# 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. In addition, I find that the impact of a temporary shock to real exchange rates is surprisingly long-lived. 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
***Keywords:*** Exchange Rates, American Manufacturing, Hysteresis, Trade

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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.

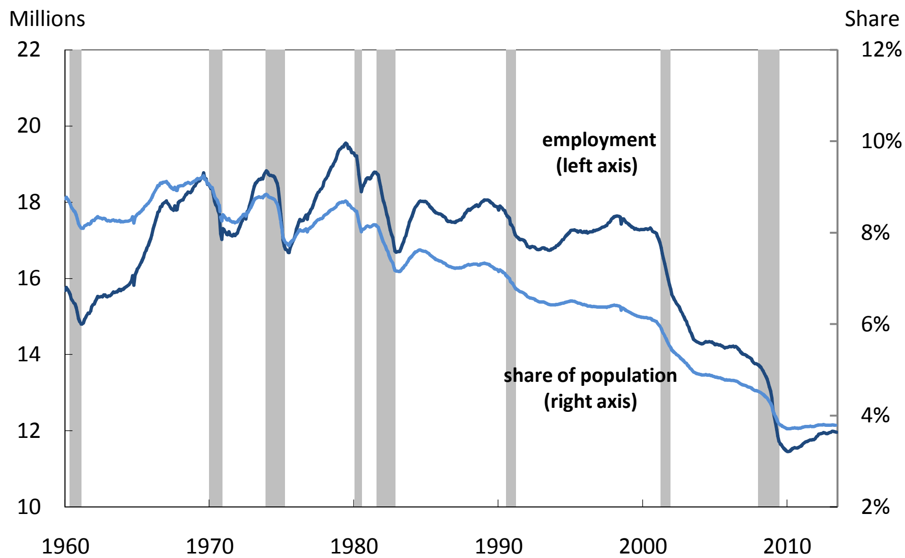



Figure 1: American Manufacturing Employment, 1960-2013.
Source: BEA

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

[1]Many 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 would 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 sole cause of the general decline.

[2]Note 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 16(a)).[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 VII)[4], while the services share of exports has been surprisingly constant over the past few decades (Figure 14(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.* (2013) 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. In another important contribution, Pierce and Schott (2012) argue that China's ascension 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.[6]

A second strand of literature studying the impact of real exchange rate movements on manufacturing mostly finds that manufacturing employment is sensitive to currency

[3]Yet, 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. 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.

[4]And, 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.

[5]There 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.

[6]Ebenstein *et al.* (2012) document a series of facts consistent with the idea that Chinese import competition reduced US manufacturing employment.

appreciations (Klein, Schuh, and Triest 2003, see Klein *et al.* 2002 for an overview).[7] 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. I then 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. 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 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.[8] 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 manufac-

[7] Other 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.

[8] I thank Thomas Wu for this suggestion.

turing 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.

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).[9] 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 price levels, and (2) the multiple benchmarking used in the creation of PWT version 8.0.[10]

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

[9]The Fed's real exchange rate index is: $I_t^d = I_{t-1} \times \Pi_{j=1}^{N(t)} (\frac{e_{j,t}p_t/p_{j,t}}{e_{j,t-1}p_{t-1}/p_{j,t-1}})^{w_{j,t}}$, where $e_{j,t}$ is the price of a dollar in terms of the currency of country j at time t, $p_t$ is the US consumer price index at time t, $p_{j,t}$ is the consumer price index of country j at time t, $N(t)$ is the number of 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.

[10]These 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.

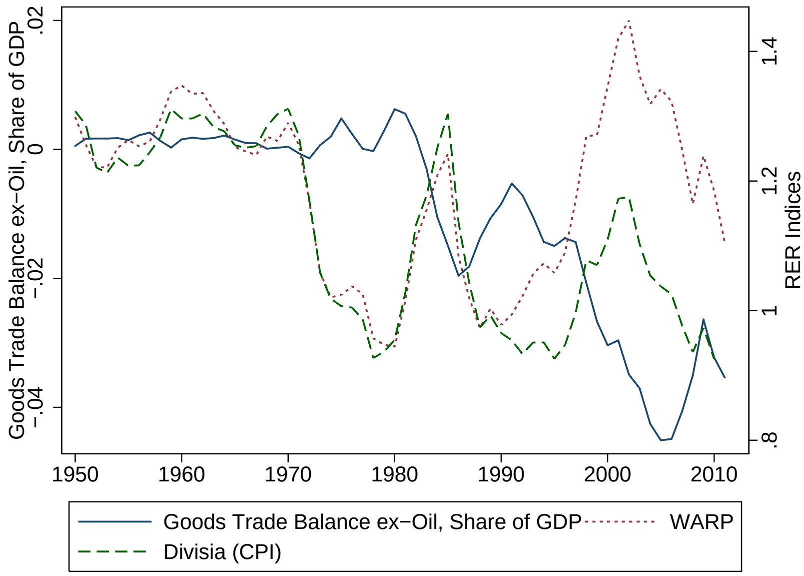



Figure 2: Real Exchange Rate Measures vs. the Current Account

Sources: BEA and Campbell (2014)

in trade with countries, such as China, that have systematically lower unit labor costs.[11] 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 from all six ICP benchmarks, and which includes developing countries such as China.[12] 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).[13]

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

[11]These 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.

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

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

what matters for employment is the level of US relative unit labor costs, rather than the change.[14] 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 suprising 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.[15] 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 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 1.9 to 2.1 million manufacturing jobs directly in the period 1995-2008.[16] Third, while economists have long taught crowding

[14] It 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 prominent financial markets and a freely floating 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.

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

[16] In this paper I do not study input-output linkages, but the fact that every dollar of manufacturing output requires 60 cents of output from other industries used in production seemingly implies that the direct estimates only represent part of the total jobs lost due to relative price movements.

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.[17]

# 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 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.[18] Even so, the various research designs (discussed below) implemented in this

[17] I 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).

[18] Note that this logic would not hold if I found that RER movements do not have an impact on

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 explictly 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 openess, as more open sectors could potentially be more sensitive to movements in the RIR. However, 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 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.[19] In any case, growth in imports from China was also 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.

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.”

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

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, effectively testing out of sample. While still not foolproof, repeated difference-in-difference regressions dramatically reduce the number of potential variables that could be perfectly 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. Such an omitted variable would also need to be a factor that has, to date, been absent from the economics literature on the causes of RER movements, as these factors are straightforward to include as controls. In addition, in each year this omitted variable needs to be very strongly correlated with openness by sector. It may be possible that such a variable exists, but the repeated element of the difference-in-difference make this a very 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, in addition to cutting against the central teaching of economics, if profit-maximizing firms did not respond to this large change in relative prices.[20]

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 openess in 1972 effectively rules out endogeneity, as a dollar appreciation in 1985 could not have "caused" a change in openness across sectors in 1972.[21] 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,

[20]In 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.

[21]I 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.

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, openess 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 (Appendix Figure 14).[22]

[22]The "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.

