, and also includes a control for the weighted average of lagged opennnes. Panel C varies the weighting scheme used in the paper, between using initial Value-Added (VA), vs. no weights, initial employment or shipments, average VA or VA lagged one period. Panel D adds and subtracts industries which are either unbalanced, or for which there are logical reasons why they should be excluded. In the first three columns of panel E, the key variables are now the import-Weighted Average RULC index interacted with import penetration, and export-WARULC interacted with the export share of shipments. In the last three columns, I interact the Fed's RER index with the Import Penetration ex-China versus Chinese Import Penetration interacted with bilateral Sino-American RULCs.

.

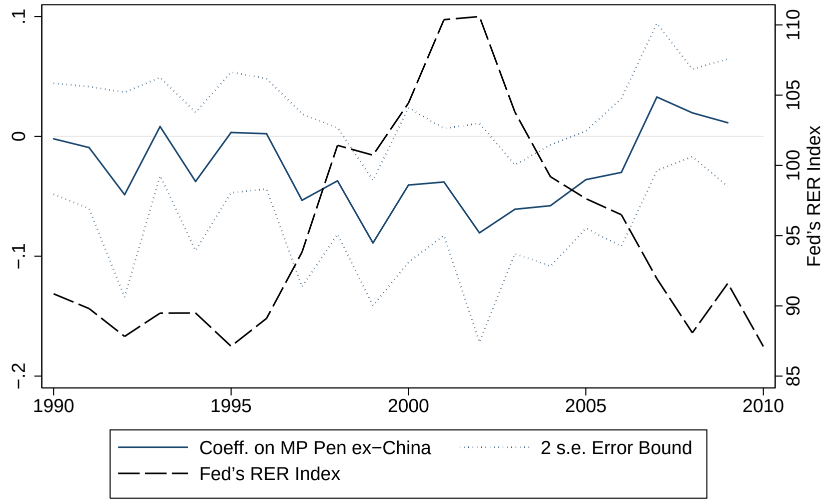


Figure 18: Was it Just China?

Note: This figure reports the coefficient on Import Penetration excluding China from the following regression: $ln\Delta L_{ht} = \alpha_t + \beta_0 MPPen.exChina_{h,t-1} + \beta_1 ChineseMPPen._{h,t-1} + \beta_2 ln\Delta D_{h,t} + \beta_3 ln\Delta TFP_{h,t} + \beta_4 PostPNTR * NTRGap_h + \beta_5 MFAExposure_{ht} + \epsilon_{ht}$, for 359 sectors. Note that the Fed's Index is calculated using an index-of-indices approach that doesn't reflect the role of rising trade integration with China. Standard errors conservatively clustered at the 3-digit SIC level. D is an IV for sectoral demand as is used elsewhere in the paper.

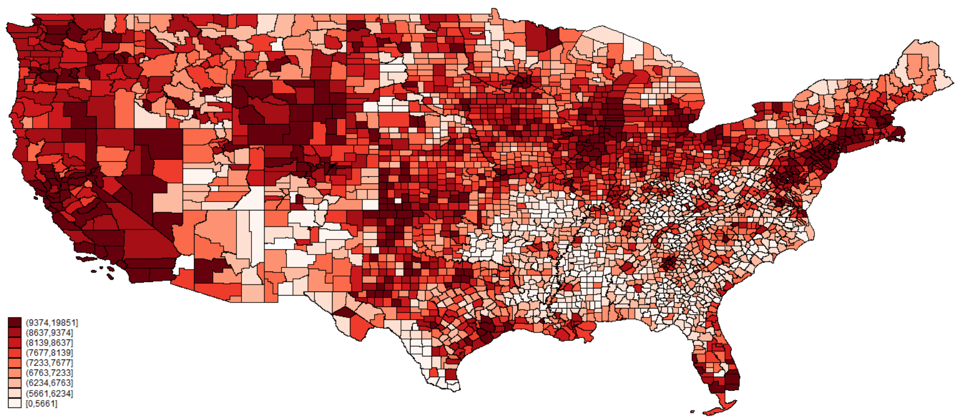


Figure 19: Income per Capita, 1979

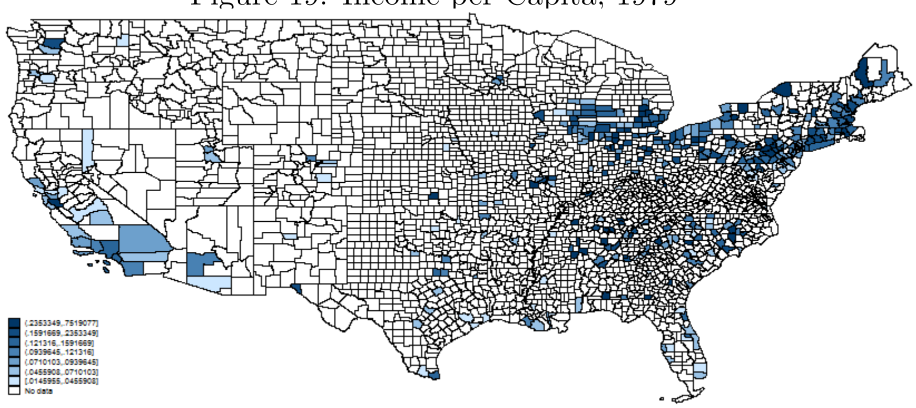


Figure 20: Import-Competing Manufacturing Employment, Share of Total Employment, 1979

Notes: 1,500 worker minimum. Sources: Census Bureau and WITS.

