

Relative Prices, Hysteresis, and the Decline of American Manufacturing

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Abstract

This study uses new measures of real exchange rates 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 US 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. I use disaggregated sectoral data and a difference-in-difference methodology, finding that an appreciation in relative unit labor costs for the US lead to disproportionate declines in employment, output, investment, and productivity in relatively more open manufacturing sectors. The two most important contributions of this paper are (1) that the impact of a temporary shock to real exchange rates is surprisingly long-lived (hysteresis), and (2) the appreciation of US relative unit labor costs can plausibly explain more than two-thirds of the decline in manufacturing employment in the early 2000s.

JEL Classification: F10, F16, L60

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American manufacturing employment suddenly collapsed in the early 2000s, falling by three million (17.4%) from 2000 to 2003 (Figure 1)¹ after having declined by just 3% from the late 1960s to 2000.² As the economy grew from 2003-2007, the lost jobs did not return. In the aftermath of the financial crisis in 2008, the manufacturing sector lost an additional 2.3 million jobs. In the past five years, fewer than 800,000 of these jobs have returned, indicating that many of the jobs lost during the recession are most likely gone permanently.

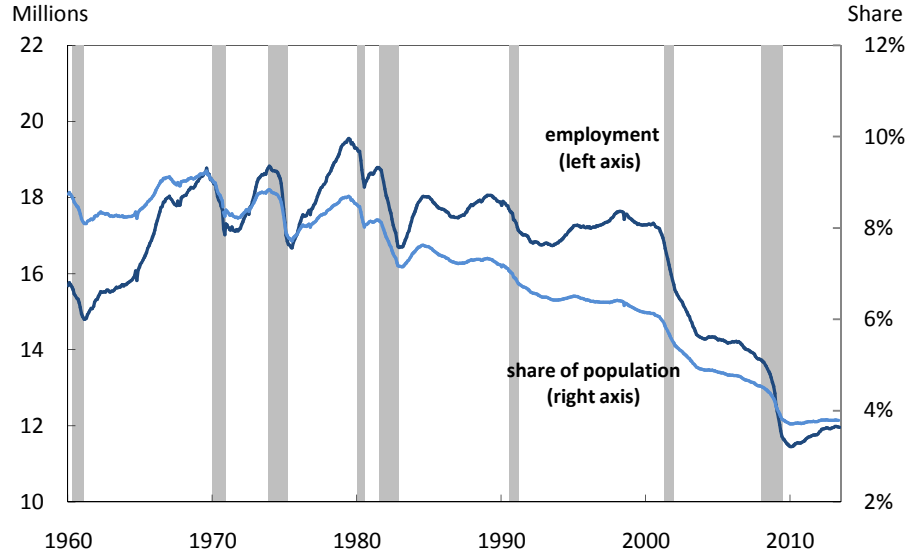


Figure 1: American Manufacturing Employment, 1960-2013.

Source: BEA

What caused the sudden collapse? Economists have generally believed that the public's concern with trade and offshoring as an explanation for the decline of American manufacturing employment is misplaced (Baily and Bosworth, 2014, Edwards and Lawrence, 2013, and Kehoe, Ruhl, and Steinberg 2014, Alessandria and Choi 2014), and that the real cause is outsized productivity gains in manufacturing and a sectoral shift

¹Many commenters and a referee have suggested plotting manufacturing employment as a share of total employment. This would also reveal that the share of manufacturing employment was below trend in the 2000s, although it would be less obvious. However, this measure could be misleading. If manufacturing constitutes all of the tradable-sector jobs in one location, and if 90% of the manufacturing jobs in this location (for example, Detroit) are suddenly eliminated, then eventually 90% of the non-tradable sector jobs in that location might also likely be eliminated. In this scenario there would be no change in the share of manufacturing jobs, even though the decline in manufacturing employment was the fundamental cause of the decline.

²Note that if one extrapolated from the trend in manufacturing employment as a share of the population from 1970 to 2000, it would imply that manufacturing employment would become *negative* by 2065. Thus, it would seem 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.

toward services. If true, this would imply that a decline in manufacturing employment is a sign of progress, and irrelevant due to growing services exports. However, aggregate measured labor productivity growth in manufacturing has been relatively constant over the post-war period, making it a strange explanation for a sudden employment collapse in this sector (Appendix Figure 17(a)), while productivity for the median manufacturing sector actually *declined* in the 2000s.³ And while the share of services in GDP has long been increasing, the decline in the share of manufacturing consumption from its average in the late 1990s to 2005 was just .5% of GDP (Table VIII)⁴, while the services share of exports has been surprisingly constant over the past few decades (Figure 16(b)). In fact, the services trade surplus actually shrank by one-third over the period 1997-2004, while the goods trade deficit ex-manufacturing also worsened. Thus, the decline in manufacturing in the early 2000s was actually part of a broad-based decline in tradable sectors.⁵

These facts give credence to recent research focusing on trade liberalization and the rise of China as explanations for the collapse of US manufacturing. In a seminal paper, Autor, Dorn and Hanson (2013) find that increasing competition with Chinese imports explains one-quarter of the aggregate loss in manufacturing employment through 2007. Acemoglu *et al.* (2015) argue that the “sag” in *overall* U.S. employment in the 2000s – a decade which began with the Federal Reserve nearly missing the zero lower bound and which ended in a liquidity trap – was partly caused by the collateral damage from increasing Chinese manufacturing imports to other sectors via input-output linkages.⁶ In another important contribution, Pierce and Schott (2015) argue that China’s ascension

³Yet, Houseman *et al.* (2010) present evidence that perhaps one-fifth to one-half of the measured growth in value-added per worker in manufacturing from 1997 to 2007 reflects upward bias due to the dramatic increase of low-priced imported intermediate inputs, and Houseman (2014) notes that most of the increase in output and productivity growth in aggregate US manufacturing happened in computer-related sectors (productivity for the median sector actually declined in the 2000s). Houseman (2014) finds that ex-computers, US manufacturing output increased just 7% from 1997 to 2012, an historical anomaly. These factors make productivity growth an even less likely cause of the employment collapse over the same period.

⁴And, some of the decline in manufacturing consumption’s share of GDP could be attributed to cyclical factors, since manufacturing consumption as a share of GDP is strongly procyclical, and the economy was stronger in the late 1990s than in the mid-2000s in terms of GDP growth and employment.

⁵There were also declines in the trade balances of agricultural produce, animal husbandry, forestry and fish according to BEA data. Two notable exceptions were natural gas and metal ores, which were likely affected by supply-side factors.

⁶Note that the poor employment growth from 2000 to 2007 despite a housing bubble also is inconsistent with the theory that the decline in manufacturing employment is really about the rise of services, or about measuring manufacturing workers vs. “factoryless goods producing” (FGP) firms (Bernard and Fort, 2013). Even if we consider all the FGPs in Bernard and Fort as manufacturing firms using their upper bound estimate, then the collapse in manufacturing employment in the early 2000s would still have been 2.4 million, still a large sudden contraction by historical standards.

to the WTO removed trade policy uncertainty and caused a large increase in imports from China, leading to a “surprisingly swift” decline in US manufacturing employment.⁷

A second strand of literature studying the impact of real exchange rate movements on manufacturing mostly finds that manufacturing employment is sensitive to currency appreciations (Klein, Schuh, and Triest 2003, see Klein *et al.* 2002 for an overview).⁸ Even though the dollar was generally strong in the early 2000s, to my knowledge these two strands of literature – on the collapse in manufacturing in the early 2000s and the impact of exchange rate movements – do not intersect. This paper shall therefore endeavor to fill the gap by asking how much of the collapse in manufacturing in the early 2000s can be explained by relative prices.

To identify a causal impact of 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 falling US dollar led to an equally sharp appreciation of the Canadian dollar. The benefit of these periods is that each contained large RER movements which I argue were likely to be exogenous from the perspective of the manufacturing sector. For the US, I use a panel difference-in-difference research design using substantial variation in lagged openness across 359 manufacturing sectors and in real exchange rates over time (from 1973 to 2009) to identify the impact of currency appreciations on manufacturing sectors with differential exposure to international trade.⁹ I find that when relative unit labor costs in manufacturing are high (even when proxied by changes in the structural budget balance in the US case, or by oil prices in the Canadian case), more open sectors experience a relative decline in employment and output. For the US, I find this is due to increased job destruction and suppressed job creation, and also find relative declines in investment, shipments, and value-added, and a modest decline in production worker

⁷Ebenstein *et al.* (2012) document a series of facts consistent with the idea that Chinese import competition reduced US manufacturing employment. Autor, Dorn, Hanson and Song (2014) look at worker-level evidence of the impact of the rise of China, while Autor, Dorn, and Hanson (2014) untangle the relative impacts of trade and technology, finding that trade had a large negative impact on manufacturing employment but not technology. 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 percent of the increase in non-employment in the 2000s was caused by the decline in manufacturing.

⁸Other key papers in this literature are Branson and Love (1986), (1987), and (1988), Gourinchas (1999), Campa and Goldberg (2001), for the U.S. and Berman *et al.*, (2012), Moser *et al.*, (2012), and Belke *et al.* (2013) for Europe. Rose (1991) and McKinnon and Schnabl (2006), by contrast, find no impact of real exchange rate movements on trade and so this question is still not settled.

⁹Where openness is defined at the sectoral level as the average of import penetration and export share: $\text{openness} = .5 * (\text{imports} / (\text{imports} + \text{shipments} - \text{exports})) + .5 * (\text{exports} / \text{shipments})$. In all exercises I will be defining openness at a lag, or even using initial period openness, as this measure could itself be impacted by RER movements.

hourly wages. I do not find evidence for a significant impact on inventory, sectoral prices, or on non-production worker hourly wages.

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.¹⁰ 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 seen 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 while Japanese industries gained market share in the US when the Yen was weak, after the Yen appreciated sharply vs. the dollar Japanese industries consolidated their gains but did not make further inroads, another indication of hysteresis.

A paper linking real exchange rates to the collapse in US manufacturing employment has not already been written likely because of a subtle but crucially important measurement issue: the Federal Reserve’s Broad Trade-Weighted Real Exchange Rate Index, the most commonly-used measure of international competitiveness for the US, suffers from an index numbers problem, as it was computed as an “index-of-indices,” which does not reflect compositional changes in trade toward countries, such as China, with systematically lower price levels (Fahle, Marquez, and Thomas 2008). The Fed’s RER index implies that the appreciation in the dollar from 1996 to 2002 was a bit 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).¹¹ By contrast, a simple trade-weighted average of relative prices (WARP) using version 8.0 of the Penn World Tables implies a much larger dollar appreciation in the early 2000s, mirroring the trade balance much more closely. The difference is mostly due to two factors: (1) the rising share of trade with countries, such as China, with relatively low

¹⁰I thank Thomas Wu for this suggestion.

¹¹The Fed’s real exchange rate index is: $I_t^d = I_{t-1} \times \prod_{j=1}^{N(t)} \left(\frac{e_{j,t} p_t / p_{j,t}}{e_{j,t-1} p_{t-1} / p_{j,t-1}} \right)^{w_{j,t}}$, 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 countries in the basket, and $w_{j,t}$ is the trade weight of country j at time t . The base year value of the index is arbitrary.

price levels, and (2) the multiple benchmarking used in the creation of PWT version 8.0.¹²

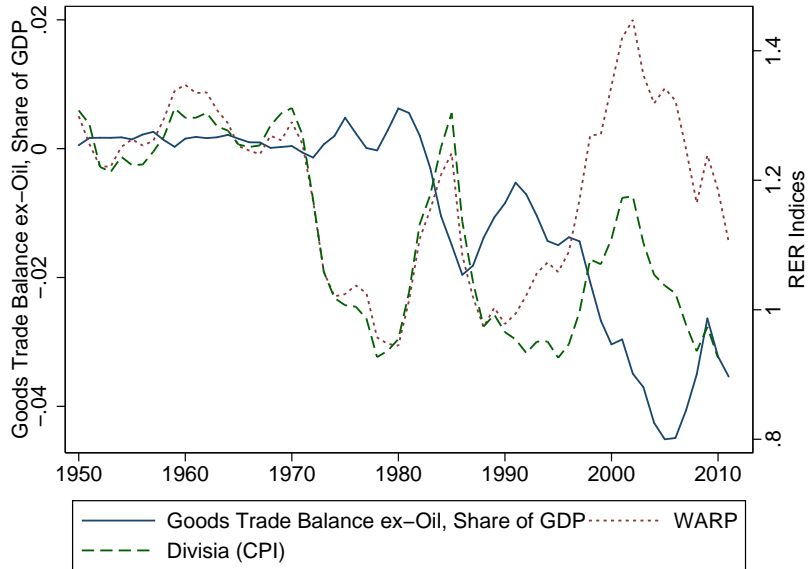


Figure 2: Real Exchange Rate Measures vs. the Current Account

Sources: BEA and Campbell (2014)

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 a number of drawbacks (Campbell 2014). One problem is that these measures are also computed as indices-of-indices, and thus they do not properly account for compositional changes in trade with countries, such as China, that have systematically lower unit labor costs.¹³ 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.

In this paper, I address all of these concerns by using a Weighted Average Relative Unit Labor Cost (WARULC) index computed for the manufacturing sector using data

¹²These factors also suggest the superiority of WARP, as China's rising share of US trade does not affect the Fed's index, and the Fed's use of country-specific deflators also becomes problematic as this data was collected using different methods and has the potential to become biased over time. WARP using version 8.0 of the PWT suffers from neither of these problems.