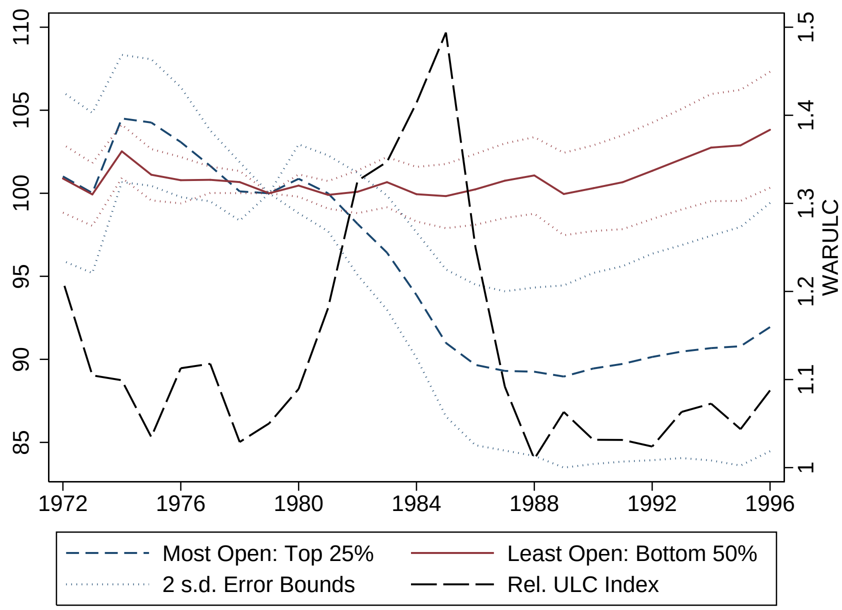



Figure 3: Employment Growth by Degree of Openness in 1972 (SIC)*

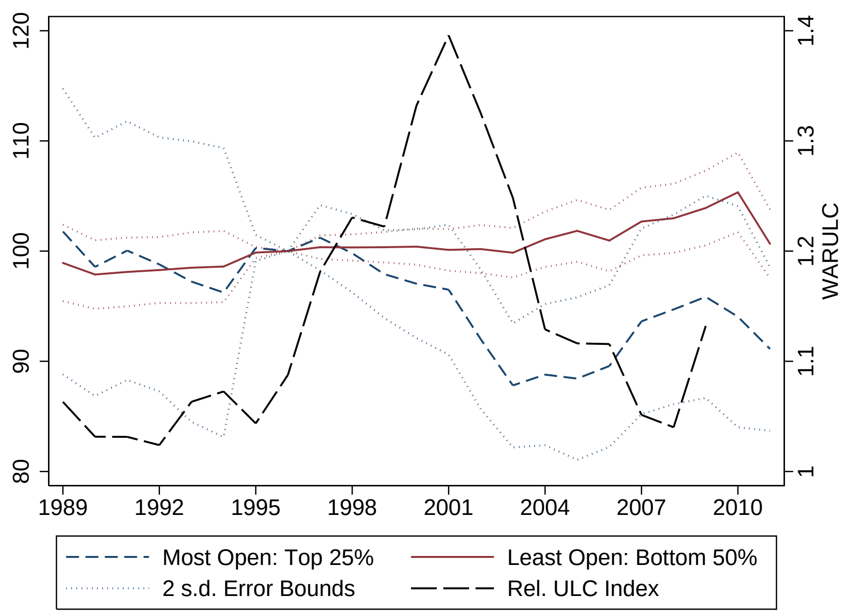



Figure 4: Employment Growth by Degree of Openness in 1989 (NAICs)*

*Notes: 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. Employment data are from the Annual Survey of Manufactures, and WARULC (Weighted-Average Relative Unit Labor Costs) is from Campbell (2014).

# 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 outdated, 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 previous versions of the Penn World Tables). Both measures are plotted in Figure 5 vs. the IMF's RULC index.[23] 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.[24]

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, 2014). Data on intermediate imports are from the BEA's Input-Output tables for the year 1997. The classification of broad industrial sectors by markups is borrowed from Campa and Goldberg (2001).[25]

The summary statistics for the most relevant variables in select years are reported in

[23]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 $ULC_{i,t} = \frac{w_{i,t}}{e_{i,t}}/\frac{Y_{i,t}}{PPP_{i,t}}$, 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.

[24]All 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

Table I: Data Summary for Select Years

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

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

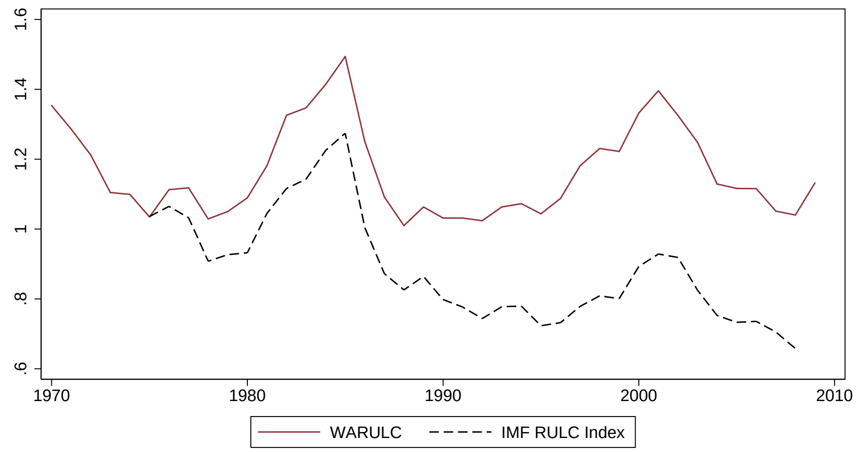


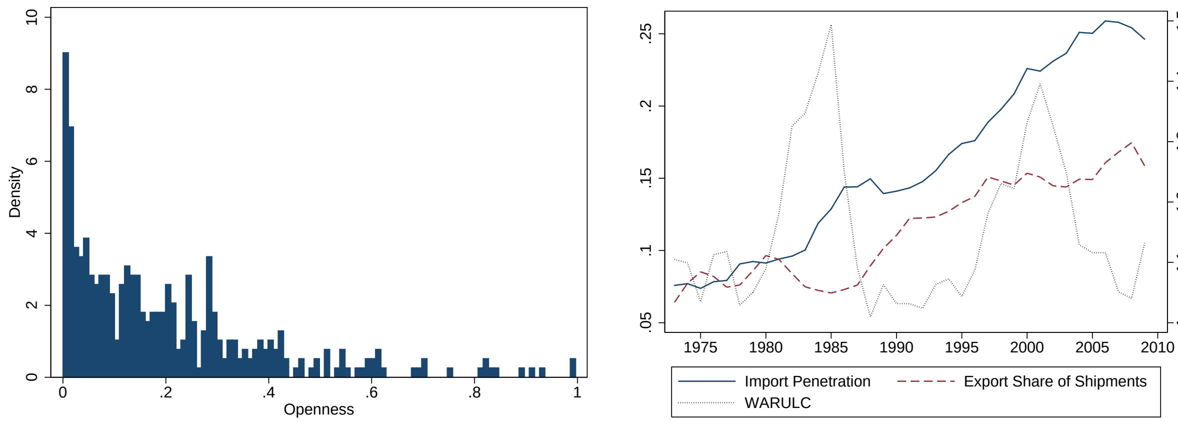

Figure 5: WARULC vs. IMF RULC Index

Sources: Campbell (2014) and the IMF

Table I. 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%. Chinese import penetration increased from almost nothing in the 1980s to 12.4% by 2005. 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 I, 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.

(2014).

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




(a) Openness (b) Trade Growth vs. WARULC

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

# 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 and shipments per production worker.[26] The annual coefficients are plotted in blue vs. WARULC, along with 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.[27] Note that the annual coefficient becomes

[26]This regression is $ln(L_{ht}/L_{h,t-1}) = \alpha_t + \beta_0 Rel.Openness_{h,t-1} + \beta_2 ln(D_{h,t}/D_{h,t-1}) + \beta_3 ln((TFP)_{h,t}/(TFP)_{h,t-1} + \epsilon_{ht}$, $h = 1, ..., 359$, $for\, each\, year = 1973, ..., 2009$. 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 openess 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.

[27]The 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.

significant in 1998, while China was awarded permanent MFN status and joined the WTO in December of 2001.

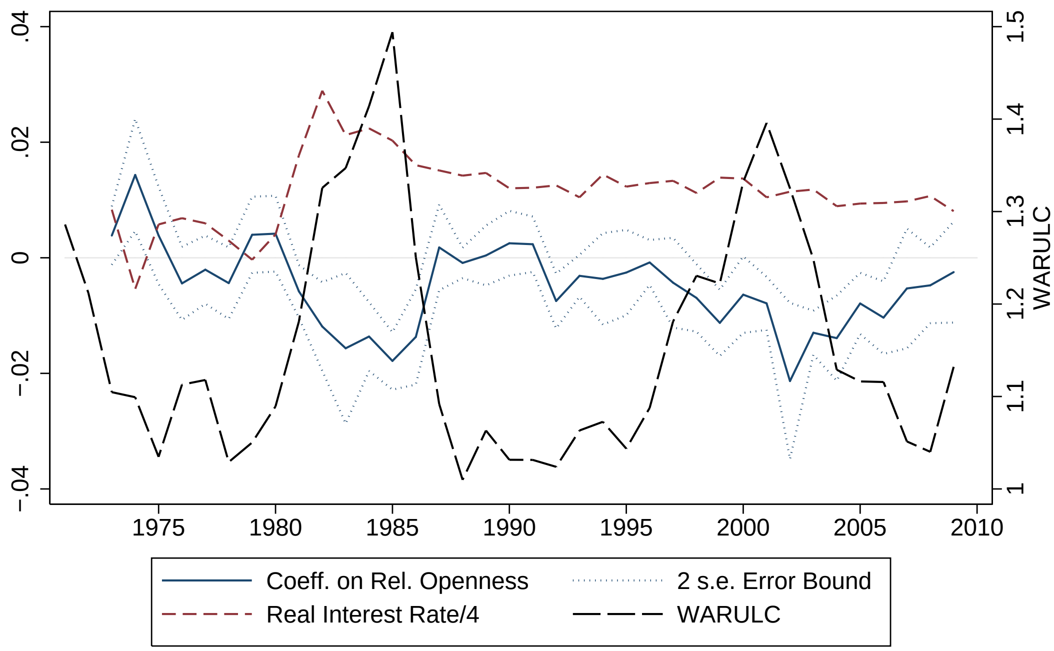



Figure 7: Impact of Relative Openness by Year

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 on relative openness are from annual regressions of log changes in employment on changes in demand and productivity 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 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)[28], while including controls from the theoretical model presented in the appendix

[28] Although this is not necessarily a bulletproof strategy, as increases in imports are likely to be

(equation 10.6).

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

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

$$\forall h = 1, ..., 359, \ t = 1973, ..., 2009,$$

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 Cs are various other controls.[29] $\varphi(L)$ 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 $\alpha_h$, year fixed effects $\nu_t$, 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. The results do not appear to be sensitive to the choice of weights, as qualitatively similar results attain when weighting by average value-added, employment, or shipments, although the key coefficient is the largest when weighting by employment or when not weighting. 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.[30]

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

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autocorrelated. The solution to use fixed categories of openess based on initial data, which is exactly the strategy I followed 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.