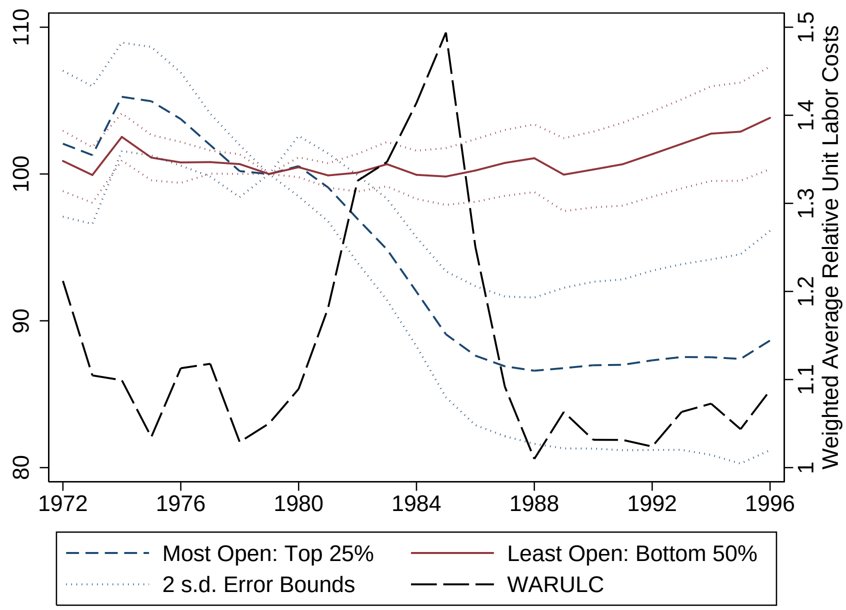


Figure 21: Employment Growth by Degree of Openness in 1972 (SIC)*

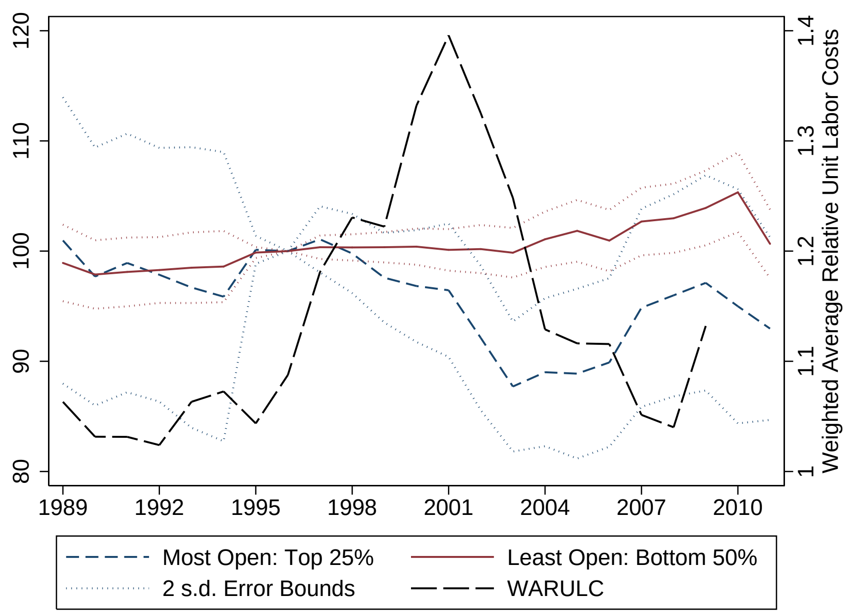


Figure 22: Employment Growth by Degree of Openness in 1989 (NAICs)*

*Notes: Openness = m*imports/(imports+shipments-exports)+(1-m)*(exports/shipments), where m = imports/(imports + exports). Employment is indexed to 1979 in Figure 3, which uses SIC data, and to 1996 in Figure 4, which uses NAICs data, and is updated with residuals from a regression controlling for demand, productivity, and year fixed effects. Thus the blue dashed lines in the figures tell us how employment in more open sectors evolved after controlling for other key factors. The cutoff for the non-open sectors was 3.8% in 1972 and 9.7% in 1989, and the lower bound for the open sectors was 8.3% in 1972 and 20.9% in 1989.