¹³These issues are explained in more detail in Campbell (2014). 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 is the same problem that afflicted older vintages (predating version 8.0) of the Penn World Tables.

from all six benchmarks from the World Bank’s International Comparison Project (ICP), and which includes developing countries such as China.¹⁴ I find that this index does a remarkably good job of predicting manufacturing employment declines, and in particular does much better than CPI-based real exchange rate indices or the RULC indices created by the Federal Reserve, the IMF and the OECD. 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 Fahle *et al.* (2008) or the Balassa-Samuelson adjusted WARP index created by Campbell (2014).¹⁵

One puzzle is that RER appreciations have been noted to lead to declines in employment, while 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.¹⁶ The reason is conceptually easy to understand – if unit labor costs were the same in the US and China, 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 in trading partners, there is clearly an economic incentive to shift production, while firms already located abroad would have a competitive advantage. This finding 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 also affect current economic outcomes. Empirically, I find strong evidence that temporary shocks to relative prices have persistent effects on the manufacturing sector. Indeed, the observation that improvements in the US aggregate trade balance lagged the depreciation of the dollar in the late 1980s spawned a large theoretical literature on hysteresis, with the progenitors of increasing returns and new trade theory, including Dixit (1989a, 1989b, 1991, 1992), Krugman (1987, 1988), Krugman and Baldwin (1987, 1989), and Baldwin (1988, 1990), all weighing in with multiple contributions. By contrast, more recently, new trade theory models often omit sunk costs and make scant reference to path-dependence.¹⁷ Nevertheless, Figure 2 shows that the pattern for the 1980s is also apparent in the 2000s. US relative prices have become steadily more competitive since 2002, but while the trade deficit shrank due to declining

¹⁴I am greatly indebted to Professor Paul Bergin for suggesting I apply the Fahle *et al.* (2008) insight to unit labor costs.

¹⁵The details of the construction of these indices are included in a companion paper, Campbell (2014).

¹⁶It just happens to be the case that the US hasn’t experienced being undervalued in the past 50 years, perhaps not surprising for a developed country with advanced financial institutions, an open capital market, and a freely floating hard currency. Thus, the periods when the dollar falls correspond to periods in which the level of RULCs are the same as US trading partners, while the periods of appreciation correspond to periods when US RULCs are higher than trading partners.

¹⁷With some notable exceptions, including Alessandria and Choi (2007, 2014a, 2014b), and Roberts and Tybout (1997), all finding evidence for sunk fixed costs of exporting.

domestic demand during the recession, as demand began to recover by 2011, the trade deficit worsened, lagging the improvement in relative prices. The chief contribution of this paper lies in documenting the phenomenon of hysteresis at a disaggregated level for 437 SIC manufacturing sectors for both the 1980s and the 2000s.

A second important finding in this paper is that the measured elasticity of manufacturing employment with respect to changes in relative unit labor costs and the magnitude of the appreciation in relative prices—Campbell (2014) shows that the US price level had not been as richly valued relative to trading partners since the worst year of the Great Depression—are large enough to explain the loss of 2.1 million manufacturing jobs directly in the period 1995-2008, and perhaps 3 million jobs if changes in trade policy, such as China’s WTO ascension and the expiration of textile quotas, are also taken into account.¹⁸ These estimates are more than five times larger than the direct estimates produced by Acemoglu, Autor, Dorn, Hanson and Price (2015). Third, while economists have long taught crowding out due the impact of fiscal deficits on real interest rates, the results I present suggest that deficit spending may have the sharpest impact on the most tradable sectors via relative prices.¹⁹

1 Empirical Approach

When estimating the impact of real exchange rate movements on manufacturing, RER movements, in general, cannot simply be assumed to be exogenous. The three key problems facing any researcher in International Economics are endogeneity, the potential for omitted variables, and spurious correlation arising from, for example, overfitting. I employ a variety of methods, including a repeated difference-in-difference research design using disaggregated data, out-of-sample testing, the use of proxy variables for RER movements, and falsification tests in order to identify a causal effect of RER movements on manufacturing.

Several salient facts about capital flows and manufacturing trade make the task of identification in this case more manageable. First, capital flows dwarf trade flows by a factor of 300 to 1, meaning that in the short run exchange rates are largely determined by capital flows, and they are famously difficult to predict based on fundamentals such

¹⁸In this paper I do not study input-output linkages, but Acemoglu *et al.* (2015) estimate a multiplier of about four for the input-linkages in and out of the manufacturing sector. Even if we applied a more conservative multiplier of two, it would imply the loss of 6 million jobs, which is already an astounding figure.

¹⁹I also provide a theoretical motivation in the online Appendix, where I sketch a variation of the Melitz (2003) model, and show that sunk costs lead to a dynamic gravity equation (also a new result).

as interest rates (Meese and Rogoff, 1983). Thus, it is at least plausible that sharp movements in nominal exchange rates are not always driven by events in the manufacturing sector. Evidence that this is the case is that nominal exchange rates are volatile, even in the course of a day or a week, while manufacturing employment and output are relatively stable. Second, while endogeneity is still a concern, a collapse in manufacturing output should theoretically lead to a decline in the real exchange rate, leading to a downward bias in the magnitude of the estimated impact. If the large estimated negative impact of RER appreciations on manufacturing employment is in fact a floor, it would only increase the salience of the results in this paper, but the bias would not affect the estimated magnitude of the total number of jobs lost. Third, trade has long been noticed to respond to exchange rate movements with a lag, mitigating the impact of reverse causality. It is hard to imagine why a collapse in manufacturing employment in 1986 should have caused the dollar to appreciate at all, much less in 1985. This would therefore appear to be a rare case in economics in which endogeneity is not a serious concern.²⁰ Even so, the various research designs (discussed below) implemented in this paper should reduce the probability of endogeneity even further.

A more serious potential problem is the possibility that a third factor could cause both a RER 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 openness is always defined at a lag so that it is not potentially endogenous). For example, one may be concerned that high real interest rates (RIRs) could cause an appreciation of the real exchange rate 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 capital intensity and openness, as more capital-intensive or open sectors could potentially be more sensitive to movements in the RIR. However, I find that import-competing manufacturing sectors, which suffered mightily when the dollar appreciated in the mid-1980s, are actually 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, and although RIRs were high in the early 1980s, the timing of the peak

²⁰Note that this logic would not hold if I found that RER movements do not have an impact on manufacturing employment. In that case, endogeneity could be a potential problem. For example, after the Asian Financial Crisis in 1997, many Asian countries experienced manufacturing collapses and RER depreciations. Obviously, it was the crises that caused both events, while someone who didn’t know about the crisis might conclude that RERs are not important for manufacturing, or even that RER movements have the “wrong sign”.

in RIRs does not match the 1980s collapse in manufacturing nearly as well as relative prices.

Another plausible third factor is that perhaps China was simply growing really fast in the early 2000s for a variety of reasons unrelated to relative prices. Yet, US imports from countries other than China actually increased by a larger amount than Chinese imports in the early 2000s, suggesting that China is unlikely to be the only factor in the collapse in manufacturing employment during this period.²¹ In any case, growth in imports from China was certainly a large part of the story, and it is plausible that China's growth had many causes aside from having relatively low unit labor costs (wages relative to productivity), the chief measure of the RER used in this paper. It is important to note, however, 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, or the suppression of labor unions, would also be factors that would lower China's relative unit labor costs (RULCs). Even so, RULCs are admittedly unlikely to 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, asking 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 an 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, effec-

²¹It is also true that Chinese imports were increasing at a faster pace, but Chinese imports started from a much lower base.

tively testing out of sample. While still not foolproof, repeated difference-in-difference regressions dramatically reduce the number of potential variables that could be perfectly correlated with the treatment. In this case, such a variable would have to be very strongly correlated with the US, Canadian, and Japanese RERs over a period of decades, and in Japan’s case, it needs to be a factor that is perfectly correlated with that nation’s bilateral RER with the US and UK. In addition, in each year this omitted variable needs to be very strongly correlated with openness by sector. While such a variable may exist, the repeated element of the difference-in-difference make this a high hurdle. Spurious results have a well-known tendency not to hold out of sample.

Another method to reduce the probability of endogeneity, omitted variables, or spurious correlation is to focus on periods in which it can plausibly be argued that movements in exchange rates are the result of known shocks exogenous from the perspective of the manufacturing sector. For example, in the 1980s, a major contributing factor to the dollar’s strength was large fiscal imbalances, which have been found to affect RERs in the way standard theory would suggest (Guajardo *et al.* 2014). For Canada in the 2000s, the cause of the appreciation was a falling US dollar and rising oil prices. In addition, the episodes I study contain very large movements in RERs, which increase the signal-to-noise ratio and provide insulation from spurious results. For example, in the US from 1979 to 1985, US relative unit labor costs appreciated 50%. Given that labor costs were 40% of value-added for the average sector, it would be implausible if profit-maximizing firms did not respond to this large change in relative prices.²²

Lastly, another guard against spurious findings is various falsification exercises. If employment is impacted by RER movements, then many other variables, such as trade, output, productivity, and investment, should also be impacted. On the other hand, RER movements should not cause a differential impact on the input prices of more open sectors (as openness is defined by output). In addition, future leads of the RER should not impact employment or output today. These falsification exercises show that the estimation method is not prone to finding significant relationships when none should exist.

The core difference-in-difference research design of this paper is displayed graphically in Figure 3. It plots the evolution of employment indices by fixed categories of openness in 1972 vs. a measure of the RER, Weighted Average Relative Unit Labor Costs (WARULC) for the manufacturing sector. Note that using initial openness in 1972 effectively rules out endogeneity, as a dollar appreciation in 1985 could not have “caused” a

²²In the online Appendix, I also provide a theoretical justification for why RER movements should impact manufacturing employment to help motivate the regressions in the sections that follow.

change in openness across sectors in 1972.²³ The employment index for each sector is given a base year value of 100 in 1979, and then the changes in the employment indices not due to changes in demand or productivity, or due to general movements in all sectors by year, are plotted over time with error bounds. Comparing the top 25% of sectors by openness as of 1972 vs. the bottom 50%, the pretreatment trends are very similar in the 1970s, but when the dollar appreciated in the 1980s, the more open sectors lost roughly 10% of their employment relative to less 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, and thus a 50% increase in labor costs relative to trading partners should have left a differential impact on more exposed sectors. Interestingly, after the dollar fell in the late 1980s, this differential impact seems to have decayed very modestly. Given that the main cause of the appreciation in relative prices in this period, large government deficits, which are exogenous from the perspective of manufacturing employment, is known, this period is a prime candidate to be a canonical example of hysteresis.

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 here, this is in part a function of the fact that both of these categories of industries contain larger amounts of openness than in the 1980s, and each category also includes substantial variation (in the panel regressions which follow, openness will be defined instead as a continuous variable). In both periods, the decline in the more open sectors took place at the same time as a decline in aggregate “structurally adjusted” manufacturing employment (Figure 16 in the appendix).²⁴

2 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 (2014) to address 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

²³I thank an anonymous referee for suggesting that openness might be endogenous here, when in fact endogeneity cannot be a factor here due to the long time lag.

²⁴The “structurally adjusted” employment was computed at quarterly intervals by subtracting off 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, used because it has data at quarterly intervals.

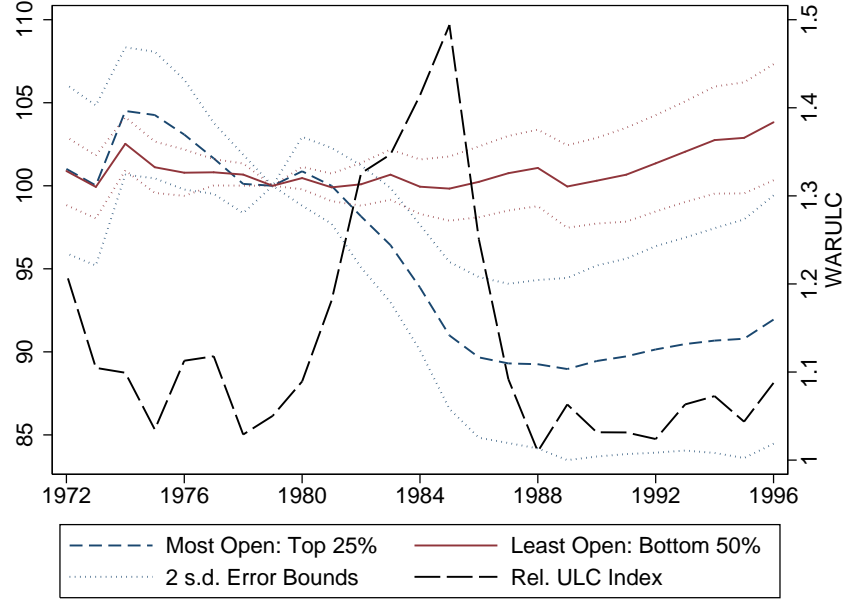


Figure 3: Employment Growth by Degree of Openness in 1972 (SIC)*

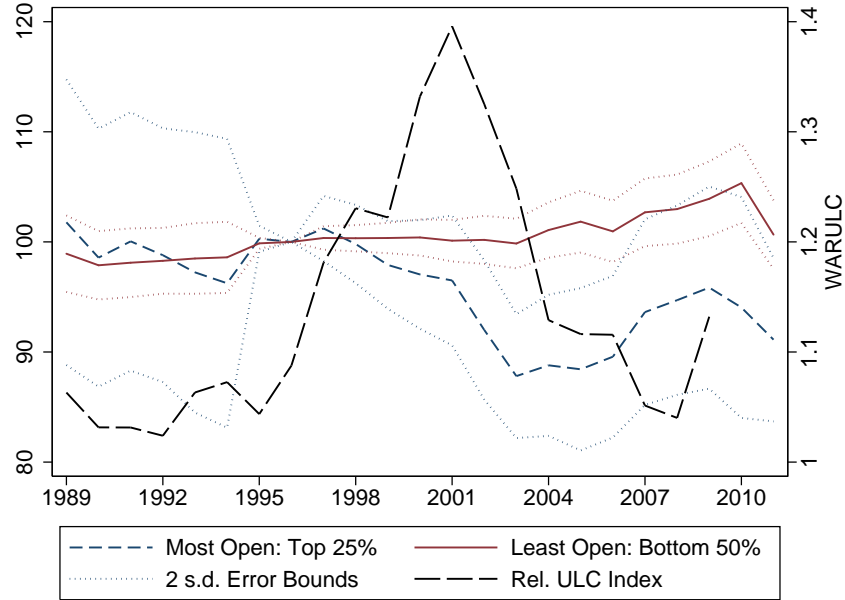


Figure 4: Employment Growth by Degree of Openness in 1989 (NAICs)*

*Notes: $\text{Openness} = .5 * \text{imports} / (\text{imports} + \text{shipments} - \text{exports}) + .5 * (\text{exports} / \text{shipments})$. 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.

outdated (Japan still held a 20% weight in the 2000s while China was excluded)²⁵, and (4) uses country-specific deflators, which can become biased over time without the benefit of multiple benchmarks (this is the same problem that afflicted older versions of the Penn World Tables predating version 8.0). Campbell’s (2014) measure is instead 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.²⁶ Both measures are plotted in Figure 5 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. WARULC, by contrast, implies that US manufacturing became less competitive in the early 2000s.²⁷

Sectoral data on employment, shipments, value-added, wages, investment, and capital, and the prices of shipments, materials, and energy are provided by the BEA’s Annual Survey of Manufactures, via the NBER-CES Manufacturing Industry Database for the 4-digit SIC data from 1958 to 2009, and were taken directly from the BEA 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, Romalis, and Schott (2002) from 1972-2005. Sectoral tariff data for 1974-2005 come from Schott (2008) via Feenstra, Romalis, and Schott (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, 2015). Data on intermediate imports are from the BEA’s Input-Output tables for the year 1997. The classification of

²⁵Note that most real exchange rate indices, such as those produced 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, Schuh, and Triest (2002).