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

[30] These 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 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, 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. Lastly, one could control for import penetration and export share separately instead of combining them into a single openness measure. The coefficient on each is not statistically distinct, but these measures are highly correlated with each other and thus have a problem with multicollinearity, and the export share term interacted with the relevant RER index is generally of the right sign but not significant.

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 II, 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.[31]

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). Following Pierce and Schott (2014), I also include 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. I find that this variable is generally significant, supporting the findings of Pierce and Schott (2013). 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.[32]

[31]In 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, in which levels are implicitly assumed not to matter.

[32]The results are also unchanged when including controls for tariffs, the cost of insurance and freight,

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

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L |
| L.Relative Openness | -0.010** | -0.0053 | -0.0092 | -0.0036 | -0.0036 | 0.0032 |
| | (0.0044) | (0.0036) | (0.0059) | (0.0059) | (0.0056) | (0.0036) |
| L.Rel.Open*ln $\Delta$ WARULC*Pos. | -0.088* | | -0.20** | -0.098 | | |
| | (0.052) | | (0.100) | (0.098) | | |
| L.Rel.Open*ln $\Delta$ WARULC*Neg. | -0.0048 | | 0.011 | 0.0014 | | |
| | (0.052) | | (0.057) | (0.045) | | |
| L.ln(WARULC)*Rel. Openness | | -0.056*** | | -0.068*** | -0.090*** | -0.082*** |
| | | (0.016) | | (0.015) | (0.021) | (0.013) |
| *ln* $\Delta$ Demand | | | 0.45*** | 0.45*** | 0.38*** | 0.54*** |
| | | | (0.062) | (0.061) | (0.066) | (0.046) |
| L.(K/L) | | | 0.044 | 0.045* | 0.028 | 0.065* |
| | | | (0.027) | (0.027) | (0.029) | (0.034) |
| L.(K/L)*Real Interest Rate | | | -0.18 | -0.29 | -1.33*** | -1.15* |
| | | | (0.29) | (0.29) | (0.48) | (0.65) |
| L.*ln* $\Delta$ Wages | | | 0.021 | 0.018 | 0.021 | 0.015 |
| | | | (0.023) | (0.022) | (0.026) | (0.014) |
| L.*ln* $\Delta$ Price of Shipments | | | 0.036** | 0.035** | 0.041** | 0.019* |
| | | | (0.016) | (0.016) | (0.016) | (0.011) |
| $ln\Delta$ VA-per-Production Worker | | | -0.21*** | -0.21*** | | |
| | | | (0.035) | (0.035) | | |
| $ln\Delta$ TFP | | | | | -0.076 | -0.26*** |
| | | | | | (0.073) | (0.049) |
| Post-PNTR x NTR *Gap_i* | | | | | 0.051*** | 0.058*** |
| | | | | | (0.012) | (0.013) |
| Low Markup*L.ln(WARULC) | | | | | 0.017 | 0.0100 |
| | | | | | (0.028) | (0.015) |
| Imported Inputs*L.ln(WARULC) | | | | | 0.070 | -0.19** |
| | | | | | (0.18) | (0.089) |
| L.Rel.Openness*RIR | | | | | 0.0093 | 0.0068 |
| | | | | | (0.0086) | (0.0048) |
| L.*ln* $\Delta$ PM*(M/S) | | | | | -0.17** | -0.15** |
| | | | | | (0.081) | (0.071) |
| L.*ln* $\Delta$ PI*(I/S) | | | | | -1.15** | -0.39 |
| | | | | | (0.57) | (0.65) |
| L.*ln* $\Delta$ PE*(E/S) | | | | | -0.26 | -0.19 |
| | | | | | (0.19) | (0.21) |
| 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 (6) repeats the specification using a quantile regression, 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.

The results in this table include 359 sectors with complete, balanced data, and exclude all sectors in the 2-digit SIC category publishing, which is not classified as manufacturing by NAICS. The results are robust to excluding either the year or SIC fixed effects (which control for trends), and are also robust to including both publishing and the unbalanced sectors, for a total of 448 industries.

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.

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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 alterative 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 (2012), such as Chinese production subsidies and export eligibility by sector, are not yet publicly available.

# 4 Proxies and Alternative Measures of RER Indices

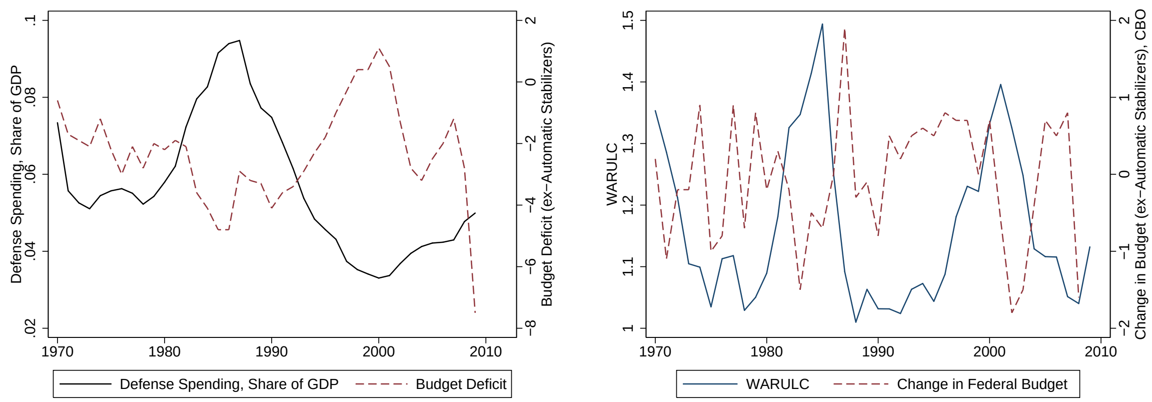
Large US fiscal deficits were a likely potential cause of the dollar's strength during the early 1980s. Fiscal deficits can affect the tradables sector in at least three ways. First, even in a closed economy setting, higher government spending could induce more resource allocation away from manufacturing via rising wages or real interest rates. Secondly, in 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 8(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 8(b)), although the correlation with other measures of the real exchange rate, such as WARP or the Fed's index, is even more pronounced.

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 9 compares several state-of-the-art measures of relative prices which use PWT v8.0 data and methodology




(a) Defense Spending vs. Budget Deficit

(b) Structural Budget Deficit vs. WARULC

Figure 8: Defense Spending, the Structural Budget Deficit, and RULCs
Sources: FRED and CBO

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 fairly 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 (2013b), 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

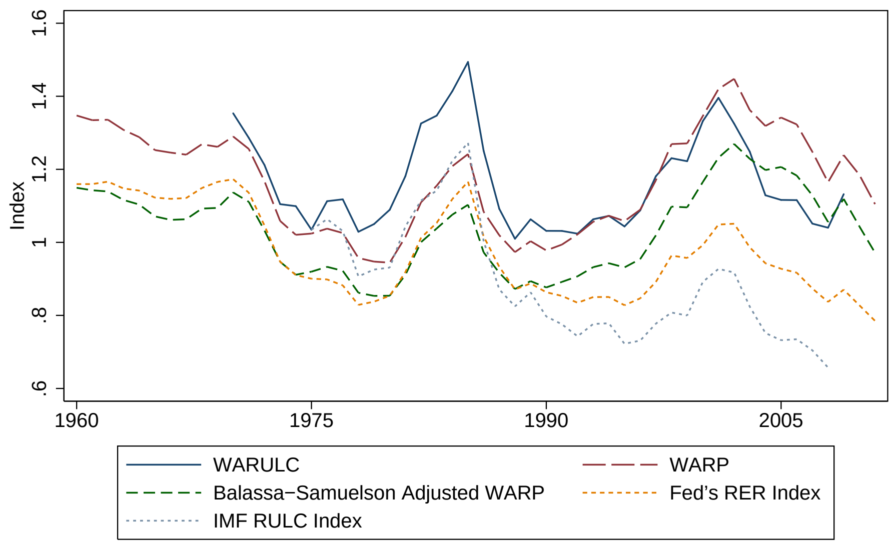



Figure 9: Comparing Various Exchange Rate Measures
Source: Campbell (2014) and the IMF

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 WARP index, and 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, 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.[33] 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.[34]

[33] I 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.

[34] While 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: Using Alternative Measures of Relative Prices, and Proxies for the RER

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L |
| L.Rel.Openness* $ln\Delta$ (Defense/GDP) | -1.00*** | | | | | |
| | (0.25) | | | | | |
| L.Rel.Openness* $ln\Delta$ (Defense/Shipments) | | -1.06*** | | | | |
| | | (0.18) | | | | |
| L.Rel.Openness*$\Delta$ Structural Budget | | | 0.60** | | | |
| | | | (0.26) | | | |
| L.Rel.Openness*ln(WARP) | | | | -0.064*** | | |
| | | | | (0.018) | | |
| L.Rel.Openness*ln(BSWARP) | | | | | -0.070*** | |
| | | | | | (0.019) | |
| L.ln(Sectoral WARULC) | | | | | | 0.021** |
| | | | | | | (0.011) |
| L.Rel.Openness*ln(Sectoral WARULC) | | | | | | -0.035*** |
| | | | | | | (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 II), 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.