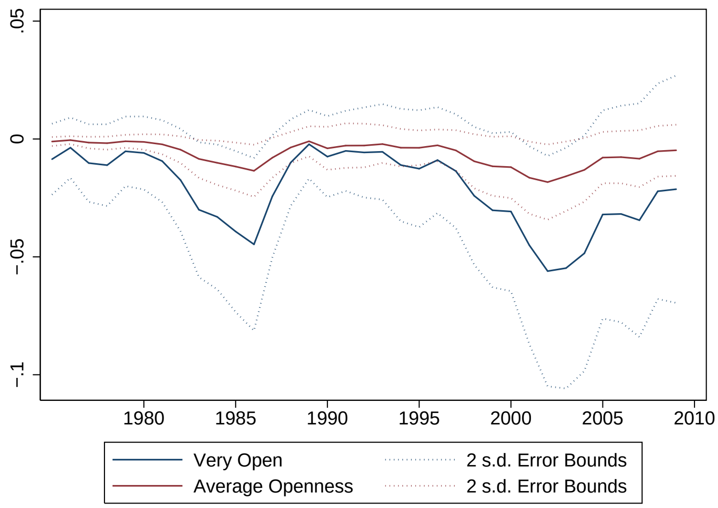


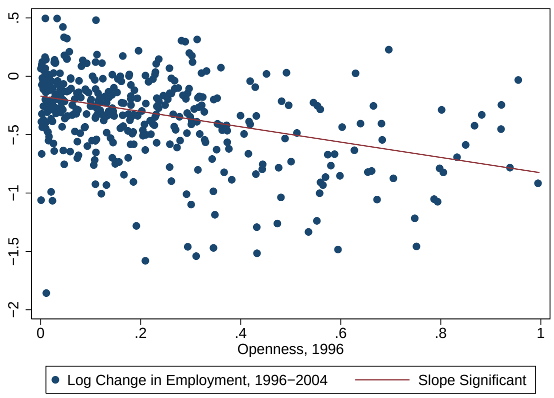
Figure 23: Implied Job Losses for Two Sectors

Note: This figure estimates the linear combination of $\beta_0 Avg.Openness_{h,t-3,t-6} + \beta_1(ln(WARULC_{t-1}))* Avg.Openness_{h,t-3,t-6}$ from the benchmark regression in Column 5 in Table 1 for two sectors. One sector has average openness and the other is one of the most open sectors in the economy (with an average openness of 50% in the early 1980s. The y-axis is thus the log change in sectoral employment. I thank a referee for the suggestion.

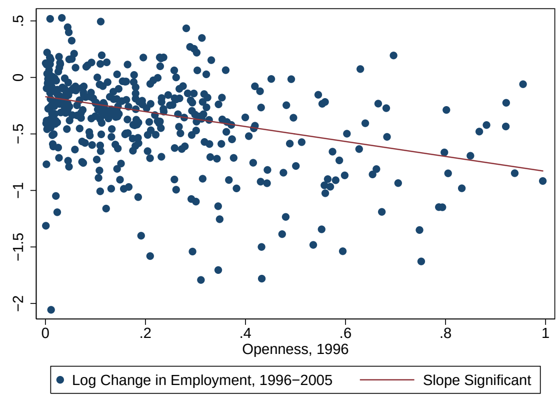
7.7 Proxies and Alternative Measures of RER Indices

Large US fiscal deficits were a likely cause of the dollar's strength during the early 1980s. Fiscal deficits can affect the tradable sector in at least four ways. First, even in a closed economy setting, higher government spending could induce more resource allocation away from manufacturing via rising wages or real interest rates. Secondly, government purchases of defense equipment could impact those sectors directly (part of the motivation for controlling for domestic demand growth, and for dropping defense-related sectors). Thirdly, in an open economy, higher real interest rates can cause currency appreciation due to international interest rate parity. Additionally, a larger supply of US Treasuries may induce foreign purchases of dollars given that there is a globally limited supply of safe, highly liquid, positive-yielding assets whose value appreciates during periods of financial turmoil. Empirically, Guajardo et al. (2014) examine the impact of fiscal changes on RERs in OECD countries, finding that fiscal consolidation leads to RER depreciation precisely as textbook theory predicts.

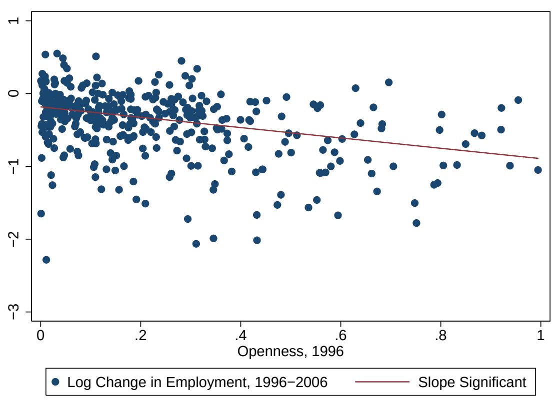
Hence, in this section, I estimate reduced-form regressions using changes in defense spending and the budget deficit ex-automatic stabilizers to predict differential changes in employment in more tradable sectors. The benefit of this research design is that the changes in defense spending and budget posture were the result of longstanding campaign