²⁶This last point will be subtle for general readers, and so I would refer interested parties to Campbell (2014). Specifically, the WARULC index from Campbell (2014) is computed as $I_{US,t}^{WARULC} = \prod_{i=1} \left(\frac{ULC_{US,t}}{ULC_{i,t}} \right)^{\Omega_{i,t}}$, where $ULC_{i,t} = \frac{w_{i,t}}{e_{i,t}} / \frac{Y_{i,t}}{PPP_{i,t}}$, $\Omega_{i,t}$ 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 (which equals 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.

²⁷All four of the adjustments 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 Campbell (2014).

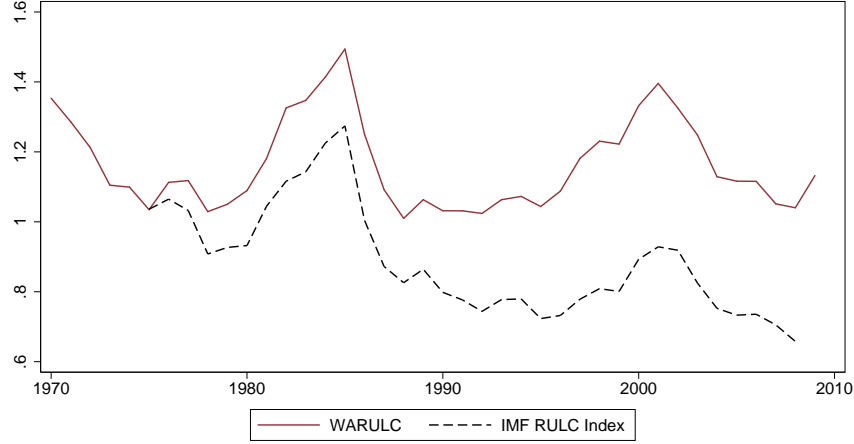


Figure 5: WARULC vs. IMF RULC Index
Sources: Campbell (2014) and the IMF

broad industrial sectors by markups is borrowed from Campa and Goldberg (2001).²⁸

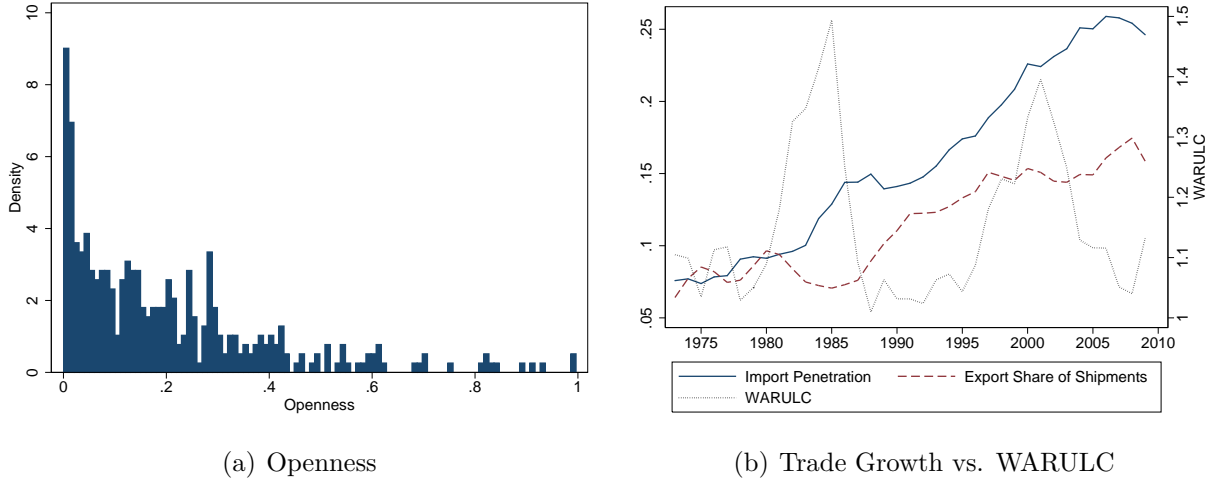


Figure 6: Trade Growth and the Distribution of Openness in 1997
Sources: BEA, Comtrade, and Campbell (2014)

The summary statistics for the most relevant variables in select years are reported in Table VII in the Appendix. Openness increased from about 7% in 1972 to 24% in 2001 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%.

²⁸The 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 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 about 9.6% of customs costs in 1974, and was still 9.8% in 2005. The last two entries in Table VII, 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 Bartelsman and Gray (1996). Finally, panel (a) of Figure 6 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.

3 Difference-in-Difference Panel Estimation

The first empirical approach I take is to compare how employment in relatively more open sectors does when unit labor costs in the US are relatively high compared to when these costs at home are close to a weighted average of trading partners. Figure 7 displays the results from regressing the log change in employment on lagged relative openness by year, controlling for demand growth, shipments per production worker, and two other China-related controls, following Pierce and Schott (2015).²⁹ The first is a control for the interaction between China’s ascension 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, Khandelwal, and Schott (2010) and Khandelwal, Schott, and Wei (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, disproportionate impact on the sectors in which the quotas were binding. Thus I have also included a control for weighted average of the fill rate – the imports divided by the allowable quotas – just before the quotas were lifted (also following Pierce and Schott, 2015).³⁰ The annual coefficients are plotted in blue vs. WARULC, along with

²⁹This regression is $\ln(L_{ht}/L_{h,t-1}) = \alpha_t + \beta_0 Rel.Openness_{h,t-1} + \beta_2 \ln(D_{h,t}/D_{h,t-1}) + \beta_3 \ln((TFP)_{h,t}/(TFP)_{h,t-1}) + \beta_4 (PostPNTR * NTRGap)_h + \beta_5 MFAExposure_{h,t} + \epsilon_{ht}$, $h = 1, \dots, 359$, for each year = 1973, ..., 2009. I have also plotted the real interest rate, defined as the interest rate on 30 year mortgages minus the core CPI (both from FRED). Note that the timing of the correlation between the real interest rate and the coefficient on relative openness is only approximately correct in the early 1980s. For example, from 1985 to 1987, the RIR only declined slightly, yet the coefficient on relative openness went from -.02 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.

³⁰*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

two standard deviation upper and lower error bounds (with standard errors clustered at the 3 digit level). The results suggest a strong correlation between the level of relative unit labor costs and the annual coefficient on lagged openness.³¹ Note that the annual coefficient becomes significant in 1998, while China was awarded permanent MFN status and joined the WTO in December of 2001. Also note that after WARULC returns closer to parity in the later half of the 2000s, more open sectors stop losing more jobs relative to less open sectors, even though imports from China continued to increase.

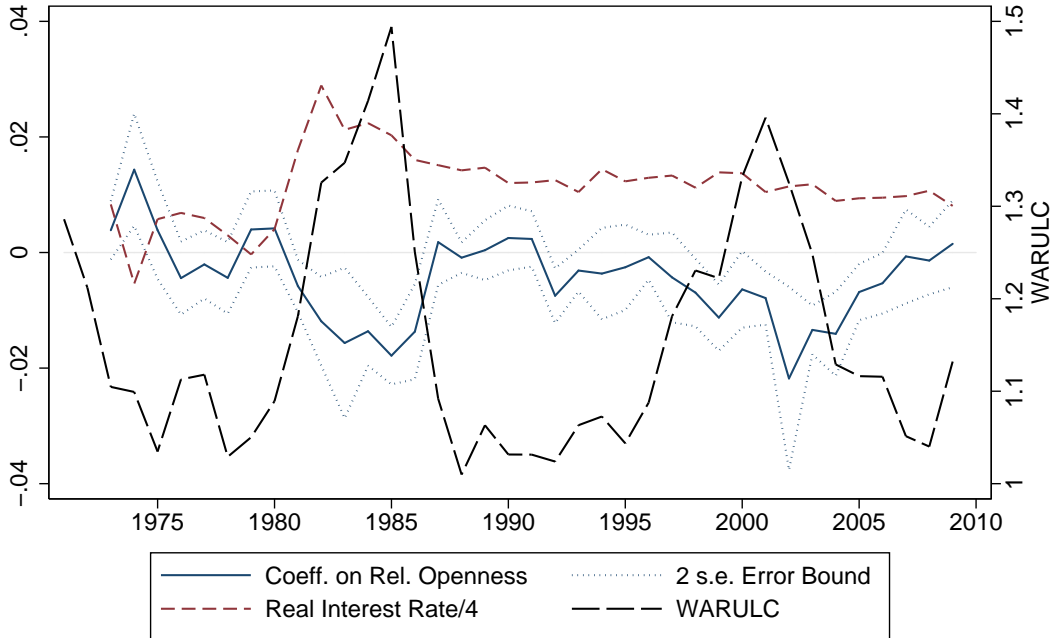


Figure 7: Impact of Relative Openness by Year

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 from Campbell (2014), and the coefficients came from annual regressions of log changes in employment on changes in demand, productivity, the China Post-PNTR*NTR Gap and MFA Exposure (explained in the text), with standard errors clustered at the 3-digit SIC level.

Figures 3, 4, and 7 suggest a functional form for the relationship between relative unit labor costs and the evolution of sectoral manufacturing employment. When unit labor

using the concordance provided by Pierce and Schott, 2012).

³¹The one period that appears to be slightly anomalous is 2005-2007. One explanation may be that during this period, the WARULC index implies lower relative prices than either WARP or the Balassa-Samuelson adjusted WARP index from Campbell (2014), even though the three series are broadly similar and yield similar results on the whole (although WARULC does well predicting the decline in 2002). Nonlinearities in the impact of relative price misalignment are also possible, as large overvaluations relative to China may have trumped mild undervaluation relative to Canada and Europe during this period.

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 one, 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 of 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.

The next step is to pool the data and run a panel regression of the log change in employment on lagged relative openness (note that the lag mitigates against endogeneity here)³², while including controls from the theoretical model presented in the appendix (equation 11.6).

$$\ln(L_{ht}/L_{h,t-1}) = \alpha_t + \beta_0 R.Openness_{h,t-1} + \beta_1 (\varphi(L) \ln(RER_{t-1})) * R.Openness_{h,t-1} + (3.1)$$

$$\beta_2 \ln(D_{h,t}/D_{h,t-1}) + \beta_3 \ln(TFP_{h,t}/TFP_{h,t-1}) + \sum_{i=4}^n \beta_i C_{i,t} + \alpha_h + \nu_t + \epsilon_{ht},$$

$$\forall h = 1, \dots, 359, \quad t = 1973, \dots, 2009,$$

where L_{ht} is employment in sector h at time t , $R.Openness_{h,t-1}$ is relative openness in sector h at time $t-1$ (a continuous measure), RER is a measure of the real exchange rate, such as WARULC, $D_{h,t}$ is real sectoral demand, $TFP_{h,t}$ 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 C s are various other controls.³³ $\varphi(L)$ 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. 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, and all regressions are weighted by initial period value-added. Additionally, one gets very similar results by simply using openness rather than relative openness, and by clustering at the 3-digit SIC level instead of the SIC level, given the correlation of errors at higher levels of industry aggregation.³⁴

³²Although this is not necessarily a bulletproof strategy, as increases in imports are likely to be autocorrelated. One solution is to use fixed categories of openness based on initial data, which is exactly the strategy in Figure 3 and Figure 4. In addition, the panel results are also robust to using relative openness in 1972 rather than relative openness lagged one year, or to multi-year lags in openness. This robustness check is in the online appendix.

³³This setup is similar to Klein *et al.* (2003) and Bernard *et al.* (2006).

³⁴These controls, and many others, are contained in the Additional Appendices in this .pdf and online on my webpage: <http://dougcampbell.weebly.com/>. For instance, the results would not change significantly using a geometric rather than an arithmetic average of export share and import penetration as a

I test various functional forms for WARULC, such as using the level of the log of WARULC (equivalent to setting $\varphi_i = 0, \forall i$) vs. an alternative specification using log changes in weighted average relative unit labor costs (equivalent to setting $\varphi_1 = -1$, and $\varphi_i = 0, \forall i > 1$). The most intuitive alternative would be to include log changes interacted with openness and a dummy variable for appreciations, and a second control for log changes interacted with openness and a dummy for depreciations (historically this is what the literature has done, including Klein, Schuh, and Triest, 2003). This flexible specification allows different impacts for appreciations and depreciations.