# 5 Impact on Output, 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.[35] 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.[36]

In Table IV, I show that production worker hourly wages in more open sectors only decline slightly when relative prices are elevated (I separately found no significant impact on non-production worker wages), and that investment, value-added and shipments all fared worse. There was no significant impact on the log change in prices or on inventory. Since theory does not necessarily provide a strong rationale why inventory should be affected by movements in real exchange rates, this is arguably a falsification exercise. Predicting the changes in the sectoral deflators for investment, materials, and energy are perhaps even stronger candidates for falsification exercises, since any finding that real exchange rate movements lead to disproportionate changes in the costs of more open sectors would likely be spurious, raising doubts as to whether the estimation method in

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

[36] In 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.

this paper has a tendency to find spurious results. However, I find that the interaction term on WARULC and openness does not significantly predict the growth of any of these deflators, even for various leads and lags.[37] 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 TFP (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 on Hours, Investment, Production, Inventory and Prices

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

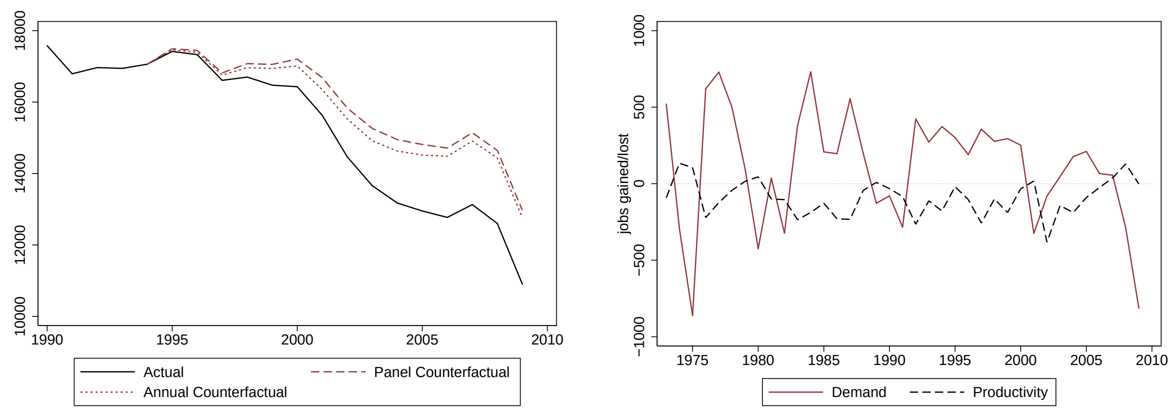
Two-way clustered standard errors in parentheses, clustered by year and industry. *$p < 0.1$, ** $p < 0.05$, *** $p < 0.01$. All regressions weighted by initial sectoral value-added, and include 4-digit SIC industry and year fixed effects over the period 1973-2009. The dependent variables are 1) log changes in production worker hourly wages, 2) investment, 3) value-added, 4) shipments, 5) inventories, and 6) shipments' prices.

# 6 Accounting for Jobs Lost

Figure 10 presents the results from two counterfactuals which add back the cumulative jobs lost from the dollar's strength in the late 1990s and early 2000s (blue dashes), using

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

the regression coefficients displayed in Figure 7 and a second estimate using the panel regression from Column (5) of Table II. The estimates of jobs lost are calculated by multiplying the coefficient on the interaction term by the level of WARULC interacted with relative openness times lagged sectoral employment, and then summing across sectors for each year to derive an estimate of the total jobs lost due to WARULC appreciation. The estimates using the annual regressions imply that 1.86 million jobs were lost due to trade competition over the period 1995-2008, while the panel estimates suggest 2.07 million jobs were lost. Both of these are substantially *lower* than the 3.9 million jobs lost according to a straightforward accounting approach (Table VII) based on the rise in the manufacturing trade deficit.[38] However, what is clear is that even both of these counterfactuals imply a substantial fall in manufacturing employment after 2000. What accounts for this decline?




(a) Manufacturing Employment Counterfactuals

(b) Impact of Demand and Productivity

Figure 10: Accounting for Labor Lost

Notes: In Panel (a), the "Panel Estimate" counterfactual is computed using the coefficient on relative openness from the regression in Column (5) of Table II. The "Annual Estimate" uses regression coefficients plotted in Figure 7. The coefficient on lagged import penetration is multiplied by lagged sectoral employment and then summed by year.

Figure 10(b) details the impact of changes in demand and productivity on changes in manufacturing employment (using the regression coefficients from Column (5) of Table II 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

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

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. Every dollar of output of apparel manufacturing requires 30 cents of output from textile mills.[39] Every dollar of industrial machinery requires 6.9 cents worth of the output from iron and steel mills. Overall, every dollar of aggregate manufacturing output generally requires about 60 cents worth of additional output from other manufacturing industries (I get a similar estimate using detailed IO data). This suggests that it is quite likely that closer to 3 million manufacturing jobs were lost from the dollar's appreciation.[40]

# 7 International Evidence

## 7.1 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 11 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.[41] 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 12).[42] As Canadian unit labor costs have increased sharply relative to trading partners (including the US)

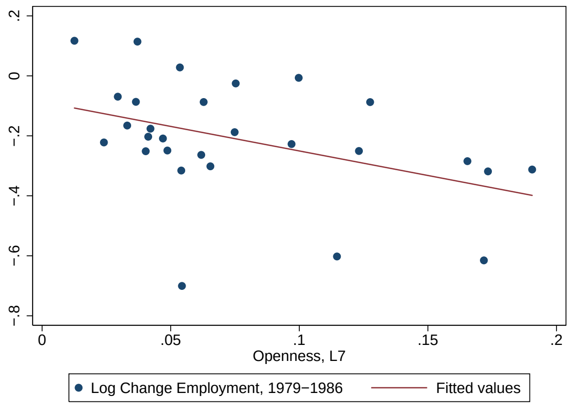
[39] Data come from the BEA's Total Requirements Input-Output table.

[40] This 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.

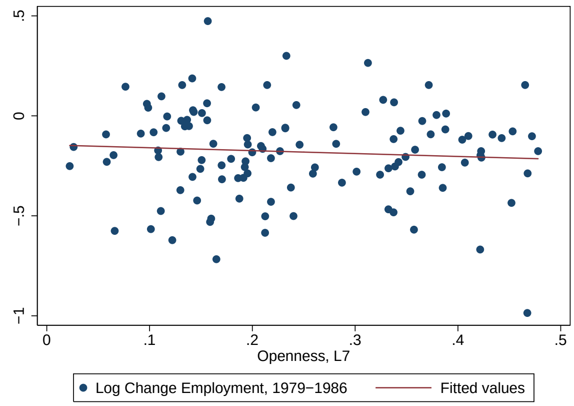
[41] In the Additional Appendix, I also show that there is no correlation between openness and employment for years when the dollar was weak.

[42] Canadian 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.

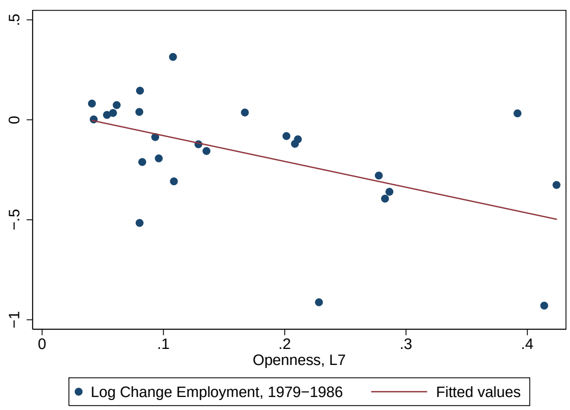
since 2003, Canadian manufacturing has lost more than twice as many manufacturing jobs as the US as a share of 2003 employment, with the losses concentrated in the more open Canadian manufacturing sectors (Figure 12, Panel (b)).