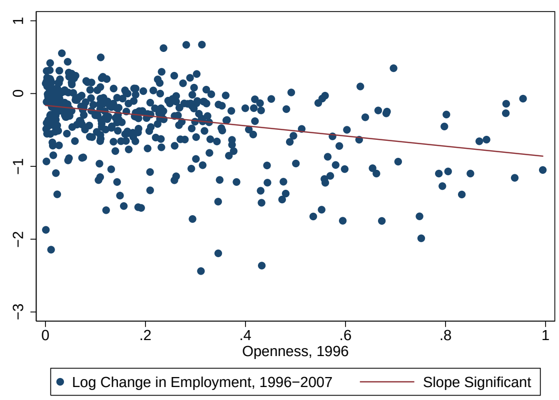
(a) 1996-2004 (Dollar Overvalued)



(b) 1996-2005 (Dollar Overvalued)



(c) 1996-2006 (Dollar Overvalued)



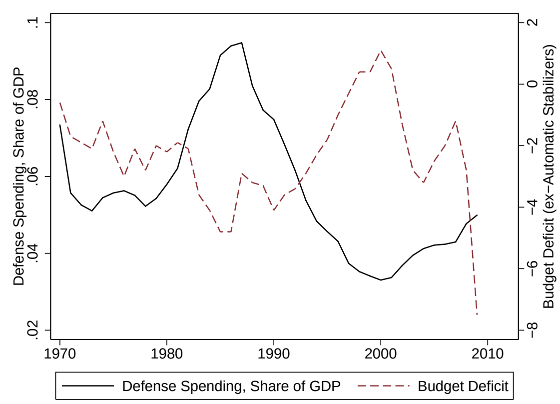
(d) 1996-2007 (Dollar Overvalued)

Figure 24: Employment Growth vs. Openness: 1996 to 2005 vs. 2004, 2006, & 2007

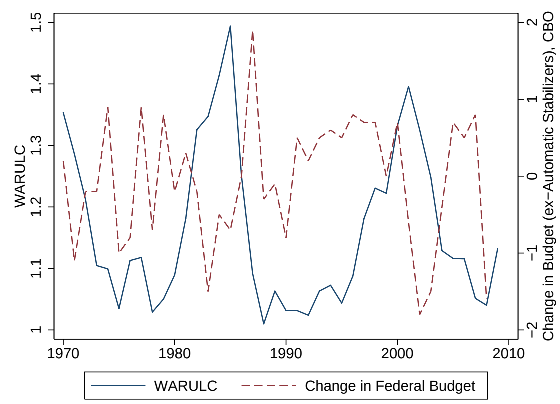
Notes: At the request of a referee, we compare the correlation between openness in 1996 with other ending dates beside 2005. The correlation holds up if we consider 2004, 2005, 2006, or 2007. Note that the y-axis does change as the job losses become more severe.

promises that came to fruition after the outcomes of close presidential elections. Thus, I would argue that these elections were exogenous from the perspective of the subsequent evolution of manufacturing employment in more open sectors.

Figure 25(a) shows that defense spending as a share of GDP increased dramatically after the US election of 1980, and then increased again after the election in 2000. Changes in the US budget deficit appear to be related to changes in WARULC (Figure 25(b)), although the correlation with other measures of the real exchange rate, such as WARP or the Fed's index, is even more pronounced.



(a) Defense Spending vs. Budget Deficit



(b) Structural Budget Deficit vs. WARULC

Figure 25: Defense Spending, the Structural Budget Deficit, and RULCs
Sources: FRED and CBO

In Table 17 column (1), I regress lagged relative openness interacted with log changes in defense spending over GDP (divided by ten to normalize the coefficient). Once again, I get a negative, statistically significant coefficient, which implies that in 1985, when defense spending as a share of GDP increased by 10%, a sector with a relative openness of twice the average would have experienced a decline in employment by two percent relative to a closed sector. This effect is not driven by GDP as the denominator, since if we deflate defense spending with total manufacturing shipments instead, as in column (2), the results only get stronger. In column (3), I use the interaction of relative openness with changes in the budget deficit ex-automatic stabilizers and find that increases in the budget balance are also good for relatively more tradable sectors.

Next I consider alternative measures of relative prices, including several versions of Weighted Average Relative Price (WARP) indices, and sector-specific WARULC indices (discussed more in Appendix Section 7.3). As argued in Campbell (2016), unit labor cost-based relative price measures are not necessarily *a priori* better measures of competitiveness than Penn-Adjusted Weighted Average Relative Price (PWARP) indices. This is because manufacturing requires many more inputs, including nontraded inputs, than just labor, as labor costs fell to just 23% of total costs by 2007 (or 32% of value-added). Thus broader measures of prices may be just as appropriate to gauge competitiveness as ULC indices.