Table I, column (1) shows that appreciations in relative unit labor costs are associated with a decline in employment for more open sectors, but that depreciations are not. Column (2) uses the log of the level of WARULC instead as a control, and has a higher R-squared than column (1) despite one fewer control. Column (3) includes controls for productivity, demand, 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 relative openness, and find that the RER appreciation and depreciation variables lose significance. I then 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 hysteresis.³⁵

The coefficient of $-.068$ suggests that in 1985, when US ULCs were 50% (or 1.5, for a log value of .4) above a weighted average of ULCs of US trading partners, an industry with an openness twice that of the average industry would have lost an additional 5.3% of employment from 1985 to 1986 ($=\exp(-.068*0.4*2)-1$), as compared with a completely closed industry, and 2.6% more than an industry with average openness. Over the entire 1982-1986 period, this industry would have lost a cumulative 19% of employment relative to a closed industry, and 9% more than an industry with average openness.

measure of openness, or if either or both of the fixed effects were excluded. Additionally, the results are robust to omitting defense and computer-related sectors (Table II), given that the periods of dollar appreciation are associated with large increases in defense-spending and also since the official productivity data for the computer sector has been called into question by Houseman *et al.* (2010). Changes in import penetration and export share are also highly correlated with changes in employment—a necessary condition for lagged relative openness interaction with the real exchange rate to predict innovations in employment.

³⁵In addition, that it appears to be the level of relative prices which matters for changes in employment rather than changes in relative prices, this is another reason to prefer the class of ‘WAR’ exchange rate indices, in which levels matter, as opposed to divisia-based indexes (also called Tornquist indices), in which levels are implicitly assumed not to matter as these are computed as indices-of-indices.

Table I: Exchange Rates, Openness, and US Manufacturing Employment

	(1) <i>ln</i> Δ L	(2) <i>ln</i> Δ L	(3) <i>ln</i> Δ L	(4) <i>ln</i> Δ L	(5) <i>ln</i> Δ L	(6) <i>ln</i> Δ L
L.Relative Openness	-0.010** (0.0044)	-0.0053 (0.0036)	-0.0092 (0.0059)	-0.0036 (0.0059)	-0.0019 (0.0055)	0.0045 (0.0040)
L.Rel.Open*ln Δ WARULC*Pos.	-0.088* (0.052)		-0.20** (0.100)	-0.098 (0.098)		
L.Rel.Open*ln Δ WARULC*Neg.	-0.0048 (0.052)		0.011 (0.057)	0.0014 (0.045)		
L.ln(WARULC)*Rel. Openness		-0.056*** (0.016)		-0.068*** (0.015)	-0.093*** (0.021)	-0.085*** (0.015)
<i>ln</i> Δ Demand			0.45*** (0.062)	0.45*** (0.061)	0.38*** (0.066)	0.54*** (0.051)
L.(K/L)			0.044 (0.027)	0.045* (0.027)	0.028 (0.029)	0.065* (0.037)
L.(K/L)*Real Interest Rate			-0.18 (0.29)	-0.29 (0.29)	-1.32*** (0.48)	-1.08 (0.71)
L.ln Δ Wages			0.021 (0.023)	0.018 (0.022)	0.020 (0.026)	0.012 (0.012)
L.ln Δ Price of Shipments			0.036** (0.016)	0.035** (0.016)	0.041** (0.016)	0.018 (0.012)
<i>ln</i> Δ VA-per-Production Worker			-0.21*** (0.035)	-0.21*** (0.035)		
<i>ln</i> Δ TFP					-0.079 (0.073)	-0.26*** (0.054)
Post-PNTR x NTR <i>Gap_i</i>					0.039*** (0.012)	0.044*** (0.013)
MFA Exposure					-0.052*** (0.016)	-0.038*** (0.012)
Low Markup*L.ln(WARULC)					0.014 (0.028)	0.0020 (0.014)
Imported Inputs*L.ln(WARULC)					0.096 (0.18)	-0.18* (0.10)
L.Rel.Openness*RIR					0.010 (0.0087)	0.0075 (0.0054)
L.ln Δ PM*(M/S)					-0.17** (0.080)	-0.14** (0.067)
L.ln Δ PI*(I/S)					-1.13** (0.56)	-0.16 (0.64)
L.ln Δ PE*(E/S)					-0.27 (0.18)	-0.26** (0.12)
Observations	13185	13185	13185	13185	12715	

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. 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.

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 control for low-markup industries (as used by Campa and Goldberg, 2003) interacted with the level of WARULC and shares of intermediate imports interacted with WARULC. Neither are significant in column (5). I also add in the two China-related controls from Pierce and Schott (2015), the Post-PNTR*NTR gap variable (described above), and a second control for MFA exposure, and find that both had significant adverse impacts on employment (the NTR gaps are all negative).

Lastly, to control for the possibility that more open sectors also may be more sensitive to movements in real interest rates, I also include an interaction between openness and the real interest rate, where the real interest rate is 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.³⁶

Column (6) repeats the specification using a quantile regression, reporting errors clustered by SIC and year. While the magnitude of the interaction term on the RER interacted with relative openness is little changed, the impact of faster TFP growth on employment becomes negative and significant, which is what we would expect theoretically. Thus this would appear to be a textbook case in which the quantile regression, which is less sensitive to outliers since it minimizes the sum of absolute deviations, may be preferable to OLS. In addition, sectors with more imported intermediate inputs are also shown to lose more jobs when domestic unit labor costs rise relative to foreign when using a quantile regression (not so with OLS), which is consistent with a rise in offshoring induced by relative price movements.

³⁶The results are also unchanged when including controls for tariffs, the cost of insurance and freight, unionization, unionization interacted with RER movements, tariffs faced by US industries in China, and tariffs faced by US industries interacted with the share of shipments bound for China. Since these variables did not have complete coverage, there was no space to include each of these robustness checks in this table. 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. Even as of 2008, the typical industry only sent about 1.4% of shipments to China, so it is not surprising to find no effect of Chinese tariff policy. 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. Data on unionization came from unionstats.org, and data on Chinese tariffs came from Brandt *et al.* (2012). Other China-related variables from Pierce and Schott (2015), 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.

4 Robustness Exercises

In Table II, I include a variety of robustness checks. 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 I. In Panel B, I show that the key results are unchanged by different choices of weights – using initial value-added, no weights, initial employment or shipments, average value-added, or value-added lagged one period. In Panel C, I add and subtract industries which one might want to exclude for various reasons. In the baseline regressions in Table I, I excluded unbalanced sectors and publishing, as publishing was eventually re-classified out of manufacturing. In the second and third columns of Panel C, 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 in column 6. The results are little-changed.

In Panel D, I run quantile regressions at different points of the distribution, and in Panel E, I separate import and export-weighted WARULC (iWARULC and eWARULC), and import penetration from the export share of shipments. Over the full period, I do not find a significant difference between the coefficients on the interaction between iWARULC and relative import penetration, and eWARULC and the relative export share of shipments, which was my rational for using overall openness rather than separating them from the outset, or focusing on import penetration, which appears to account for much, if not all, of the action in the period since 1990 (column 2 of Panel E). However, the correlation between import penetration and export share across sectors increases dramatically over time, as the correlation was negative in the 1970s, but strongly positive by the late 1990s. By the early 2000s, there were very few remaining sectors with substantial exports but no imports, thus there may be a slight multi-collinearity problem in the later period.

Finally, in columns 4-6 of Panel E of Table II, I interact the Fed’s Broad Trade-Weighted RER Index with Import Penetration ex-China, and separately control for Chinese Import Penetration interacted with the log of Sino-American bilateral Relative Unit Labor Costs (RULC).³⁷ One reason to run this regression is to show that the col-

³⁷*I.e.*, $\text{Import Penetration Ex-China} = (\text{Total Imports} - \text{Chinese Imports}) / (\text{Shipments} - \text{Exports} + \text{Imports})$. I could also have used openness here, except that in the later period, since the previous regressions suggest the impact mostly comes via import penetration in this period, it seemed more natural to use import penetration here. Note that the smaller coefficient on the China term comes

Table II: 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.ln(WARULC)*Rel. Openness	-0.094*** (0.022)	-0.094*** (0.022)	-0.10*** (0.021)	-0.080*** (0.017)	-0.100*** (0.023)	-0.093*** (0.021)
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. Altering Weights						
L.ln(WARULC)*Rel. Openness	-0.093*** (0.021)	-0.091*** (0.017)	-0.099*** (0.022)	-0.089*** (0.021)	-0.076*** (0.025)	-0.082*** (0.024)
Weights	VA, 1972	None	Emp., 1972	Ship., 1972	Avg. VA	L.VA
C. Adding and Subtracting Sectors						
L.ln(WARULC)*Rel. Openness	-0.093*** (0.021)	-0.093*** (0.021)	-0.093*** (0.021)	-0.094*** (0.021)	-0.091*** (0.021)	-0.093*** (0.021)
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
D. Quantile Regressions						
L.ln(WARULC)*Rel. Openness	-0.076*** (0.019)	-0.082*** (0.011)	-0.085*** (0.014)	-0.075*** (0.013)	-0.065*** (0.011)	-0.069*** (0.027)
Quantile	.15	.35	Median	.6	.75	.9
E. Imports, Exports, and China						
L.ln(iWARULC)*R.Import Pen.	-0.054 (0.041)	-0.071*** (0.027)	-0.061** (0.026)			
L.ln(eWARULC)*R.Export Sh.	-0.084** (0.042)	0.013 (0.034)	-0.051 (0.034)			
L.ln(FedRER)*MPPen.(ex-China)				-0.43*** (0.085)	-0.40*** (0.098)	-0.54*** (0.084)
L.Chinese Import Pen.*ln(RULC)				-0.044* (0.024)	-0.063* (0.035)	-0.087*** (0.015)
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. Panel B alters 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 C adds and subtracts industries which are either unbalanced, or for which there are logical reasons why they should be excluded. Panel D runs quantile regressions at various stages in the distribution. 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.

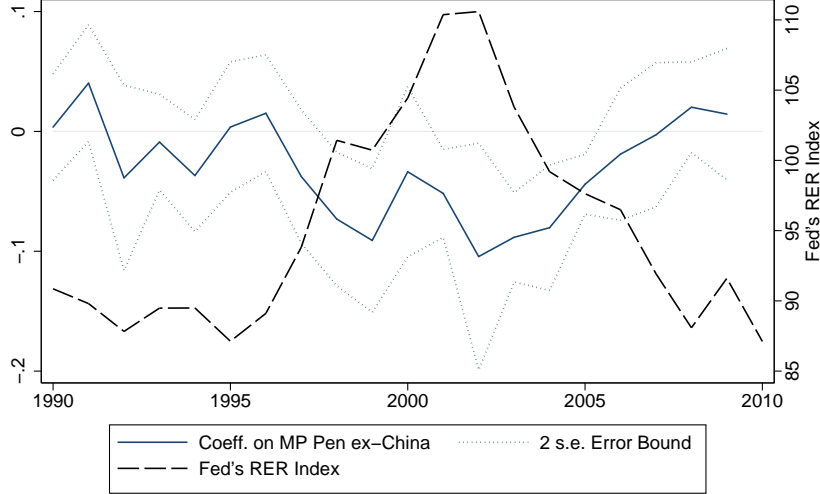


Figure 8: Was it Just China?

Note: This figure reports the coefficient on Import Penetration excluding China from the following regression: $\ln(L_{ht}/L_{h,t-1}) = \alpha_t + \beta_0 MPPen.exChina_{h,t-1} + \beta_1 ChineseMPPen_{h,t-1} + \beta_2 \ln(D_{h,t}/D_{h,t-1}) + \beta_3 \ln((TFP)_{h,t}/(TFP)_{h,t-1}) + \beta_4 PostPNTR * NTRGap_h + \beta_5 MFAExposure_{ht} + \epsilon_{ht}$, 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.

lapse in manufacturing in the early 2000s was not *solely* about the rise of China. One may have worried that Chinese import growth happened for reasons aside from either faster GDP growth in China or due to low RULCs, and that this growth itself, which is highly autocorrelated, increased WARULC and led to a collapse in manufacturing, generating spurious results.³⁸ However, this should not be a concern with these regressions, since the Fed's RER measure uses an index-of-indices method which does not reflect the role of rising trade integration with China, India and other low price/wage economies. And Figure 8 shows that after the Fed's RER index depreciated in the mid-2000s, relatively import-competing sectors (ex-China) stopped hemorrhaging jobs.

5 Proxies and Alternative Measures of RER Indices

Large US fiscal deficits were a likely potential cause of the dollar's strength during the early 1980s. Fiscal deficits can affect the tradables sector in at least three 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, in

because the $\ln(RULC)$ for China

³⁸I thank Noam Yuchtman for highlighting this possibility.

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 hinged on the outcomes of presidential elections, and thus are arguably exogenous from the perspective of the subsequent evolution of manufacturing employment in more open sectors.

Figure 9(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 9(b)), although the correlation with other measures of the real exchange rate, such as WARP or the Fed's index, is even more pronounced.