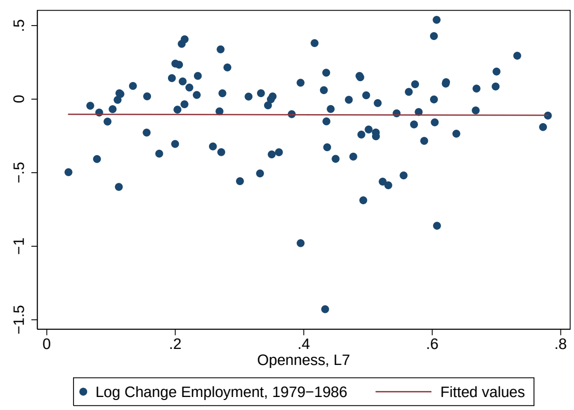

(a) US, 1979-86




(b) Other Major Economies, 1979-86




(c) US, 1995-2002




(d) Other Major Economies, 1995-2002

Figure 11: Employment Growth vs. Lagged Openness

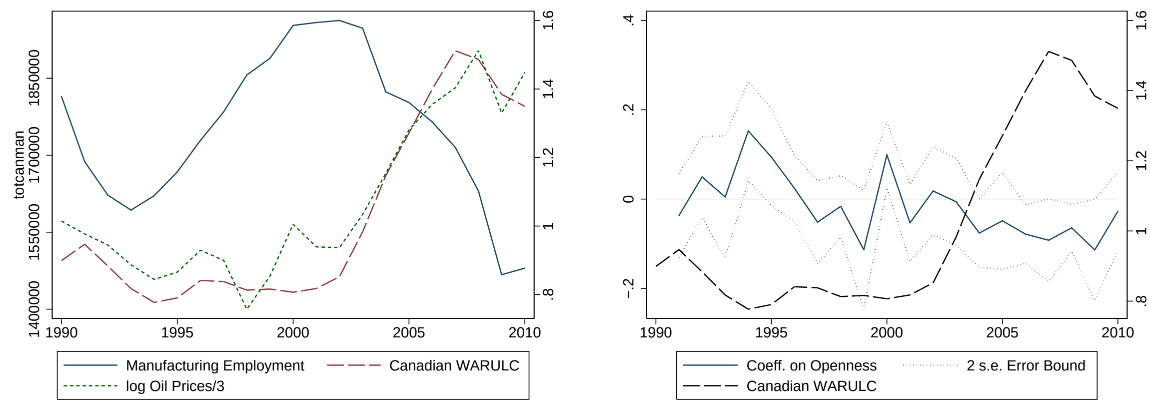
Source: UNIDOs (3-digit ISIC manufacturing sectors). Other major economies include Canada, France, Germany, Italy, and the UK.

Thus, we now estimate:

$$ln(\frac{L_{US,h,t}}{L_{US,h,t-1}}) - ln(\frac{L_{G5,h,t}}{L_{G5,h,t-1}}) = \alpha_t + \beta_1((WARULC - 1) * Openness)_{h,t-1} + \quad (7.1)$$

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

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




(a) Total Employment vs. WARULC

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

Figure 12: 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 openess by sector on employment growth. The negative correlation between openness and employment growth begins once WARULC appreciates.

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

The dependent variable is now the log change in sectoral US employment minus the average log change in employment in Canada, France, Germany, Italy and the UK. The manufacturing data are 3-digit ISIC Rev. 2 data from UNIDOs, which does not report data for the US for the year 1996. 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. 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.[43]

In the third column of Table V, I estimate the relative difference-in-difference regression in equation (7.1), 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 depen-

[43]In 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.

Table V: International Evidence

| | (1) ln $\Delta L$ | (2) ln $\Delta Y$ | (3) ln $\Delta L$ Rel. | (4) ln $\Delta Y$ Rel. | (5) ln $\Delta L$ Canada | (6) ln $\Delta L$ Canada |
|---|---|---|---|---|---|---|
| L.Openness | 0.048 | 0.059*** | 0.072 | -0.027 | 0.048 | 0.030 |
| | (0.030) | (0.022) | (0.056) | (0.032) | (0.035) | (0.033) |
| L.Openness*(WARULC-1) | -0.58*** | -0.53*** | -0.76*** | -0.64*** | | |
| | (0.10) | (0.095) | (0.090) | (0.078) | | |
| ln $\Delta(Y/L)$ | -0.90*** | | | | -0.83*** | -0.82*** |
| | (0.041) | | | | (0.041) | (0.042) |
| ln $\Delta$ Demand | 0.89*** | 0.97*** | | | 0.82*** | 0.82*** |
| | (0.040) | (0.040) | | | (0.064) | (0.066) |
| ln $\Delta(Y/L)$ (Relative) | | | -0.52*** | | | |
| | | | (0.078) | | | |
| ln $\Delta$ Demand (Relative) | | | 0.59*** | 0.91*** | | |
| | | | (0.066) | (0.040) | | |
| L.Openess*(WARULC-.85) | | | | | -0.15*** | |
| | | | | | (0.042) | |
| L.Openess*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.

dent 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.[44] Also, it appears that for Canada, 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.[45] Finally, in the last column, I proxy movements in Canadian relative unit labor costs using the log of oil prices minus three, and again find that when oil prices are high, the more open sectors in Canada tend to lose ground relative to less open sectors.

## 7.2 Japan

Just as China as 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 Trea-

[44] This 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.

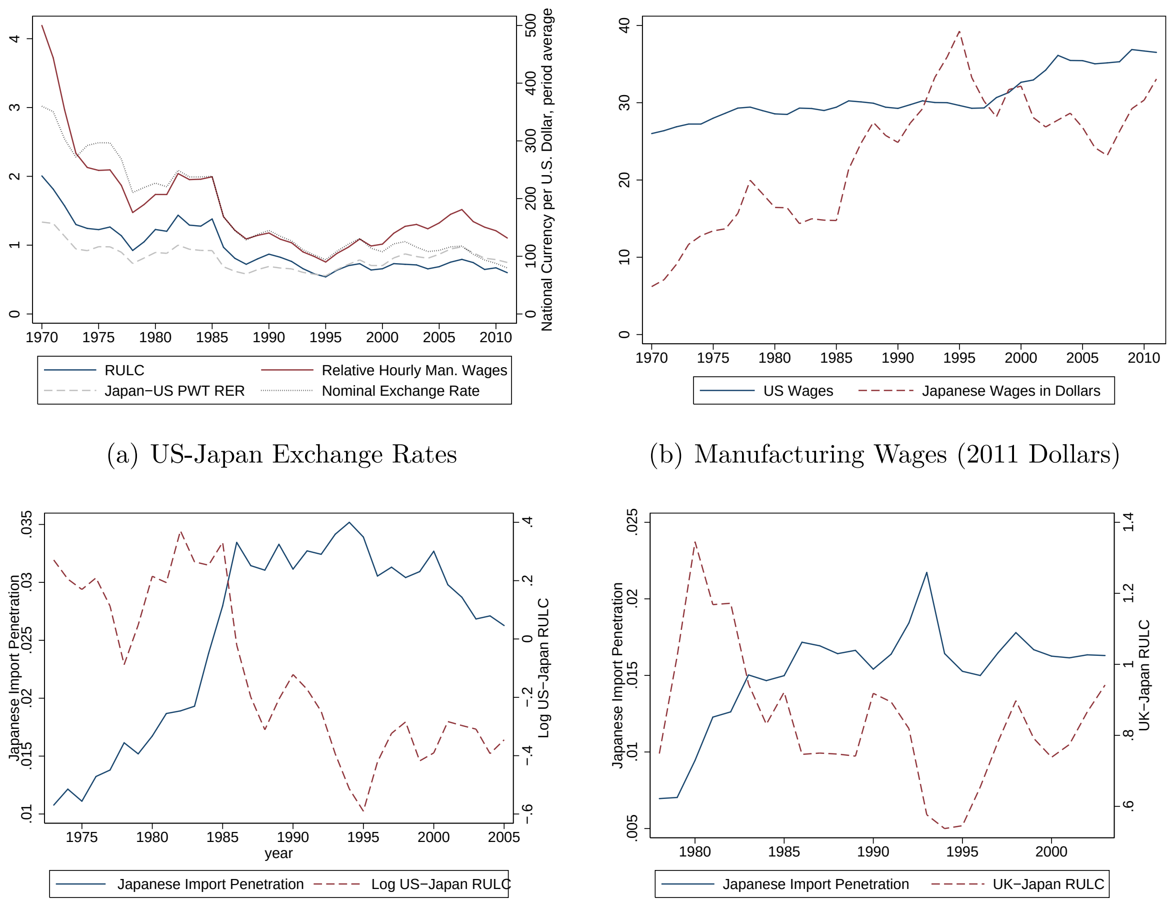
[45] This could be due to a country-specific bias in the data collection, tariff policy, or any number of other factors.

sury, added substantial additional liberalization measures in the Yen-Dollar Agreement (Frankel, 1990). As the dollar continued to soar in 1985, the Reagan Administration responded with the Plaza Accord, an agreement among major nations to reduce fiscal imbalances and intervene in the currency markets to weaken the dollar, and the 1985 Gramm-Rudman-Hollings Deficit Control Act.

Figure 13, 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.

The result of this real appreciation was that as wages in the Japanese manufacturing sector suddenly increased substantially relative to their American counterparts, the meteoric Japanese export growth from 1946 to 1986 suddenly ground to a halt (Figure 13(c)). However, Japan kept the gains in market share it had made even though it did not make further inroads—another validation 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, Japanese import penetration decreased. 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 this period, Japanese import penetration fell relative to the period when the Yen was strong. In column (3), I




(a) US-Japan Exchange Rates

(b) Manufacturing Wages (2011 Dollars)

(c) US

(d) UK

Figure 13: RULCs and Japanese Import Penetration

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

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. In addition, the pattern of White House intervention when the dollar was overvalued points toward potential policy solutions for the present.