In Table 17, I show that the results hold for the other WAR exchange rate indices. In column (4), I use the lagged log of a GDP-Weighted Average Relative Price (GWARP) index. This is an important robustness check for those who may be concerned that the trade-weights themselves are endogenous and may be driving the result. In column (5) I use the log of the PWARP index (the Penn or Balassa-Samuelson adjusted version of WARP). In each case, the results are little changed.

Table 17: RER Proxies and Alternative Measures of Relative Prices

	(1) $ln\Delta$ L	(2) $ln\Delta$ L	(3) $ln\Delta$ L	(4) $ln\Delta$ L	(5) $ln\Delta$ L	(6) $ln\Delta$ L
L.3-6yr.Openness* $ln\Delta$ (Defense/GDP)	-4.52**					
	(1.78)					
L.3-6yr.Openness* $ln\Delta$ (Defense/Shipments)		-2.75***				
		(1.03)				
L.3-6yr.Openness*Δ Structural Budget			3.26***			
			(1.17)			
L.3-6yr.Openness*ln(G-WARP)				-0.22**		
				(0.097)		
L.3-6yr.Openness*ln(PWARP)					-0.30***	
					(0.094)	
L.ln(Sectoral WARULC)						0.0058
						(0.011)
L.3-6yr.Openness*ln(Sectoral WARULC)						-0.083**
						(0.035)
L.3-6yr.Openness*ln(WARULC)						-0.39***
						(0.10)
Observations	12357	12357	12357	12357	13783	12357

**$p < 0.05$, *** $p < 0.01$. All regressions are weighted by initial sectoral value-added, and include 359 SIC industry FEs and year fixed effects over the period 1975-2009. The dependent variable is the log change in sectoral manufacturing employment. All other controls from Table 1 are suppressed for space.

Additionally, in column (6), I use WARULC computed with sector-specific trade weights (following Revenga (1992) and Gourinchas (1999)) in addition to controlling for the sector-wide WARULC. The only change with sectoral WARULC is that the trade weights are computed as imports plus exports at the sectoral level, as opposed to using economy-wide trade data. Unfortunately, complete unit labor cost data, including for manufacturing PPP, is not available internationally at a disaggregated level. Sectoral real exchange rates may *a priori* seem like a vast improvement over using real exchange rates for the manufacturing sector as a whole, and, indeed, they do add significant explanatory power as the "between" R-squared nearly doubles, while the overall R-squared also increases modestly, providing further evidence that relative prices affect manufacturing employment. However, in earlier versions of this paper which simply used single lags in openness and relative openness, I had also found that this result was sometimes sensitive the exact specification and controls, which is why I chose to use the economy-wide rate in the main regression tables.

7.8 Using Alternative Measures of Openness

An alternative measure of openness is simply to take total trade and divide this by total shipments. I compare this second measure of openness in Figure 26 below. In Figure 27, I compare the employment declines in both periods of appreciation using each measure of openness, to gauge the fit. In fact, the fit looks good for both, which isn't surprising given that the measures are highly correlated. One difference though is that most observations of Trade/Shipments are less than 1, so that it's hard to see how good the fit is for the majority of the sectors.

Thus, in Tables 18 and 21, we test the R-squareds for how openness predicts employment declines for the two periods when the dollar was overvalued. We do this for the full sample in Table 18, and for a restricted sample in Table 21, where we eliminated sectors with (1) negative raw values for import penetration, (2) very large values for trade/shipments, (3) publishing,

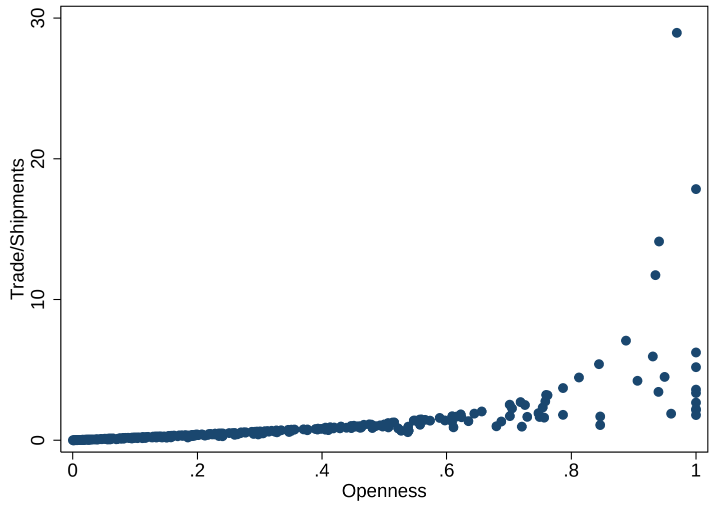


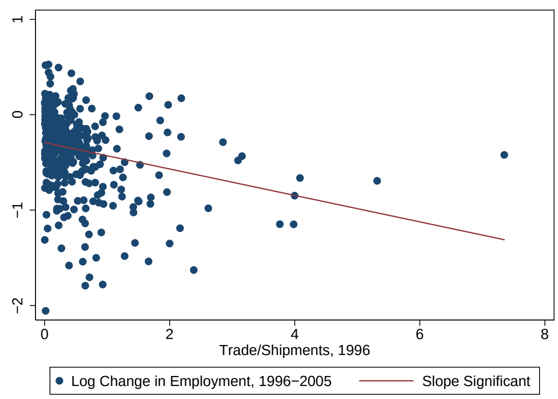
Figure 26: Comparing Two Measures of Openness