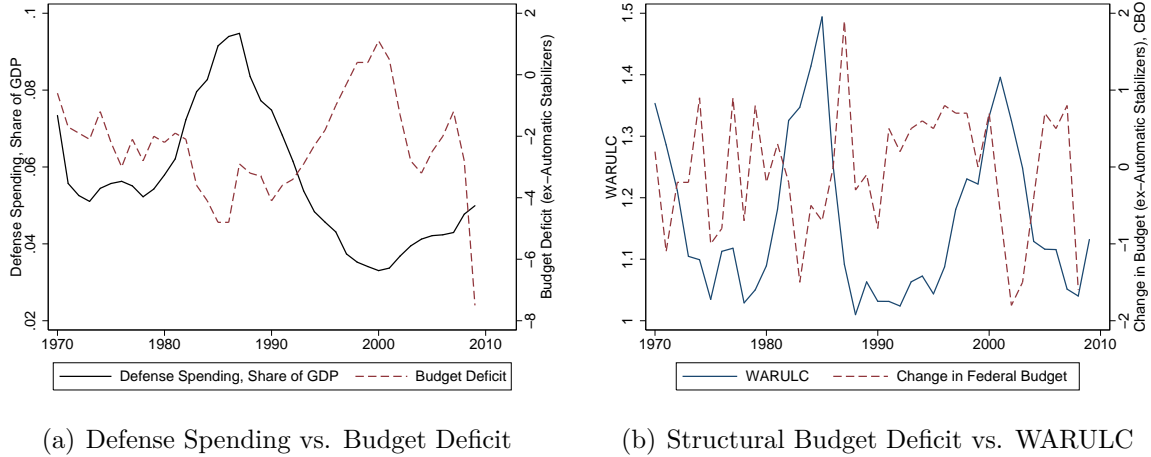


Figure 9: Defense Spending, the Structural Budget Deficit, and RULCs

Sources: FRED and CBO

In Table III 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. Figure 10 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 sounds implausible. I have also plotted an updated version of Fahle *et al.*’s (2008) Weighted Average Relative Prices (WARP) using PWT v8.0, and Balassa-Samuelson Adjusted Weighted Average Relative Prices (BSWARP), introduced in Campbell (2014). 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 relatively open manufacturing sectors continued to fair poorly in this period (Figure 7). Another slight difference is the 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.

As argued in Campbell (2014), unit labor cost-based relative price measures are not necessarily *a priori* better measures of competitiveness than Balassa-Samuelson Adjusted Weighted Average Relative Price (BSWARP) 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 III, I show that the results hold for the other WAR exchange rate indices. In column (4), I use the lagged log of the GDP-Weighted Average Relative Price (G-WARP) index.³⁹ This is an important robustness check for those who may be concerned that the

³⁹Alternatively, the results are also robust to using standard WARP with trade weights (see previous drafts of this paper).

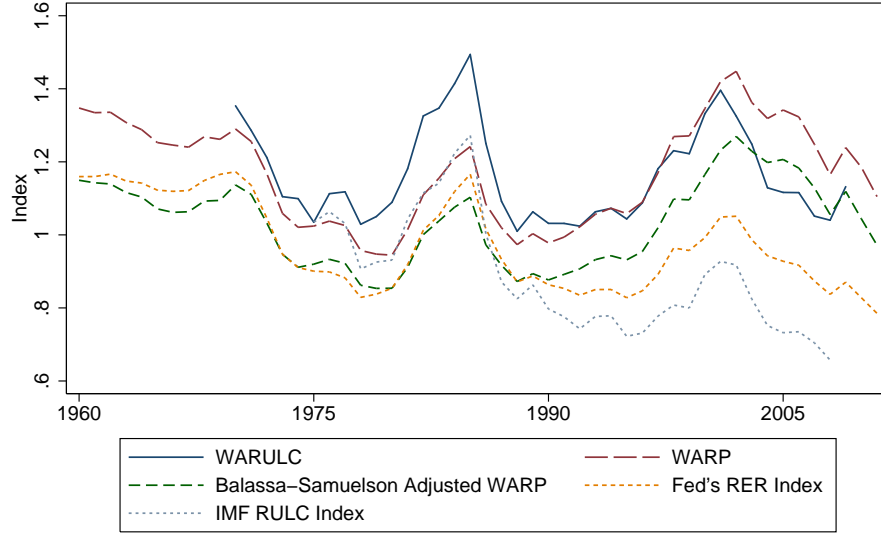


Figure 10: Comparing Various Exchange Rate Measures

Source: Campbell (2014) and the IMF

trade-weights themselves are endogenous and may be driving the result. In column (5) I use the log of the BSWARP index (the Balassa-Samuelson adjusted version of WARP). In each case, the results are little-changed.

Additionally, in column (6), I use WARULC computed with sector-specific trade weights (following Revenga, 1992), with the difference being only that the trade weights are imports plus exports at the sectoral level, as complete unit labor cost data, including for manufacturing PPP, are only available internationally for manufacturing as a whole.⁴⁰ 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, the “between” R-squared nearly doubles, while the overall R-squared also increases modestly, providing further evidence that relative prices affect manufacturing employment. However, the magnitude is much smaller in part because the variance of the sector-specific exchange rate is much higher. Estimating with this index implies more jobs lost in periods when the overall WARULC index is low, but also implies fewer jobs lost when relative prices are high.⁴¹

⁴⁰I thank a discussant, Tadashii Ito, for the suggestion to use sectoral producer data collected by Sato *et al.* (2012). However, the Sato *et al.* data covers just 7 years and 26 countries, and does not include relative price levels.

⁴¹While using either the overall WARULC or the sectoral version yields broadly similar results, there are subtle complications with the sectoral version of WARULC which may lead one to prefer the overall WARULC index. The wider dispersion of sectoral WARULC values, ranging from .52 to 6.35 (over six

Table III: 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.Rel.Openness* $\ln\Delta$ (Defense/GDP)	-0.99*** (0.25)					
L.Rel.Openness* $\ln\Delta$ (Defense/Shipments)		-1.07*** (0.18)				
L.Rel.Openness* Δ Structural Budget			0.61** (0.26)			
L.Rel.Openness* \ln (G-WARP)				-0.049*** (0.018)		
L.Rel.Openness* \ln (BSWARP)					-0.070*** (0.019)	
L. \ln (Sectoral WARULC)						0.023** (0.011)
L.Rel.Openness* \ln (Sectoral WARULC)						-0.034*** (0.010)
Observations	13073	13073	13073	13073	13073	13073

Two-way clustered standard errors in parentheses, clustered by year and 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. All other controls from Table 2 are suppressed for space.

Other specifications area also possible. For example, one could separate import-competing and export-competing sectors, and also compute import and export-Weighted Average Relative Unit Labor Costs. I tend to find a larger coefficient on import-competing sectors, although the difference is generally not significant (see online appendix). One could also include an additional interaction for the labor share of costs, which I find to be occasionally significant but not robust. However, the presence of local inputs other than labor could arguably be just as affected by currency movements, so the more relevant control is the imported content of inputs (which I control for in Table I), so I have not included these additional regressions in this paper.

times higher than trading partners) implies movements in the dollar will lead to proportionally smaller changes in these high-WARULC indices relative to the difference between the high-value WARULC sectors and the low-value WARULC sectors. Thus the sectoral WARULC index will tend to predict a more constant rate of job losses, while the overall WARULC index will not predict any jobs lost when the overall unit labor costs are the same at home and abroad. The larger sectoral WARULC values also give rise to a multicollinearity issue for some sectors, as the interaction term between lagged relative openness and sectoral WARULC will not vary as much for high-index value sectors compared to lower-index value sectors. Additionally, there is incomplete ULC data for developing countries, which implies that some of the movements in the sectoral WARULC index may be spurious, as China's share of trade increased in certain sectors at the expense of countries, such as Thailand, with missing data. This is much less of a problem for the overall index, which may be why when I control for both in the same regression, most of the action comes from the overall index.

6 Impact on Investment, 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 investment, this would suggest that the apparent impact on employment may be spurious. 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.⁴² In this section, I test the impact of relative price movements on a multitude of other variables, and provide additional falsification tests.

First, for exchange rate movements to impact manufacturing employment, a necessary condition is that exchange rates affect trade. Figure 15 shows that when the dollar 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 2005.⁴³

In Table IV, I show that production worker hourly wages in more open sectors decline, albeit slightly, when relative prices are elevated. This result is new, as Ebenstein *et al.* (2014) only found effects on wages of globalization generally using the Current Population Survey when they looked at the impact on occupations rather than on specific industries. I separately found no significant impact on non-production worker wages, and also that investment, value-added and TFP all fared worse. 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

⁴²Note 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.

⁴³In the Additional Appendix I present the results from a panel vector error correction model which also indicates that lagged changes in real exchange rates affect the level of trade flows.

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 spurious results. 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.⁴⁴ 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 destruction, and shipments (the regression results for these variables are reported in the Additional Appendix). 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 important “fingerprint” of hysteresis. Nearly four good years of job creation are needed for every bad year of destruction.

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

	(1)	(2)	(3)	(4)	(5)	(6)
	<i>ln</i> Δ PW Wages	<i>ln</i> Δ I	<i>ln</i> Δ VA	<i>ln</i> Δ TFP	<i>ln</i> Δ Inventory	<i>ln</i> Δ Prices
L.Relative Openness	0.00356*** (0.000993)	0.00630 (0.0109)	-0.00256 (0.00692)	0.00136 (0.00280)	0.000683 (0.00721)	-0.00361 (0.00241)
L. <i>ln</i> (WARULC)*Open.	-0.0163** (0.00641)	-0.148*** (0.0427)	-0.0904*** (0.0228)	-0.0285*** (0.00727)	-0.0121 (0.0234)	-0.000368 (0.00858)
<i>ln</i> Δ VA-per-Prod. Worker	0.0589*** (0.00971)	-0.0998 (0.0648)	0.647*** (0.0464)	0.268*** (0.0256)	-0.706*** (0.0438)	-0.0919*** (0.0313)
<i>ln</i> Δ Demand	0.0106 (0.0116)	0.601*** (0.101)	0.460*** (0.0674)	0.188*** (0.0256)	-0.0536* (0.0281)	-0.0819*** (0.0248)
L.K/L	-0.0515** (0.0224)	-0.150 (0.169)	0.0265 (0.0512)	0.0257 (0.0273)	-0.0562 (0.0808)	0.0150 (0.0326)
L.(K/L)*Real Interest Rate	-1.096* (0.587)	-6.873*** (2.049)	-4.091*** (1.247)	0.0449 (0.448)	0.0928 (1.717)	-3.749*** (1.193)
L. <i>ln</i> Δ Price of Shipments	0.0102 (0.00763)	0.224*** (0.0653)	0.0284 (0.0456)	0.000431 (0.0168)	0.0226 (0.0540)	
Observations	13185	13185	13185	13185	13185	14864

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) inventories, and 6) prices of shipments.

⁴⁴These results are also in the additional appendix. I thank Scott Carrell for suggesting this as a robustness check.

7 Accounting for Jobs Lost

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 I and the annual regression displayed in Figure 8 to back out the total impact of trade on employment. The approach is to multiply the coefficient on the interaction term, Relative Openness*ln(WARULC), by the interaction term itself and the lagged level of employment, and then to sum across industries. While any estimates coming from regression results are likely to be approximate, and suggestive rather than conclusive, the results are quite striking. They suggest that trade was directly responsible for as many as 3 million jobs lost from 1995 to 2008, with about 2.1 million jobs stemming directly from the appreciation of US relative prices over this period, and the balance due to China’s WTO ascension and the end of the MFA agreement. This complete estimate 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 I calculated using a straightforward, back-of-the-envelope accounting approach (Table VIII), which suggests that 3 million jobs directly due to trade is plausible.⁴⁵

Using the annual regression in Figure 8, we can derive a separate estimate to determine the relative importance of China vs. the dollar’s general strength in the early 2000s, and find very similar results, with total jobs lost due to all four sources at about 2.9 million, with 1.3 million due to the dollar appreciation (not directly related to China, though perhaps indirectly via China’s vast accumulation of dollar reserves).⁴⁶ Panel (a) of Figure 11 plots a “counterfactual”, where I add back the jobs lost due to the dollar appreciation ex-China, and a second exercise where I also add back the jobs lost from all three China-related factors. However, what is clear is that this counterfactual exercise still implies a substantial fall in manufacturing employment after 2000. What accounts for this decline?

⁴⁵This 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.

⁴⁶This time, I multiplied Import Penetration (ex-China) by the variable itself and the lagged level of employment, and also did the same for Chinese import penetration, the Post-PNTR*NTR Gap variable (from Pierce and Schott, 2015) and the MFA Exposure variable. Thus, the total jobs lost is calculated as $Total = \sum_h L_{h,t-1}(\beta_0 * MPPen.exChina_{h,t-1} + \beta_1 * ChineseMPPen_{h,t-1} + \beta_4 * PostPNTR * NTRGap_h + \beta_5 * MFAExposure_{ht})$ from the regression listed in the notes of Figure 8.

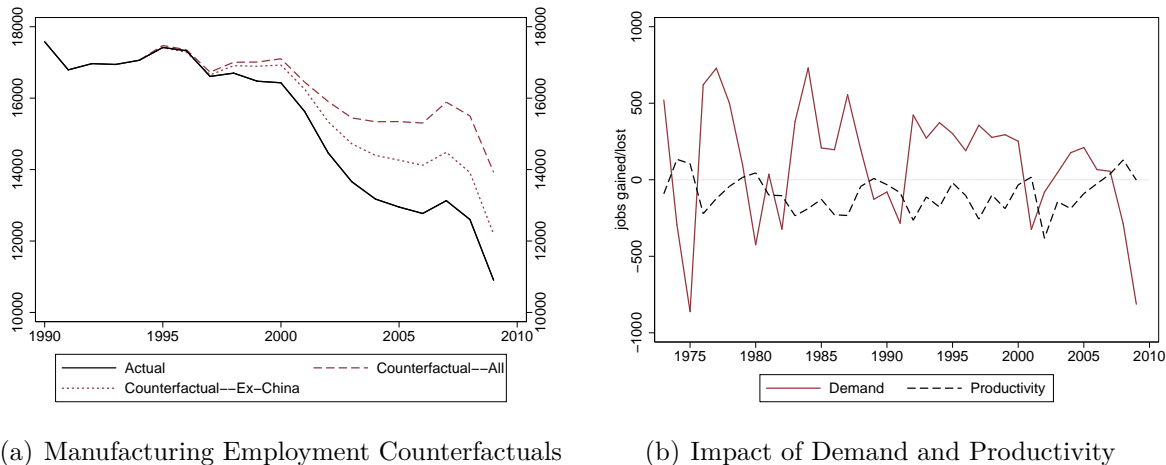


Figure 11: Accounting for Labor Lost

Notes: In Panel (a), the “Counterfactual–All” is computed from all four trade-related coefficients in the annual regression in Figure 8, and yields slightly more conservative estimates than does the panel regression in Column (5) of Table I. The “Annual Estimate” uses regression coefficients plotted in Figure 7. The Counterfactual–Ex-China adds back the job losses only from the RER appreciation excluding the impact of China.