Table VI: Japanese Exports and the Yen

| | (1) US | (2) US | (3) UK | (4) US | (5) G6 |
|---|---|---|---|---|---|
| ln Δ Import Pen. | 0.82*** | 0.80*** | 0.74*** | 0.76*** | 0.87*** |
| | (0.18) | (0.19) | (0.16) | (0.068) | (0.050) |
| L.ln(RULC) | 0.13*** | | 0.25*** | 0.11*** | 0.13*** |
| | (0.027) | | (0.051) | (0.021) | (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 |

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. The dependent variable is the log change in sectoral Japanese import penetration. Columns (1), (2), and (4) use US data, column (3) uses UK data, and column (5) includes stacked observations from the US, the UK, Canada, Germany, Japan, France, and Italy. The data come from Comtrade, UNIDOs, and Campbell and Pyun (2014).

# 8 Conclusion

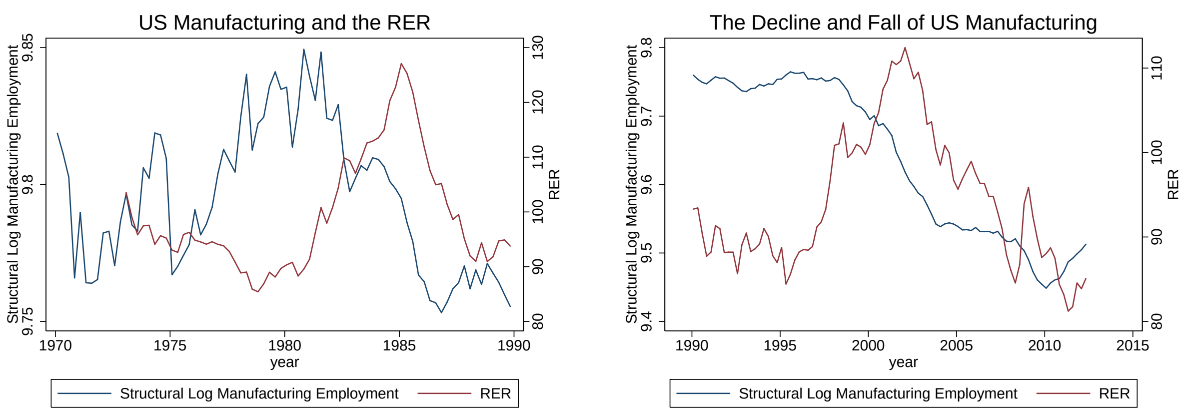
When nominal exchange rates move, the nominal rigidity of wages leads to large changes in Weighted Average Relative Unit Labor Costs, a new measure of competitiveness for the manufacturing sector created specifically for this research. I examine periods, such as the US and Japan in the 1980s, and Canada 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 explain at least close to two-thirds of the decline in American manufacturing employment in this period, and perhaps 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.[46] And the lesson of hysteresis reminds us that the consequences of continued slow-growth will be diminished economic possibilities for years to come.

[46]See Dooley *et al.* 2004, 2005, 2007, and 2009.

# 9 Appendix

Table VII: Manufacturing Employment Accounting

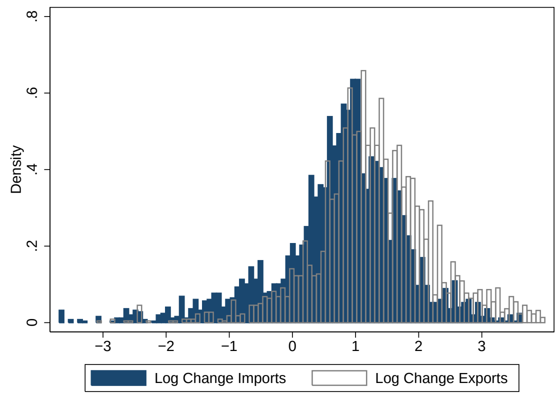
| Year | Manufacturing Consumption (billions) | Manufacturing Consumption (Share of GDP) | Manufacturing Trade Deficit (billions) | Productivity (thousands per worker) | Deficit Δ from 1995 over Productivity | Lost in Man. Since 1995 |
|---|---|---|---|---|---|---|
| 1995 | 1340 | 18.1% | 159 | 68 | 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 |



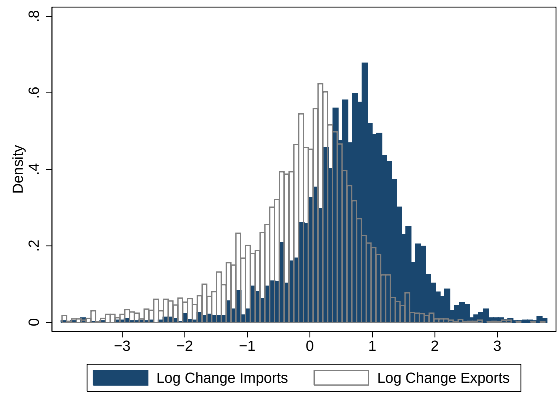

(a) 1970s and 1980s

(b) 1990s and 2000s

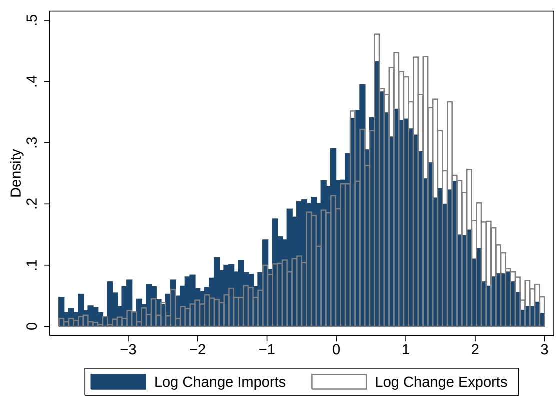
Figure 14: Structural Manufacturing Employment vs. the RER



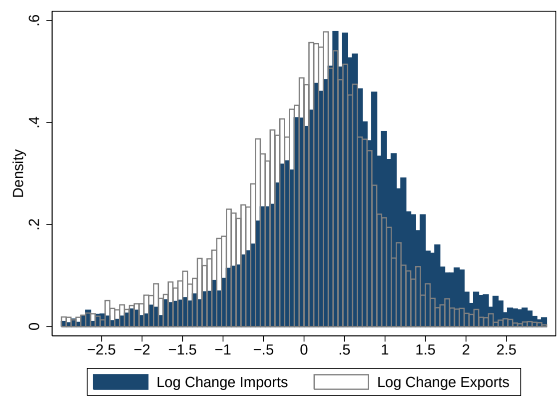

(a) Dollar Depreciation: 1972-1979




(b) Dollar Appreciation: 1979-1986



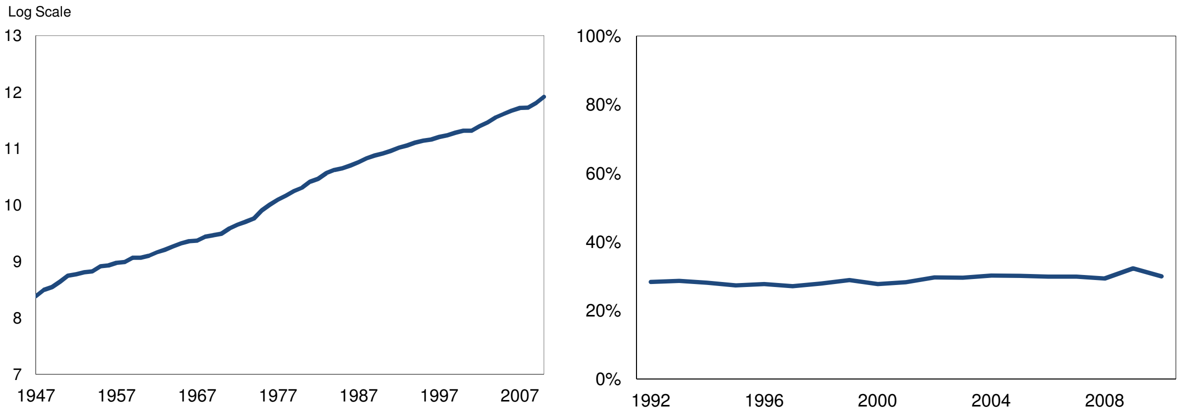

(c) Dollar Depreciation: 1986-1996




(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




(a) Value-Added per Worker

(b) Services Share of Exports

Figure 16: The Usual Suspects: Explanations for the Decline of Manufacturing
Source: BEA

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# 10 Online Appendix

## 10.1 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). In this model, households in the home country consume from a continuum of goods, $\omega$, from a set of goods in H+1 sectors, $\Omega_h$, 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.

$$U_t = q_{0t}^{\mu_0} \prod_{h=1}^{H} \Big( \int_{\Omega_h} q_h(\omega)_t^{\frac{(\sigma_h - 1)}{\sigma_h}} d\omega \Big)^{\frac{\sigma_h \mu_h}{(\sigma_h - 1)}}, \; \sigma_h > 1 \forall h \,. \tag{10.1}$$

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

$$q_h(\omega)_t = \frac{\mu_h Y_t p_h(\omega)_t^{-\sigma_h}}{P_{ht}^{1-\sigma_h}}. \tag{10.2}$$