Note: This Figure compares two measures of openness. One is total trade/Shipments (special thanks to an anonymous referee for suggesting). The second is a weighted average of import penetration and the export share of shipments: openness = m*(imports/(imports+shipments-exports) + (1-m)*(exports/shipments), where m = imports/(imports+exports).

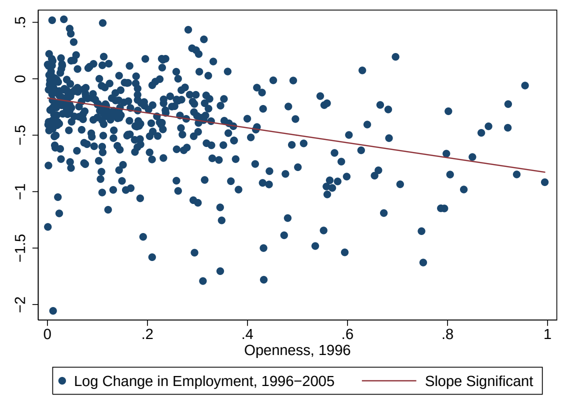
Table 18: Comparing the Fit of Two Measures of Openness (Unrestricted Sample)

	(1) 1979-1986	(2) 1979-1986	(3) 1996-2005	(4) 1996-2005
L7.Trade/Shipments	-0.17***			
	(-2.59)			
L9.Trade/Shipments			-0.028**	
			(-2.17)	
L7.Openness		-0.58***		
		(-4.55)		
L9.Openness				-0.54***
				(-5.19)
Observations	444	444	395	395
r2	0.068	0.078	0.027	0.092

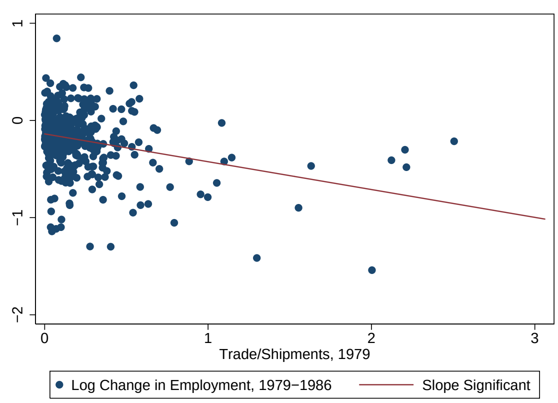
**$p < 0.05$, *** $p < 0.01$. T-statistics in parenthesis.



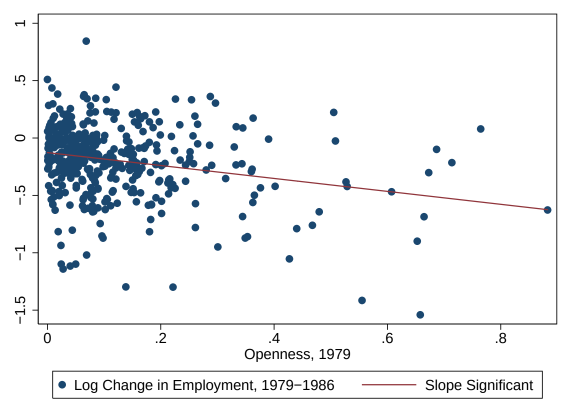
(a) 1996-2005 (Trade/Shipments)



(b) 1996-2005 (Openness)



(c) 1979-1986 (Trade/Shipments)



(d) 1979-1986 (Openness)

Figure 27: Comparing Trade/Shipments vs. Openness

Notes: At the request of a referee, we compare the measure of openness we use in the paper vs. trade/shipments.

Table 19: Comparing the Fit of Two Measures of Openness (Restricted Sample)

	(1) 1979-1986	(2) 1979-1986	(3) 1996-2005	(4) 1996-2005
L7.Trade/Shipments	-0.218**			
	(-2.59)			
L9.Trade/Shipments			-0.263***	
			(-5.13)	
L7.Openness		-0.469***		
		(-2.95)		
L9.Openness				-0.789***
				(-5.71)
Observations	358	358	354	354
r2	0.0516	0.0527	0.153	0.161

**$p < 0.05$, *** $p < 0.01$. The first two regressions compare openness in 1979 vs. sectoral employment growth from 1979 to 1986. The second two regressions compare openness in 1996 vs. sectoral employment growth from 1996 to 2005. In this case, we've restricted the sample in various ways, limiting outliers with large values of openness, and negative values of import penetration. We've also limited to the full balanced sample we use in our main regression table, and have not included publishing.