Figure 11(b) details the impact of changes in demand and productivity on changes in manufacturing employment (using the regression coefficients from Column (5) of Table I multiplied by the actual changes in demand and labor productivity for each sector). While the jobs lost due to productivity gains after 2000 look unimpressive, 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.⁴⁷ 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.⁴⁸ 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

⁴⁷Data from the BEA.

⁴⁸This would also not be a complete estimate, as the collapse in manufacturing employment may have led to the “secular stagnation” since 2000 resulting with the US falling into a liquidity trap in the fall of 2008, with resulting slow growth.

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 2000.⁴⁹ Of course, these are micro estimates, and do not factor in the jobs gained from the Fed's low interest rates in the mid-2000s and the ensuing housing bubble. Yet, neither do they count the employment impact of the collapse of the housing bubble or the slide into a liquidity trap in 2008. Thus, a full consideration of the macro impacts could well inflate the impact.

8 International Evidence

8.1 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 in the previous section, 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 12 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.⁵⁰ 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 (Panel (a) of Figure 13).⁵¹ 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

⁴⁹Bernanke (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>.

⁵⁰In the Additional Appendix, I also show that there is no correlation between openness and employment for years when the dollar was weak.

⁵¹Canadian manufacturing employment also increased over the 1990-2004 period, suggesting that Canada was not more exposed to trade competition with China despite the lack of a threat of returning to Smoot-Hawley level tariffs as there was in the US. In addition, when the Canadian dollar appreciated later in the 2000s, there was also a correlation between openness and employment declines.

open Canadian manufacturing sectors (Figure 13, Panel (b)).

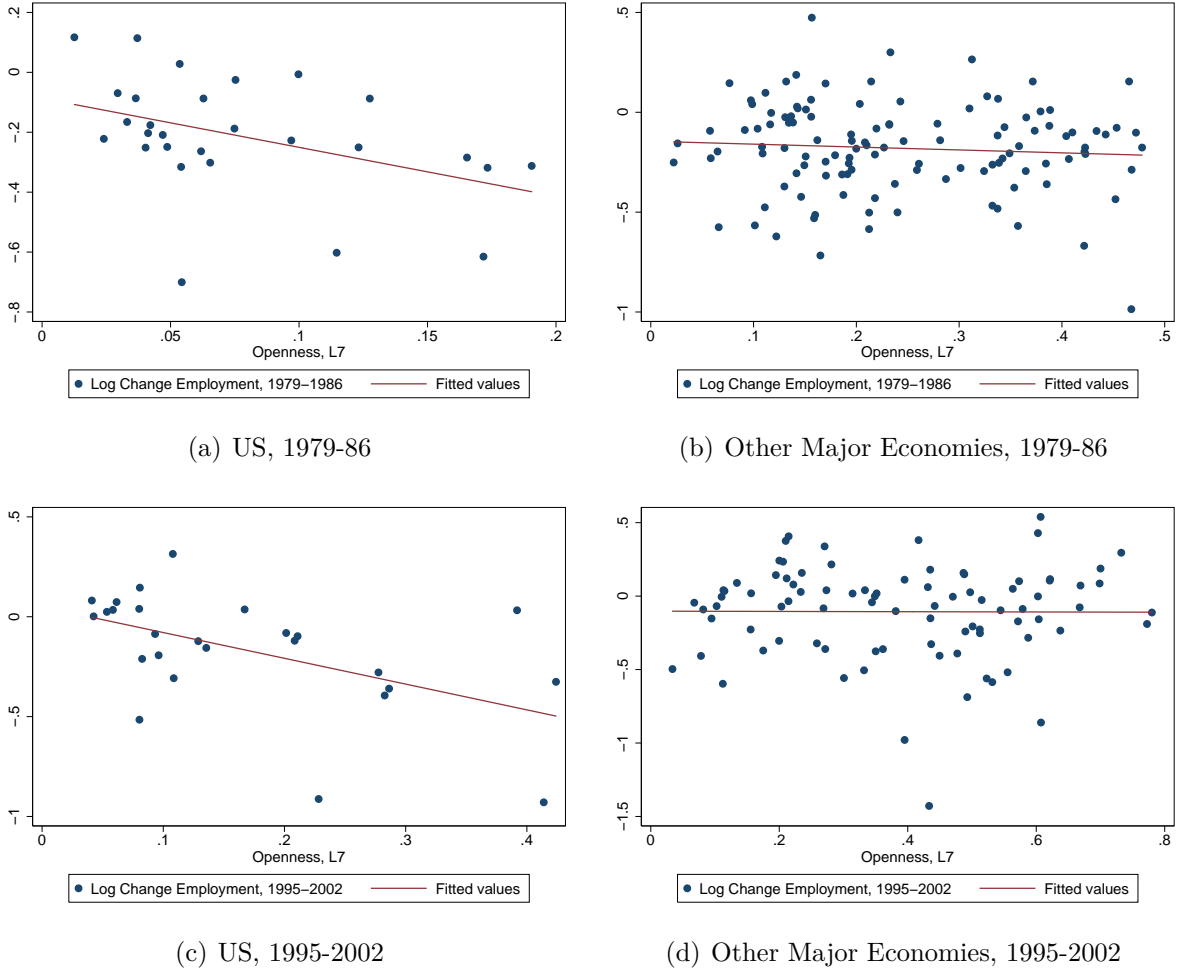


Figure 12: Employment Growth vs. Lagged Openness

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

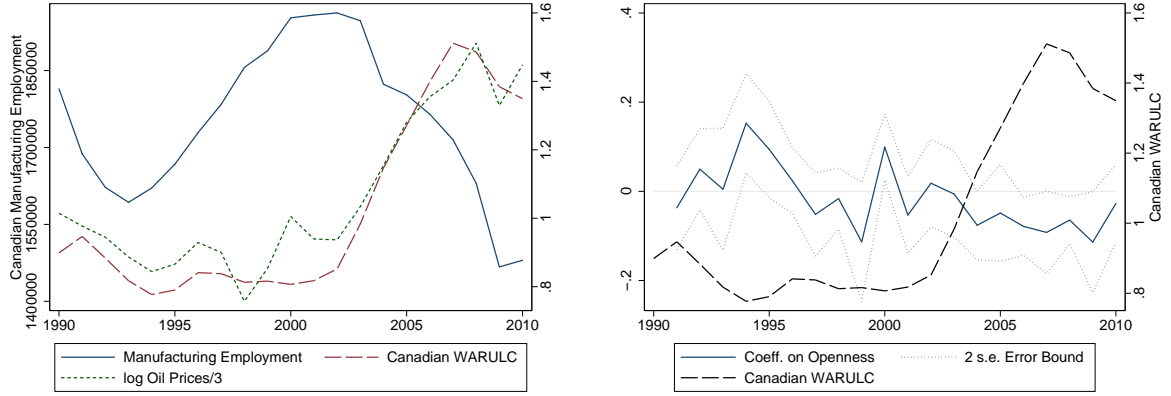
Thus, we now estimate:

$$\ln\left(\frac{L_{US,h,t}}{L_{US,h,t-1}}\right) - \ln\left(\frac{L_{G5,h,t}}{L_{G5,h,t-1}}\right) = \alpha_t + \beta_1((WARULC - 1) * Openness)_{h,t-1} + \quad (8.1)$$

$$\beta_2\left(\ln\left(\frac{D_{US,h,t}}{D_{US,h,t-1}}\right) - \ln\left(\frac{D_{G5,h,t}}{D_{G5,h,t-1}}\right)\right) + \beta_3\left(\ln\left(\frac{(S/L)_{US,h,t}}{(S/L)_{US,h,t-1}}\right) - \ln\left(\frac{(S/L)_{G5,h,t}}{(S/L)_{G5,h,t-1}}\right)\right) + \alpha_h + \nu_t + \epsilon_{ht},$$

$$\forall h = 1, \dots, 29, \quad t = 1978, \dots, 1995, 1998, \dots, 2003,$$

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



(a) Total Employment vs. WARULC

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

Figure 13: Canadian Manufacturing Employment, WARULC

Sources: UNIDOS, Comtrade, Campbell (2014). 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.

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. The first column in Table V runs the difference-in-difference regression using US data as in previous tables in a quantile regression with errors clustered at the ISIC 3 industry level and includes industry and year dummies. The key interaction term between openness and WARULC (normalized by subtracting one) 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. Note that here I use openness rather than relative openness precisely for reasons of international comparability.⁵² 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.⁵³ The magnitudes suggest that as a sector goes from no openness to 50% openness, employment will decline by an additional 11.6% in a

⁵²I 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 as tariffs, fiscal policy, and various other factors, the breakeven point for competitiveness need not be exactly one.

⁵³In this paper, I do not focus on Europe, in part because Chen *et al.* (2013) have already showed that Eurozone countries with relative price appreciations also experienced worsening trade balances, but also because the topic is worthy of a paper in itself.

year when WARULC is 1.4 ($-.58 \cdot .5 \cdot (1.4-1)$). In column 3, the coefficient of $-.76$ tells us that for a sector with an additional 50% openness, it will lose $(-.76 \cdot .5 \cdot (1.4-1)) = 15.2\%$ of its total employment when WARULC is 1.4 relative to the employment change of the same sector in other major economies.

Table V: International Evidence

	(1)	(2)	(3)	(4)	(5)	(6)
	$\ln \Delta L$	$\ln \Delta Y$	$\ln \Delta L$ Rel.	$\ln \Delta Y$ Rel.	$\ln \Delta L$ Canada	$\ln \Delta L$ Canada
L.Openness	0.048 (0.030)	0.059*** (0.022)	0.072 (0.056)	-0.027 (0.032)	0.048 (0.035)	0.030 (0.033)
L.Openness*(WARULC-1)	-0.58*** (0.10)	-0.53*** (0.095)	-0.76*** (0.090)	-0.64*** (0.078)		
$\ln \Delta(Y/L)$	-0.90*** (0.041)				-0.83*** (0.041)	-0.82*** (0.042)
$\ln \Delta$ Demand	0.89*** (0.040)	0.97*** (0.040)			0.82*** (0.064)	0.82*** (0.066)
$\ln \Delta(Y/L)$ (Relative)			-0.52*** (0.078)			
$\ln \Delta$ Demand (Relative)			0.59*** (0.066)	0.91*** (0.040)		
L.Openness*(WARULC-.85)					-0.15*** (0.042)	
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 sectoral and 3-digit ISIC industry fixed effects. Data for the first four regressions span 1977-1995 and 1998-2003 and 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 third and fourth 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 last column, oil prices are used as a proxy for Canada's RER by taking the log of the price of a barrel of crude oil and subtracting three.

In the third column of Table V, I estimate the relative difference-in-difference regression in equation (8.1), 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 heterogenous effects of exchange rate movements by country dependent on labor market institutions (see, for example, Berman *et. al.* (2009), Nucci and Pozzolo (2008), 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. 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.⁵⁴ Note that 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 subtracted .85 instead of one for Canada.⁵⁵ Finally, in the last column, I proxy movements in Canadian relative unit labor costs using the log of oil prices minus three,⁵⁶ and again find that when oil prices are high, the more open sectors in Canada tend to lose ground relative to less open sectors.

8.2 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

⁵⁴This result also holds up for Canadian output. The coefficient for Canada is much smaller than for the US. This may in part be due to the fact that WARP and BSWARP for Canada do not show as sharp of an appreciation in the 2000s, so estimating with these alternative (yet also appropriate) RER indices would yield a higher elasticity for Canada relative to the US. Secondly, the key coefficient for the US using these 31 sectors from UNIDOs happens to be substantially higher than the same elasticity using SIC (or NAICs) data from the BEA. A comparison of these elasticities is covered in the Not-for-publication Appendix.

⁵⁵This could be due to a country-specific bias in the data collection, tariff policy, or any number of other factors. Note that subtracting one as in Table VI is approximately the same as taking the log as in previous tables, and the results are very similar.

⁵⁶Once again, 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 the fixed effects.

imbalances and intervene in the currency markets to weaken the dollar, and the 1985 Gramm-Rudman-Hollings Deficit Control Act.

Figure 14, 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, v8.0, 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.