Firms maximize profits each period after paying a sunk fixed cost to receive a productivity draw (output per unit of labor $\varphi$) and begin producing for the home market, and then choose whether to pay a sunk entry cost to enter the foreign market (for simplicity I assume there are only two countries). Profits per period for an existing firm from sales at home are thus[47]

$$\Pi_h(\omega)_t = q_h(\omega)_t p_h(\omega)_t - \frac{q_h(\omega)_t w_t}{\varphi_h(\omega)} - f_{ht} w_t, \tag{10.3}$$

where p is price, q is output sold at home, w is the wage, $\tau$ 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 $\delta$, yet otherwise will always choose to stay in a market they have previously entered, as expected profits are strictly positive going forward. Maximizing profits, firms choose prices marked up over marginal cost $p_h(\omega)_t^*$ (denotes the price of exports)

$$p_h(\omega)_t = \frac{\sigma_h}{\sigma_h - 1} \frac{w_t}{\varphi_h(\omega)}, \quad p_h(\omega)_t^* = \frac{\sigma_h}{\sigma_h - 1} \frac{w_t \tau_t}{\varphi_h(\omega)}. \tag{10.4}$$

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

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.[48]

$$Foreign\,Entry : E_t\Pi(\omega)^*_{PV,t} = E_t\sum_{s=0}^{\infty}(1-\delta)^s\Pi(\omega)^*_{t+s} - f^x_{ht}w_t \geq 0. \tag{10.5}$$

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:

$$L_{ht} = \underbrace{\int\limits_{\omega\in\Omega}\frac{q_h(\omega)_t}{\varphi_h(\omega)_t}}_{\text{Home Production}} + \underbrace{\int\limits_{\omega\in\Omega^*}\frac{q^*_h(\omega)_t}{\varphi_h(\omega)_t}}_{\text{Export Production}} + \underbrace{M^e_{ht}(f^e_{ht}+f^x_{ht}p^x_{ht})}_{\text{Entry}} + \underbrace{\sum_{s=0}^{\infty}M^e_{h,t-s}(1-\delta)^s f_{ht}p_{h,t,-s}}_{\text{Overhead}}. \tag{10.6}$$

Here $M^e_{ht}$ is the mass of potential entrants at time t, $p^x_{ht} = 1-G(\bar{\varphi}_x)$ is the share of new firms in sector h with productivity greater than the cutoff productivity for exporting, $\bar{\varphi}_x$, and $p_{h,t-s} = 1-G(\bar{\varphi}_{f,t,-s})$ 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 (10.5) 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" draw with probability $\delta$. Thus the cutoff productivity for exporting is

$$\bar{\varphi}_{xht} = \left(\frac{P^{*(1-\sigma_h)}_{ht}w^{\sigma_h}_t}{\mu_h Y^*_t}\lambda_0\delta f^x_{h,t}\right)^{\frac{1}{\sigma_h-1}}\tau_t, \tag{10.7}$$

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

When wages, trade costs, or the sunk fixed costs of exporting rise, or the foreign mar-

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

ket either becomes more competitive or experiences an exogenous reduction in demand in sector h, the cutoff productivity for exporting will rise, meaning that fewer firms will enter.

Additionally, existing firms will exit and stop producing if revenue fails to cover per-period fixed costs. The cutoff productivity for staying in business for purely domestic firms is[49]

$$\bar{\varphi}_{fht} = \left( \frac{P_{ht}^{(1-\sigma_h)} w_t^{\sigma_h}}{\mu_h Y_t} \lambda_0 f_{ht} \right)^{\frac{1}{\sigma_h - 1}}. \tag{10.8}$$

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

$$\frac{\sum_{s=0}^{\infty} \mu_{h,t} Y_t M_{h,t-s}^e \rho^s w_t^{-\sigma_h} \lambda_1 \bar{\varphi}_{mh,t,-s}^{(\sigma_h - 1 - \gamma_h)}}{\sum_{s=0}^{\infty} \rho^s ( M_{h,t-s}^e w_t^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t-s}^{\sigma_h - 1 - \gamma_h} + M_{h,t-s}^{*e} (w_t^* \tau_{ht}^*)^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mxh,t-s}^{*(\sigma_h - 1 - \gamma_h)} )}, \tag{10.9}$$

where $\lambda_1$ and $\lambda_2$ are parameters[50], $\rho = 1 - \delta$ 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

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

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

depends positively on domestic sectoral demand ($\mu_{ht} Y_t$), negatively on domestic wages, and positively on importing trade costs, $\tau^*_{ht}$. 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 10.8), 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 (10.6) 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 (10.8). If wages, fixed overhead costs ($f_{ht}$), iceberg trade costs, or more foreign firms enter, the cutoff productivity for making a profit will rise, and some existing firms will be forced out of the market:

$$\frac{\sum_{s=0}^{\infty} \mu^*_{h,t} Y^*_t M^{*e}_{h,t-s} \rho^s w_t^{*(-\sigma_h)} \tau_t^{1-\sigma_h} \lambda_1 \bar{\varphi}_{mh,t,-s}^{\sigma_h - 1 - \gamma_h}}{\sum_{s=0}^{\infty} \rho^s M^e_{h,t-s} (w_t \tau_{ht})^{(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t-s}^{\sigma_h - 1 - \gamma_h} + \sum_{s=0}^{\infty} \rho^s M^{*e}_{h,t-s} w_t^{*(1-\sigma_h)} \lambda_2 \bar{\varphi}_{mh,t-s}^{*(\sigma_h - 1 - \gamma_h)}}. \tag{10.10}$$

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 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.

## 10.2 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 $\alpha_{ht}Y_t$:

$$X_{ht} = \sum_{s=0}^{\infty}(1-\delta)^s \alpha_h Y_{t-s} \int_{\bar{\varphi}_{t-s}}^{\infty} x_{h,t}(\varphi)\mu(\varphi)d\varphi. \qquad (10.11)$$

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:

$$X_{ht} = \frac{\mu_h^* Y_t^* (w_t\tau_t)^{1-\sigma_h}}{P_t^{*(1-\sigma_h)}} \lambda_3 \sum_{s=0}^{t}(1-\delta)^s(\alpha_h Y_{t-s}) \left( \frac{P_{h,t-s}^{*(1-\sigma)} w_{t-s}^{\sigma_h}}{\mu_{h,t-s} Y_{t-s}^*} \lambda_0 \delta f_{h,t-s}^x \tau_{t-s}^{\sigma_h - 1} \right)^{\frac{-\gamma_h+\sigma_h-1}{\sigma_h-1}}, \qquad (10.12)$$

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 (10.10).

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:

$$X_t = f(\underbrace{Y_t}_{+}, \underbrace{Y_{t-s}}_{+}, \underbrace{Y_t^*}_{+}, \underbrace{Y_{t-s}^*}_{+}, \underbrace{w_t}_{-}, \underbrace{w_{t-s}}_{-}, \underbrace{\tau_t}_{-}, \underbrace{\tau_{t-s}}_{-}, \underbrace{f_{ht}^x}_{-}, \underbrace{f_{h,t-s}^x}_{-}), s > 0. \qquad (10.13)$$

Note that if we were in a one-period world, then, as in Chaney (2008), the elasticity of substitution would not magnify the impact of iceberg trade costs, but that with multiple periods of firm entry, this result would no longer follow. How general is this dynamic gravity formulation? In the Additional Appendix, I prove that similar transition dynamics arise when moving from autarky to free trade for assumptions similar to those for key models in the new trade theory canon, including Krugman (1980) and Melitz (2003). Recent related research includes Burstein and Melitz (2011), 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 (10.12). 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), 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 Meissner and Liu (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 17 in the Appendix is a chloropleth map of per capita income by county, which can be compared to the distribution of import-competing manufacturing in Figure 18. 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.