Table 20: Comparing the Fit of Two Measures of Openness on Full Panel

	(1) Full Sample	(2) Full Sample	(3) Restricted Sample	(4) Restricted Sample
L3-6.Trade/Shipments	0.00515		0.00478	
	(1.51)		(0.62)	
L3-6.(Trade/Shipments)*ln(WARULC)	-0.0584*		-0.110***	
	(-1.87)		(-2.65)	
L.3-6yr.Openness		0.0238		0.0233
		(0.96)		(0.91)
L.3-6yr.Openness*ln(WARULC)		-0.440***		-0.452***
		(-4.52)		(-4.49)
Observations	11863	11863	11772	11772
r2	0.487	0.492	0.487	0.491

**$p < 0.05$, *** $p < 0.01$. Year and SIC fixed effects are included and errors are clustered by both year and 4-digit SIC industry. The first two regressions run the full panel regression using the benchmark setup, and omitting other controls from the benchmark table for space. The second two regressions omit observations in which the average 3-6 year lag of Trade/Shipments is larger than 5.

Table 21: Assymmetry Test: Appreciation vs. Depreciation

	(1)	(2)
	$ln\Delta$ L	$ln\Delta$ L
L.3-6yr.Openness*ln(WARULC)	-0.44***	
	(0.097)	
L.ln(WARULC)*L.Avg.Openness*Appreciate		-0.46***
		(0.15)
L.ln(WARULC)*L.Avg.Openness*Depreciate		-0.43***
		(0.087)
Observations	11863	11863
r2	0.49	0.49

$^{**}p < 0.05$, $^{***}\ p < 0.01$. Year and SIC fixed effects are included and errors are clustered by both year and 4-digit SIC industry. In the second regression, the key interaction term of ln(WARULC)*Log Average Openness is also interacted with a dummy for periods of appreciation and depreciation.

Table 22: Additional Robustness: More Control Variables

	(1)	(2)	(3)	(4)	(5)
	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L
L.3-6yr.Openness*ln(WARULC)	-0.35***	-0.33***	-0.35***	-0.32***	-0.34***
	(0.088)	(0.090)	(0.088)	(0.090)	(0.091)
L.Pay per Worker		0.0018***	0.00048		
		(0.00056)	(0.00047)		
L.Skilled Workers Ratio		-0.11***		-0.096***	
		(0.018)		(0.019)	
L.VA/Worker		-0.000025			
		(0.000016)			
L.Worker Pay (3 yr. MA)					0.0012**
					(0.00056)
L.Skilled Ratio (3 yr. MA)					-0.088***
					(0.018)
L.VA/Worker (3 yr. MA)					-0.0000073
					(0.0000051)
Observations	11863	11863	11863	11863	11863
r2	0.35	0.37	0.35	0.36	0.36

**$p < 0.05$, *** $p < 0.01$. Year and SIC fixed effects are included and errors are clustered by both year and 4-digit SIC industry. In column (2), the lags of Pay per worker, the ratio of Skilled to non-skilled workers (proxied by the non-production to production worker ratio) are added as controls, and a three year moving average of these variables is added in column (5). The three year moving average is an average of the variable lagged 1, 2, and 3 years.

Table 16: Previous Robustness Table (November, 2016 version)