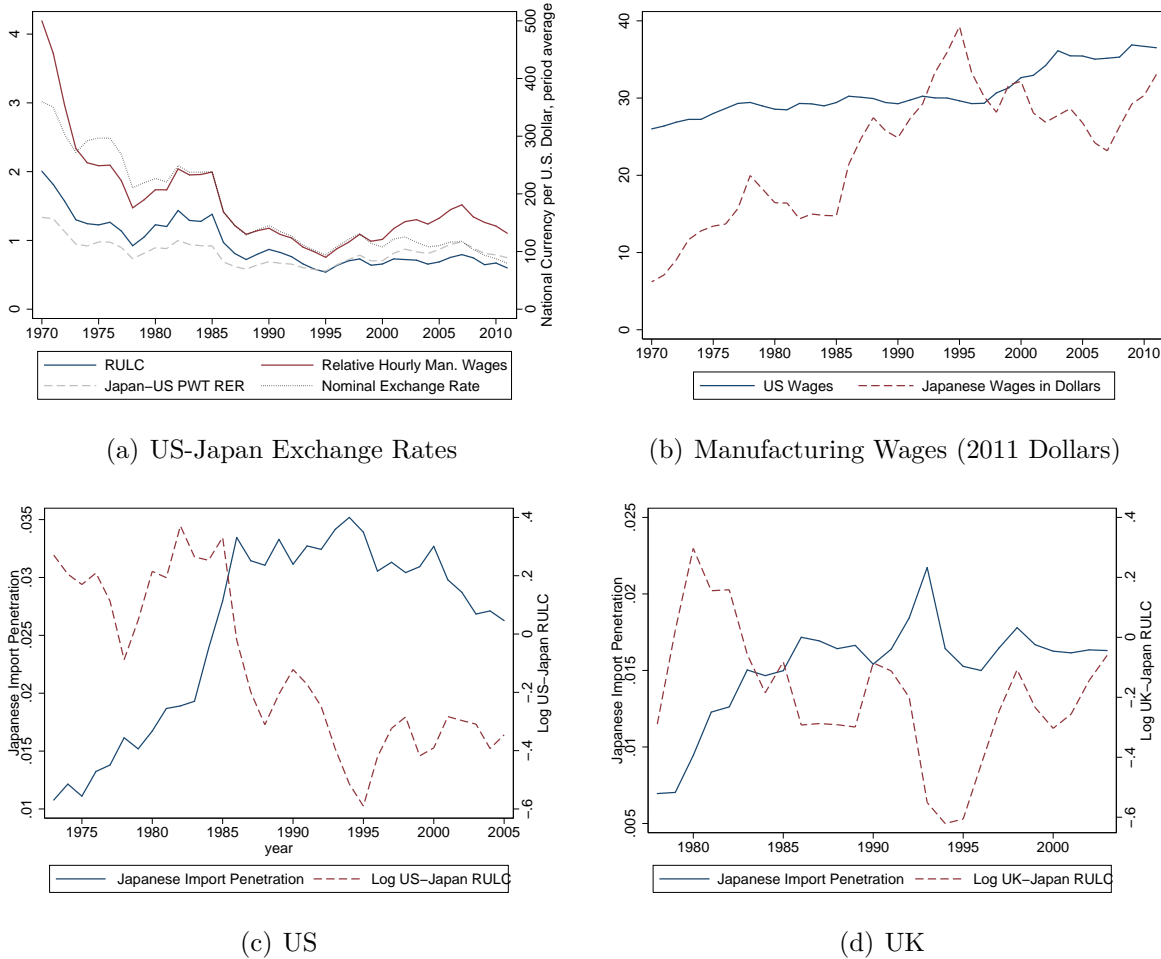


Figure 14: RULCs and Japanese Import Penetration

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

The result of this real appreciation was that as wages in the Japanese manufactur-

ing sector suddenly increased substantially relative to their American counterparts, the meteoric Japanese export growth from 1946 to 1986 suddenly ground to a halt (Figure 14(c)). However, Japan kept the gains in market share it had made even though it did not make further inroads—another indication of hysteresis. Japan’s gains through 1986 were also not 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 VI 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 the US initially.

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

Table VI: 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*** (0.19)	0.74*** (0.16)	0.76*** (0.068)	0.87*** (0.050)
L.ln(RULC)	0.13*** (0.027)		0.25*** (0.051)	0.11*** (0.021)	0.13*** (0.016)
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

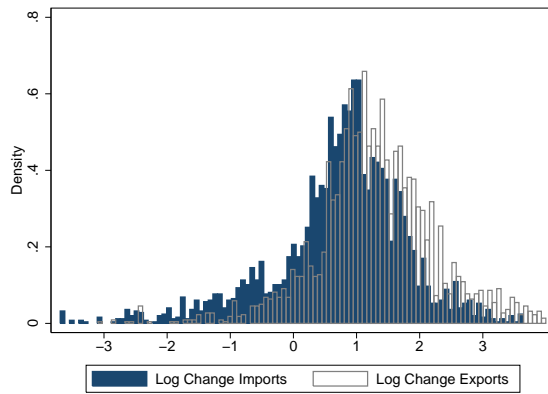
The dependent variable is the log change in sectoral Japanese import penetration. Errors clustered for 29 ISIC industries in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regressions include 3-digit ISIC Rev.2 industry fixed effects over the period 1978-2003. Columns (1), (2), and (4) 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, UNIDO, and Campbell and Pyun (2014).

9 Conclusion

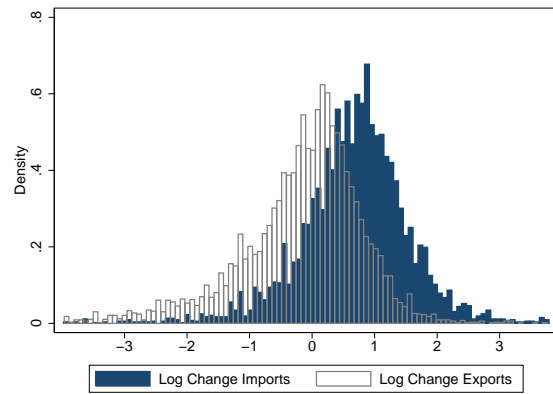
When nominal exchange rates move, the nominal rigidity of wages leads to large changes in Weighted Average Relative Unit Labor Costs, a new measure of competitiveness for the manufacturing sector created specifically for this research. I examine periods, such as the US and Japan in the 1980s, and Canada in the 2000s, when identifiable exogenous factors were likely to have driven movements in relative price levels. Exogenous shocks (from the perspective of manufacturing employment) which lead to overvalued relative unit labor costs appear to lead to increased imports and decreased manufacturing exports, and to declines in investment and employment 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 was large enough to directly explain the loss of perhaps 3 million American manufacturing jobs in this period, and substantially more if input-output linkages are taken into account. These job losses were large enough to have had a macroeconomic impact. As the “Lesser Depression” continues, the US experience with Japan in the 1980s provides an example of what presidential leadership might accomplish regarding the ongoing Bretton Woods II system of managed exchange rates, developing country capital controls, and large-scale accumulation of official dollar reserves.⁵⁷ And the lesson of hysteresis reminds us that the consequences of continued slow-growth will be diminished economic possibilities for years to come.

⁵⁷See Dooley *et al.* 2004, 2005, 2007, and 2009.

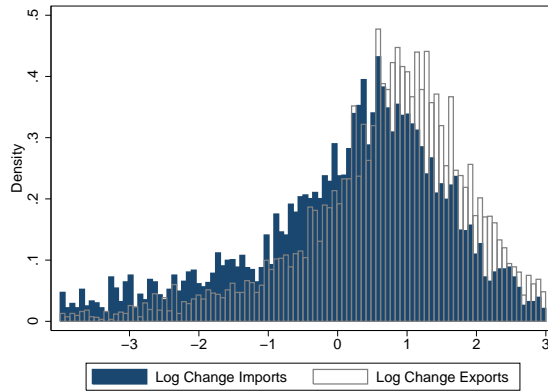
10 Appendix



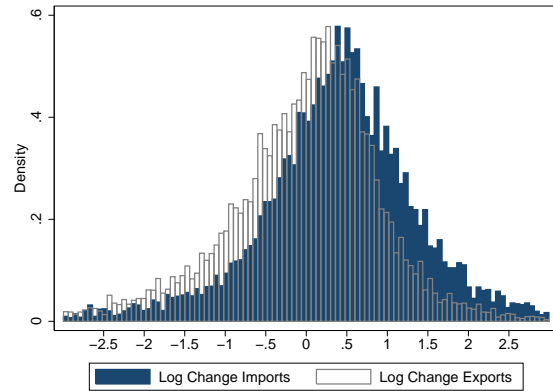
(a) Dollar Depreciation: 1972-1979



(b) Dollar Appreciation: 1979-1986



(c) Dollar Depreciation: 1986-1996



(d) Dollar Appreciation: 1996-2005

Figure 15: Distribution of Changes in Trade, by Sector and Country
Source: Trade data for 452 SIC sectors and roughly 200 countries are from Comtrade

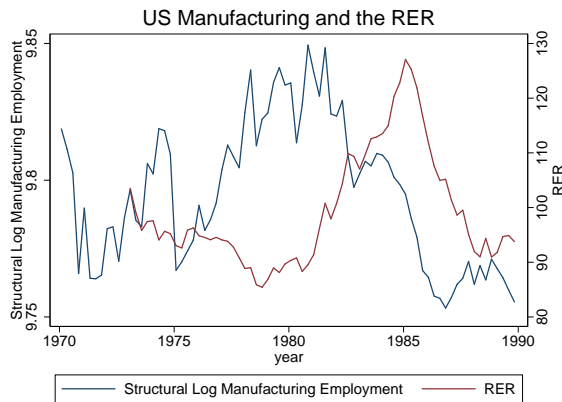
Table VII: Data Summary for Select Years

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

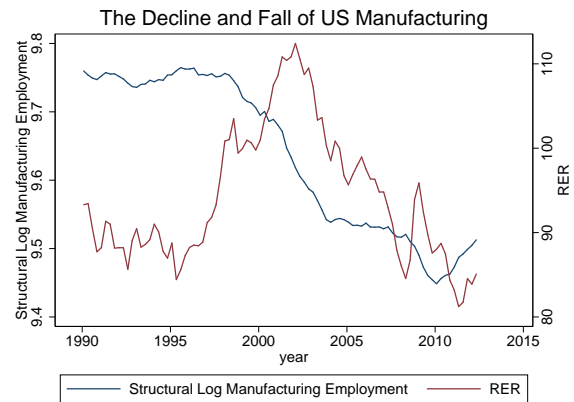
Mean coefficients; sd in parentheses. All variables have 357 observations for each year, except for duties and freight costs, which have just 308 observations in the 1970s and 1980s.

Table VIII: 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 16: Structural Manufacturing Employment vs. the RER

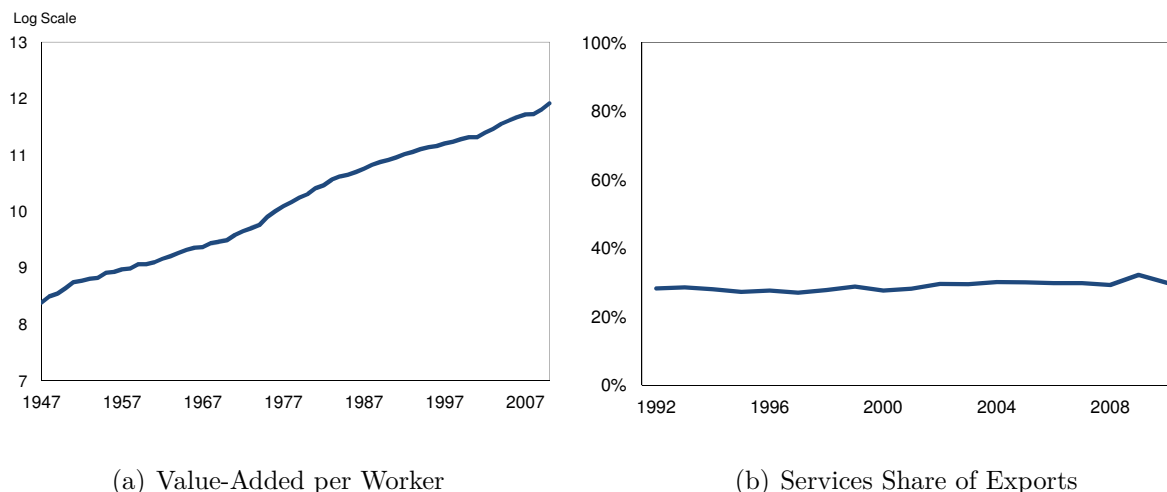


Figure 17: The Usual Suspects: Explanations for the Decline of Manufacturing
Source: BEA

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11 Online Appendix

11.1 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 homogenous numeraire good q_0 as in Chaney (2008), with one unit of labor producing w units of the good.

$$U_t = q_{0t}^{\mu_0} \prod_{h=1}^H \left(\int_{\Omega_h} q_h(\omega)_t^{\frac{(\sigma_h-1)}{\sigma_h}} d\omega \right)^{\frac{\sigma_h \mu_h}{(\sigma_h-1)}}, \sigma_h > 1 \forall h. \quad (11.1)$$

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

$$q_h(\omega)_t = \frac{\mu_h Y_t p_h(\omega)_t^{-\sigma_h}}{P_{ht}^{1-\sigma_h}}. \quad (11.2)$$

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 thus⁵⁸

$$\Pi_h(\omega)_t = q_h(\omega)_t p_h(\omega)_t - \frac{q_h(\omega)_t w_t}{\varphi_h(\omega)} - f_{ht} w_t, \quad (11.3)$$

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

⁵⁸And 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)

$$p_h(\omega)_t = \frac{\sigma_h}{\sigma_h - 1} \frac{w_t}{\varphi_h(\omega)}, \quad p_h(\omega)_t^* = \frac{\sigma_h}{\sigma_h - 1} \frac{w_t \tau_t}{\varphi_h(\omega)}. \quad (11.4)$$

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.⁵⁹

$$\text{Foreign Entry : } E_t \Pi(\omega)_{PV,t}^* = E_t \sum_{s=0}^{\infty} (1 - \delta)^s \Pi(\omega)_{t+s}^* - f_{ht}^x w_t \geq 0. \quad (11.5)$$

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:

$$L_{ht} = \underbrace{\int_{\omega \in \Omega} \frac{q_h(\omega)_t}{\varphi_h(\omega)_t}}_{\text{Home Production}} + \underbrace{\int_{\omega \in \Omega^*} \frac{q_h^*(\omega)_t}{\varphi_h(\omega)_t}}_{\text{Export Production}} + \underbrace{M_{ht}^e (f_{ht}^e + f_{ht}^x p_{ht}^x)}_{\text{Entry}} + \underbrace{\sum_{s=0}^{\infty} M_{h,t-s}^e (1 - \delta)^s f_{ht} \varrho_{h,t,-s}}_{\text{Overhead}}. \quad (11.6)$$