## 10.3 Figures and Graphs (Online Appendix)

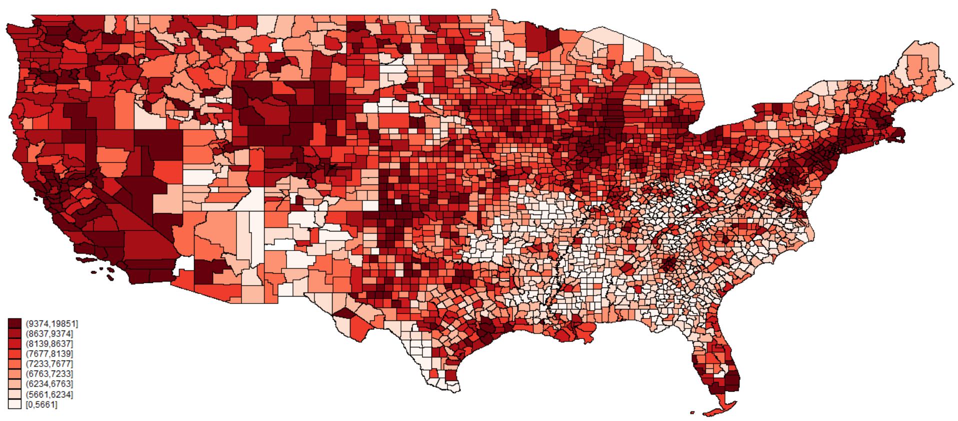



Figure 17: Income per Capita, 1979

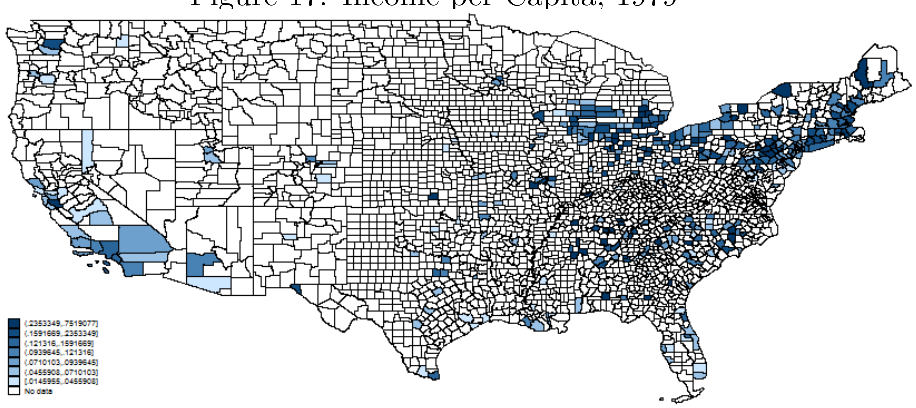
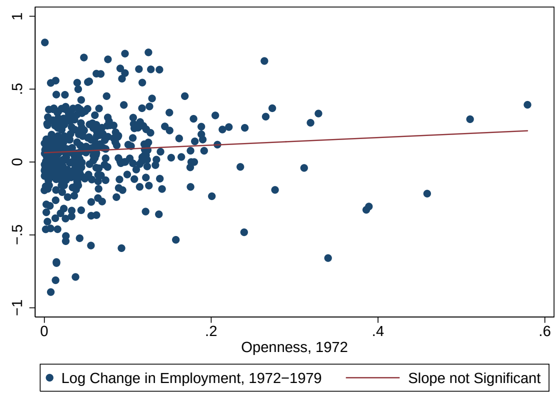
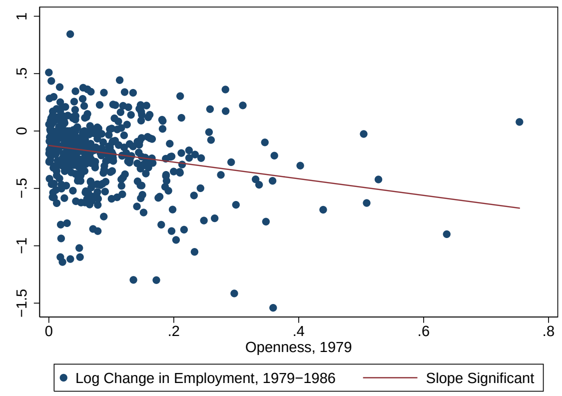



Figure 18: Import-Competing Manufacturing Employment, Share of Total Employment, 1979

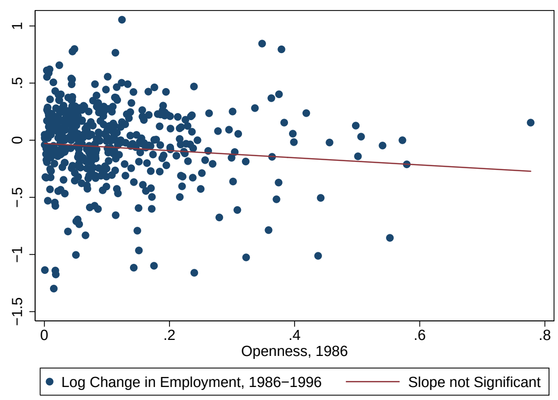
Notes: 1,500 worker minimum. Sources: BEA and WITS



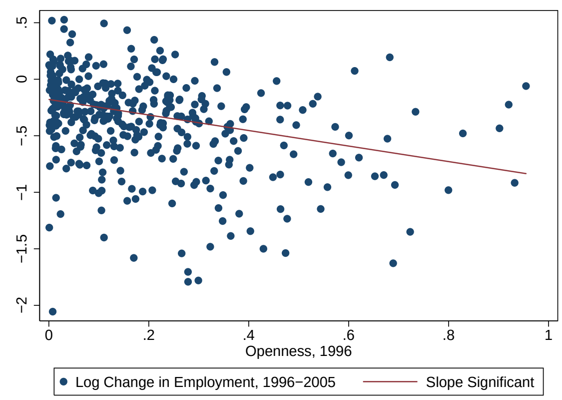

(a) Dollar Depreciation: 1972-1979




(b) Dollar Appreciation: 1979-1986




(c) Dollar Depreciation: 1986-1996




(d) Dollar Appreciation: 1996-2005

Figure 19: 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

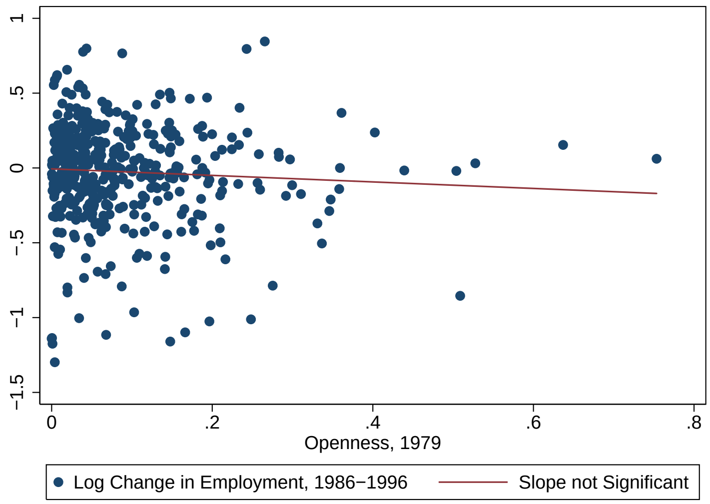



Figure 20: Hysteresis: No Rebound after Collapse

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 VIII: Falsification Exercises: Input Prices and Employment at Various Lags

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

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

## Table IX: Robustness Exercises

| | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L | $ln\Delta$ L |
|---|---|---|---|---|---|---|
| OLS Specifications | | | | | | |
| L.ln(WARULC)*Rel.Openness | -0.084*** | -0.091*** | -0.10*** | -0.080*** | -0.100*** | -0.090*** |
| | (0.021) | (0.022) | (0.021) | (0.017) | (0.023) | (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 |
| Adding and Subtracting Industries | | | | | | |
| L.ln(WARULC)*Rel.Openness | -0.090*** | -0.090*** | -0.090*** | -0.091*** | -0.091*** | -0.090*** |
| | (0.021) | (0.021) | (0.021) | (0.021) | (0.021) | (0.021) |
| Unbalanced Sectors | No | Yes | No | Yes | No | Yes |
| Defense Related Sectors | Yes | Yes | Yes | No | No | Yes |
| Full Controls | No | No | Yes | No | No | Yes |
| Number of Sectors | 359 | 437 | 363 | 426 | 352 | 448 |
| Quantile Regressions | | | | | | |
| L.ln(WARULC)*Rel.Openness | -0.072*** | -0.072*** | -0.082*** | -0.074*** | -0.062*** | -0.067** |
| | (0.015) | (0.015) | (0.013) | (0.014) | (0.011) | (0.027) |
| Quantile | .15 | .35 | Median | .6 | .75 | .9 |
| Import Penetration vs. Export Share | | | | | | |
| L.ln(iWARULC)*Rel.Import Penetration | -0.054 | -0.068** | -0.061** | -0.059** | -0.066*** | -0.066*** |
| | (0.041) | (0.027) | (0.027) | (0.024) | (0.026) | (0.026) |
| L.ln(eWARULC)*Rel.Export Share | -0.084** | 0.012 | -0.050 | -0.044 | -0.051 | -0.051 |
| | (0.042) | (0.036) | (0.034) | (0.031) | (0.034) | (0.034) |
| Year FE | Yes | Yes | Yes | Yes | Yes | No |
| Industry FE | Yes | Yes | Yes | Yes | No | Yes |
| Full Controls | Yes | Yes | Yes | No | Yes | Yes |
| Time Period | 1973-1989 | 1990-2009 | 1973-2009 | 1973-2009 | 1973-2009 | 1973-2009 |

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 four sets of six regressions, for 24 regressions total. The first set of regressions alters the fixed effects and whether there are full controls or not, where the controls are the same as in column (5) of Table 2, the main regression table in the paper, but the results are suppressed for space. The second set of regressions adds and subtracts industries which are either unbalanced, or for which there are logical reasons why they should be excluded. The third set of regressions runs quantile regressions at various stages in the distribution. The fourth separates import penetration interacted with the import-Weighted Average RULC index interacted with import penetration, and export-WARULC interacted with the export share of shipments. Note that import penetration and export share are both highly correlated across sectors and have become even more closely related over time, so multicollinearity is an issue in these regressions, particularly in the more recent period.