	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L
A. Altering FEs, Controls						
L.3-6yr.Openness*ln(WARULC)	-0.45***	-0.48***	-0.50***	-0.45***	-0.60***	-0.34***
	(0.10)	(0.11)	(0.11)	(0.086)	(0.12)	(0.11)
FEs	SIC, Year	Year	SIC	Year, SIC	None	SIC2D*Year
Full Controls	Yes	Yes	Yes	No	No	Yes
B. Quantile Regressions						
L.3-6yr.Openness*ln(WARULC)	-0.39***	-0.42***	-0.43***	-0.41***	-0.62***	-0.32***
	(0.083)	(0.076)	(0.094)	(0.073)	(0.11)	(0.061)
FEs	SIC, Year	Year	SIC	Year, SIC	None	SIC2D*Year
Full Controls	Yes	Yes	Yes	No	No	Yes
C. Altering Weights						
L.3-6yr.Openness*ln(WARULC)	-0.45***	-0.44***	-0.45***	-0.48***	-0.43***	-0.40***
	(0.10)	(0.096)	(0.093)	(0.11)	(0.097)	(0.13)
Weights	VA, 1972	None	ln(VA,1972)	Emp., 1972	Ship., 1972	L.VA
D. Adding and Subtracting Sectors						
L.3-6yr.Openness*ln(WARULC)	-0.45***	-0.45***	-0.45***	-0.45***	-0.42***	-0.45***
	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)	(0.10)
Unbalanced Sectors	No	Yes	No	No	No	Yes
Defense Related Sectors	Yes	Yes	Yes	No	No	Yes
Publishing	No	No	Yes	No	No	Yes
Computers	Yes	Yes	Yes	Yes	No	Yes
Number of Sectors	359	437	363	352	347	448
E. Alternative RER Functional Form						
L.3-6yr.Open.*I.{WARULC<1.1}	-0.0074	-0.00063	-0.027	-0.0096	-0.026	-0.0061
	(0.024)	(0.015)	(0.026)	(0.021)	(0.024)	(0.016)
L.3-6yr.Open.*I.{1.1<WARULC<1.2}	-0.048**	-0.049***	-0.015	-0.054***	-0.048**	-0.053***
	(0.024)	(0.015)	(0.025)	(0.019)	(0.022)	(0.014)
L.3-6yr.Open.*I.{1.2<WARULC<1.3}	-0.098***	-0.11***	-0.10***	-0.11***	-0.12***	-0.098***
	(0.032)	(0.024)	(0.038)	(0.029)	(0.039)	(0.020)
L.3-6yr.Open.*I.{1.3<WARULC<1.4}	-0.11**	-0.12***	-0.13***	-0.12***	-0.16***	-0.080***
	(0.051)	(0.032)	(0.044)	(0.045)	(0.029)	(0.025)
L.3-6yr.Open.*I.{1.4<WARULC}	-0.12***	-0.12***	-0.17***	-0.14***	-0.21***	-0.14***
	(0.027)	(0.025)	(0.031)	(0.028)	(0.036)	(0.022)
Reg Type	OLS	OLS	OLS	OLS	OLS	Quantile
FEs	SIC, Year	Year	SIC	Year, SIC	None	Year, SIC
Controls	Yes	Yes	Yes	No	No	Yes

Errors clustered by year and 4-digit SIC sectors. $*p < 0.1$, $**p < 0.05$, $***p < 0.01$. There are five sets of six regressions, with the same controls as in column (5) of Table I, the baseline regression, with other controls suppressed for space. Panel A varies the fixed effects (SIC industry effects, and year effects) and the inclusion of other controls. L.3-6yr. Openness is again defined as the average of openness lagged 3, 4, 5, and 6 years. Column (6) includes 2-digit SIC*year interactive fixed effects or 20*37= 740 FEs, in addition to SIC FEs. Panel B repeats Panel A using quantile regressions. Panel C varies the weighting scheme used in the paper, between using initial Value-Added (VA), vs. no weights, log initial value-added, initial employment or shipments, or VA lagged one period. Panel D adds and subtracts industries which are either unbalanced, or for which there are logical reasons why they should be excluded. In the first three columns of panel E, the key variables are now the import-Weighted Average RULC index interacted with import penetration, and export-WARULC interacted with the export share of shipments. In the last three columns, I interact the Fed's RER index with the Import Penetration ex-China versus Chinese Import Penetration interacted with bilateral Sino-American RULCs. The main difference between this table and the one in the paper is that this uses demand as as a control instead of an IV for demand.

Table 23: Controlling for Foreign Demand

	(1)	(2)	(3)	(4)
	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L	$ln\Delta$ L
L.3-6yr.Openness*ln(WARULC)	-0.38***	-0.37***	-0.36***	-0.37***
	(0.073)	(0.078)	(0.078)	(0.078)
Δ ln(Demand, IV))	0.45***	0.46***	0.45***	0.47***
	(0.090)	(0.088)	(0.093)	(0.090)
L.(K/L)	0.078**	0.087**	0.086**	0.090**
	(0.031)	(0.042)	(0.042)	(0.041)
L.(K/L)*Real Interest Rate	-1.12**	-1.10**	-1.10**	-1.12**
	(0.57)	(0.56)	(0.56)	(0.56)
L.Δ ln(Wages)	0.017	0.021	0.021	0.021
	(0.029)	(0.032)	(0.032)	(0.032)
L.ln Δ Price of Shipments	0.040**	0.019	0.018	0.020
	(0.020)	(0.019)	(0.019)	(0.019)
ln Δ VA-per-Prod. Worker	-0.066***	-0.078***	-0.078***	-0.078***
	(0.022)	(0.020)	(0.020)	(0.019)
Δ ln(Foreign GDP)		0.088		
		(0.13)		
Δ ln(Foreign Demand, IV)			0.051	
			(0.068)	
L.3-6yr.Export Share*Δ ln(Foreign Demand, IV)				-0.17
				(0.17)
Observations	12469	10979	10979	10979
r2	0.34	0.31	0.31	0.31

*$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. Two-way clustered standard errors in parentheses, clustered by year and by 4-digit SIC industry. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. This Table repeats the regression in Column (4) of Table 1, only adding in various countrols for foreign demand. Column (2) includes a control for a average of foreign demand, weighted by exports at the 4-digit SIC level. Column (3) multiplies this amount by the domestic demand elasticity for each 4-digit domestic sector (creating a quasi-IV). Column (4) interacts a weighted average of the export share and the foreign demand IV.