Here M_{ht}^e is the mass of potential entrants at time t, $\varrho_{ht}^x = 1 - G(\bar{\varphi}_x)$ 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 (11.5) 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”

⁵⁹Firms 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

$$\bar{\varphi}_{xht} = \left(\frac{P_{ht}^{*(1-\sigma_h)} w_t^{\sigma_h}}{\mu_h Y_t^*} \lambda_0 \delta f_{h,t}^x \right)^{\frac{1}{\sigma_h-1}} \tau_t, \quad (11.7)$$

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

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 is⁶⁰

$$\bar{\varphi}_{fht} = \left(\frac{P_{ht}^{(1-\sigma_h)} w_t^{\sigma_h}}{\mu_h Y_t} \lambda_0 f_{ht} \right)^{\frac{1}{\sigma_h-1}}. \quad (11.8)$$

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 (11.6) 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

$$\frac{\sum_{s=0}^{\infty} \mu_{h,t} Y_t M_{h,t-s}^e \rho^s w_t^{-\sigma_h} \lambda_1 \bar{\varphi}_{mh,t-s}^{(\sigma_h-1-\gamma_h)}}{\sum_{s=0}^{\infty} \rho^s (M_{h,t-s}^e w_t^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t-s}^{\sigma_h-1-\gamma_h} + M_{h,t-s}^{*e} (w_t^* \tau_{ht}^*)^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mxh,t-s}^{*(\sigma_h-1-\gamma_h)})}, \quad (11.9)$$

⁶⁰The 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 parameters⁶¹, $\rho = 1 - \delta$ 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 11.8), 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 (11.6) is analagous, 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 (11.8). 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:

$$\frac{\sum_{s=0}^{\infty} \mu_{h,t}^* Y_t^* M_{h,t-s}^{*e} \rho^s w_t^{*(-\sigma_h)} \tau_t^{1-\sigma_h} \lambda_1 \bar{\varphi}_{mh,t,-s}^{\sigma_h-1-\gamma_h}}{\sum_{s=0}^{\infty} \rho^s M_{h,t-s}^e (w_t \tau_{ht})^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t,-s}^{\sigma_h-1-\gamma_h} + \sum_{s=0}^{\infty} \rho^s M_{h,t-s}^{*e} w_t^{*(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t,-s}^{*(\sigma_h-1-\gamma_h)}}. \quad (11.10)$$

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 Eichengreen *et. al.* (2011), is to proxy exchange rate movements using the iceberg trade costs. Either would yield the needed result. Also note that since either of these methods imply a constant elasticity of changes

⁶¹ $\lambda_1 = \frac{(\sigma_h/(\sigma_h-1))^{-\sigma_h}}{\gamma_h - (\sigma_h-1)}$ and $\lambda_2 = \frac{1}{\gamma_h - (\sigma_h-1)}$

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.

11.2 Implications (Online Appendix)

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 $\alpha_{ht}Y_t$:

$$X_{ht} = \sum_{s=0}^{\infty} (1-\delta)^s \alpha_h Y_{t-s} \int_{\bar{\varphi}_{t-s}}^{\infty} x_{h,t}(\varphi) \mu(\varphi) d\varphi. \quad (11.11)$$

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:

$$X_{ht} = \frac{\mu_h^* Y_t^* (w_t \tau_t)^{1-\sigma_h}}{P_t^{*(1-\sigma_h)}} \lambda_3 \sum_{s=0}^t (1-\delta)^s (\alpha_h Y_{t-s}) \left(\frac{P_{h,t-s}^{*(1-\sigma)} w_{t-s}^{\sigma_h}}{\mu_{h,t-s} Y_{t-s}^*} \lambda_0 \delta f_{h,t-s}^x \tau_{t-s}^{\sigma_h-1} \right)^{\frac{-\gamma_h + \sigma_h - 1}{\sigma_h - 1}}, \quad (11.12)$$

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 (11.10).

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 :

$$X_t = f(\underbrace{Y_t}_{+}, \underbrace{Y_{t-s}}_{+}, \underbrace{Y_t^*}_{+}, \underbrace{Y_{t-s}^*}_{+}, \underbrace{w_t}_{-}, \underbrace{w_{t-s}}_{-}, \underbrace{\tau_t}_{-}, \underbrace{\tau_{t-s}}_{-}, \underbrace{f_{ht}^x}_{-}, \underbrace{f_{h,t-s}^x}_{-}), s > 0. \quad (11.13)$$

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 tran-

sition 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 lagged effects, as in equation (11.12). 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, Mayer and Ries (2010).

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 (2012) 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 18 in the Appendix is a choropleth map of per capita income by county, which can be compared to the distribution of import-competing manufacturing in Figure 19. 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.

11.3 Figures and Graphs (Online Appendix)

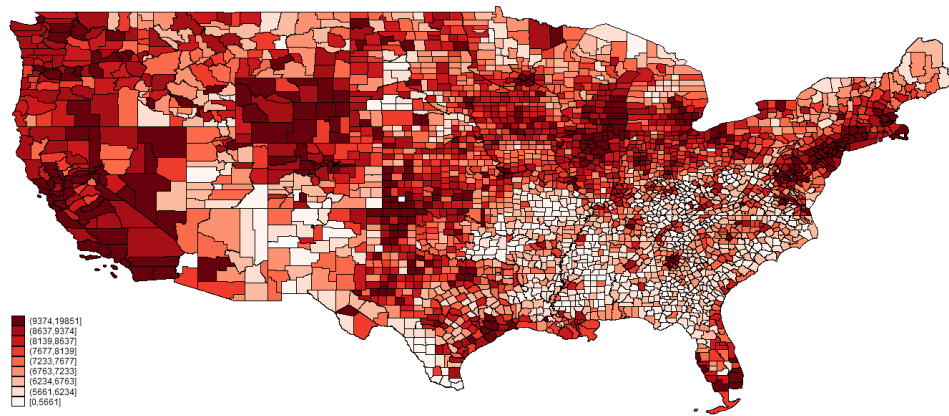


Figure 18: Income per Capita, 1979

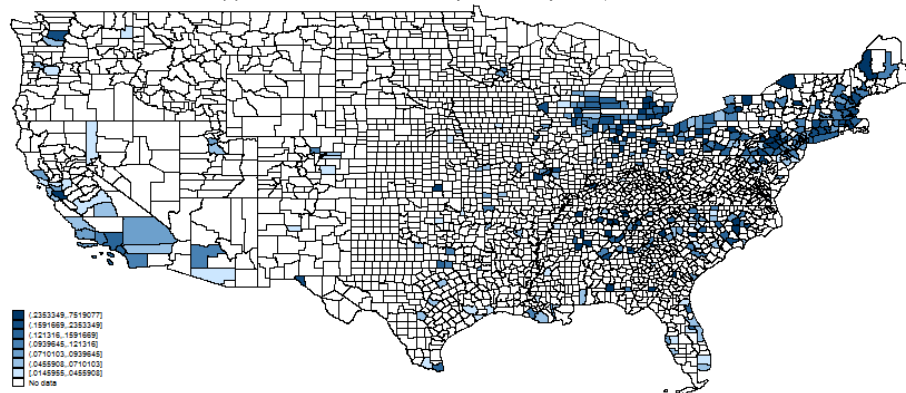


Figure 19: Import-Competing Manufacturing Employment, Share of Total Employment, 1979

Notes: 1,500 worker minimum. Sources: BEA and WITS

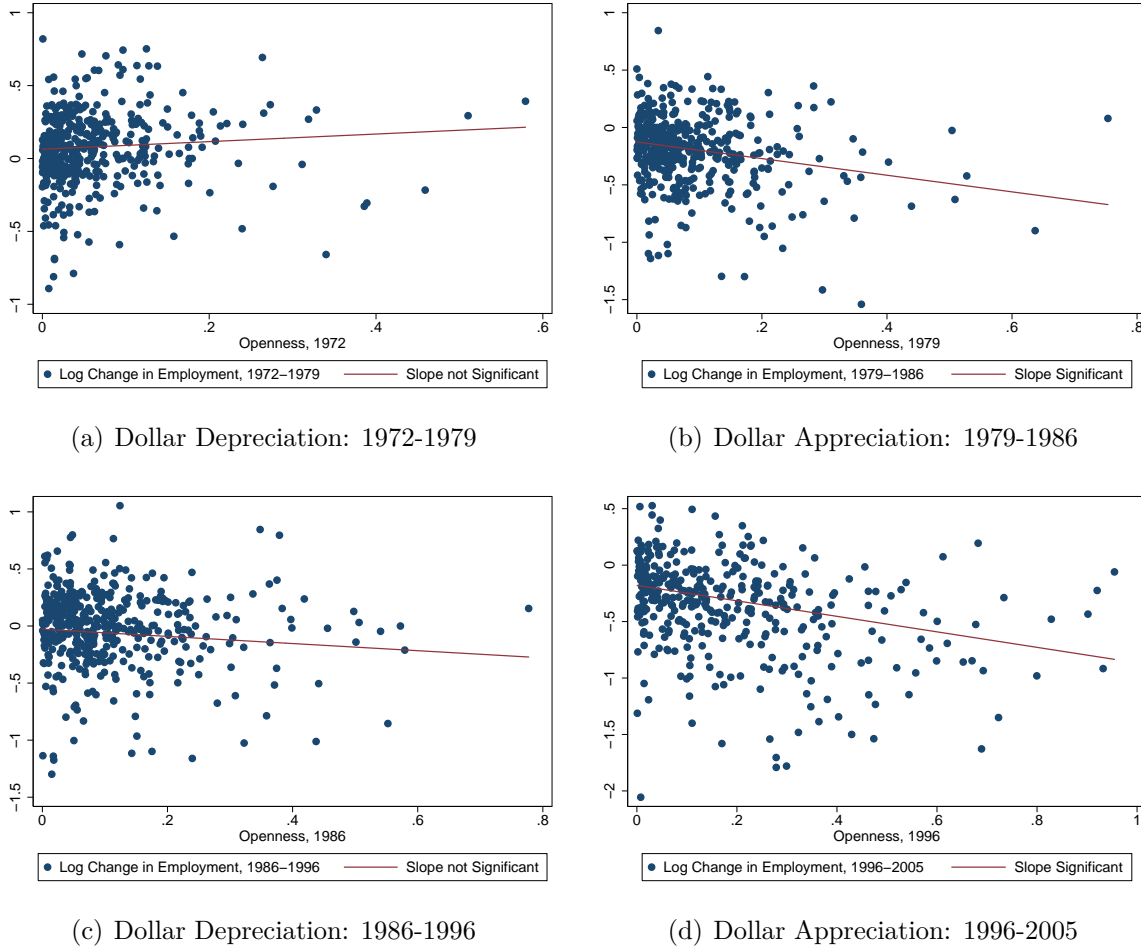


Figure 20: Manufacturing Employment vs. Openness

Notes: In the right panels, when the US price level is relatively high, more open sectors experience statistically significant and economically meaningful declines in employment. When the US price level is close to that of trading partners, there is no relationship. All regression lines weighted by initial year value-added. Source: Annual Survey of Manufactures, BEA

	$\ln \Delta L$	$\ln \Delta L$	$\ln \Delta L$	$\ln \Delta L$	$\ln \Delta L$	$\ln \Delta L$
A. Was it just China?						
L. $\ln(\text{WARULC}) \cdot \text{Rel. Openness}$	-0.090*** (0.021)	-0.067*** (0.026)	-0.071*** (0.025)	-0.093*** (0.021)	-0.078*** (0.022)	-0.083*** (0.022)
L.Chinese Import Penetration	-0.042* (0.021)		-0.037 (0.049)	-0.13*** (0.020)		-0.11*** (0.028)
L.Chinese Import Pen.* $\ln(\text{RULC})$		-0.046 (0.038)			-0.086*** (0.018)	
Industry FE	Yes	Yes	Yes	No	No	No
Time Period	1972-2009	1990-2009	1990-2009	1972-2009	1990-2009	1990-2009



Figure 21: Hysteresis: No Rebound after Collapse

Note: This figure demonstrates hysteresis, as more open sectors which did relatively worse during the downturn did not necessarily do better once US relative prices returned to unity. Sources: Annual Survey of Manufactures, BEA

Table IX: 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 (0.018)	-0.0044 (0.0085)	-0.0057 (0.0053)	0.0013 (0.0022)
L2. $\ln(WARULC)*Rel. Openness$	-0.043*** (0.016)	-0.0077 (0.011)	-0.0048 (0.0047)	-0.00059 (0.0025)
L. $\ln(WARULC)*Rel. Openness$	-0.061*** (0.022)	0.019* (0.010)	0.018 (0.011)	0.0032 (0.0034)
$\ln(WARULC)*Rel. Openness$	-0.068** (0.027)	0.0022 (0.0085)	-0.0077 (0.0065)	0.0015 (0.0026)
F. $\ln(WARULC)*Rel. Openness$	-0.038* (0.021)	0.000042 (0.011)	-0.00094 (0.0039)	0.0022 (0.0027)
F2. $\ln(WARULC)*Rel. Openness$	-0.014 (0.025)	-0.010 (0.012)	-0.0036 (0.0043)	0.0014 (0.0026)
F3. $\ln(WARULC)*Rel. Openness$	0.0039 (0.022)	-0.0093 (0.0095)	-0.00045 (0.0049)	0.0023 (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 openness 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 X: 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*** (0.020)	-0.087*** (0.020)	-0.089*** (0.027)			-0.094*** (0.021)
L.ln ΔL	0.062*** (0.020)	0.063*** (0.021)				
L2.ln ΔL		-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 openness interacted with $\ln(\text{WARULC})$ instead of relative openness as the regressor of interest, and the fifth column uses $\text{WARULC}-1$ in place of $\ln(\text{WARULC})$, 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.