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Investment responses to trade liberalization: Evidence from U.S. industries and establishments☆

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ABSTRACT

We examine the impact of trade liberalization on domestic investment in the U.S. manufacturing sector. Using a difference-in-differences identification strategy, we find that industries more exposed to an increase in import competition exhibit relative declines in investment. We find that establishment exit plays a key role in the investment adjustment, and that, along the intensive margin, the decline in investment is concentrated among establishments with low initial levels of labor productivity, capital intensity and skill intensity. Analysis of investment patterns before and after the liberalization suggests that, for certain establishments, investment activity is less lumpy following the policy change.

1. Introduction

The U.S. manufacturing sector has undergone profound changes since the turn of the century, when a shift in U.S. trade policy reduced tariff uncertainty and thereby increased import competition from China. While a range of studies link this trade liberalization to employment loss and establishment exit, less is known about the extent to which survivors adapt by making investments.[1] Greater understanding of such reactions is particularly relevant in the current policy environment, where the 2016 U.S. Presidential election and the U.K.'s vote to exit the European Union have created the possibility of major changes in tariff rates in some of the world's largest markets.

In this paper, we examine how the domestic investment and capital stocks of U.S. manufacturers respond to the October 2000 U.S. granting of Permanent Normal Trade Relations to China (PNTR), a trade liberalization that removed the threat of substantial U.S. import tariff increases on Chinese goods. By eliminating this cost uncertainty, PNTR provided U.S. producers with greater incentives to invest in finding Chinese suppliers, move production from the United States to China, or otherwise increase their competitiveness in the face of rising Chinese import competition. We use industry- and establishment-level data on

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[1] Consider, for example, this anecdote from a recent article in the Wall Street Journal (Michaels (2017)), quoted in Fort et al. (2018): “When Drew Greenblatt bought Marlin Steel Wire Products LLC, a small Baltimore maker of wire baskets for bagel shops, he knew nothing about robotics. That was 1998, and workers made products manually using 1950s equipment....Pushed near insolvency by Chinese competition in 2001, he started investing in automation. Since then, Marlin has spent $5.5 million on modern equipment. Its revenue, staff and wages have surged and it now exports to China and Mexico.”

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0022-1996/

domestic investment and capital stocks by U.S. manufacturers to examine the latter channel.[2]

Our empirical analysis takes place in three steps. First, we examine the relationship between exposure to PNTR and both physical investment and physical capital stocks at the industry-level. Second, we use confidential U.S. Census Bureau microdata to examine how individual establishments adjust investment in response to PNTR, with a particular focus on heterogeneous responses along a broad range of establishment-level attributes. The industry analysis serves as an important benchmark for our subsequent analysis of establishments because it captures the net effects of several potential reactions to trade liberalization: some plants may shrink or exit, lowering investment, while others may alter their production processes in ways that increase investment.[3] Finally, motivated by models of investment under uncertainty, we investigate the timing, frequency, and lumpiness of establishments' investment across the years before and after the change in trade policy.

We employ a generalized differences-in-differences (DID) identification strategy that estimates how investment and capital stocks change after the granting of PNTR for industries and establishments with varying levels of exposure. The baseline specification includes controls for other factors that may affect investment in manufacturing during our sample period, including changes in Chinese trade policy that occur as part of China's accession to the WTO (e.g. liberalization of export licensing), the phasing out of the global Multi-Fiber Arrangement governing quotas on developing-country textile and clothing exports, and changes in the relationship between investment and industry characteristics – such as capital and skill intensity – that may be correlated spuriously with the trade liberalization.

At the industry-level, we find that greater exposure to PNTR is associated with a relative decline in investment, that the effect is due specifically to changes in equipment investment, and that the timing of the decline corresponds closely to PNTR's implementation. We find little evidence of such a response with respect to the physical capital stock, however, an outcome that may be due to the relatively slow response of capital stocks to changes in investment flows, unobserved responses in intangible capital that feed through to the physical capital stock, or changes in the mix of investment goods purchased, which we also do not observe.

Our establishment-level analysis focuses on the investment activity of *continuing* plants observed in the quinquennial U.S. Census of Manufactures (CM), and we focus on heterogeneous responses of establishments with varying pre-PNTR characteristics. We find that while PNTR is, on average, associated with a relative decline in investment, this decline is smaller in magnitude for establishments with higher initial levels of labor productivity, capital intensity and skill intensity. The latter reactions appear consistent with U.S. comparative advantage.

PNTR's elimination of the risk of potential tariff increases also offers a setting for examining how uncertainty affects the timing and frequency of establishments' investments. Bloom et al. (2007), for example, show theoretically that greater uncertainty lowers the responsiveness of firms' investment to demand shocks, provided that investments are at least partially irreversible. In particular, because uncertainty drives a wedge between the marginal products of capital required for investment and disinvestment, it increases the "zone of inaction," rendering investment lumpier.[4]

We assess the potential impact of PNTR's reduction of uncertainty on the frequency and lumpiness of plants' investment using data from the Annual Survey of Manufactures (ASM) to compute the standard deviation, average, and share of years with positive investment across years before and after the change in policy. Here, too, accounting for heterogeneity in establishment responses is important. In specifications that control for plants' initial characteristics, we find that, for the average plant, larger reductions in tariff rate uncertainty are associated with relative reductions in the standard deviation of investment, though these reductions are smaller for establishments with initially high levels of productivity and for establishments that are initially exporters.[5]

Our findings complement a growing theoretical literature examining how how firms respond to changes in competition based on their distance from the "frontier," defined variously in terms of technology, productivity or profitability. A prominent strand of this literature is developed by Aghion et al. (2005), 2009), and focuses on the impact of new entrants on the innovative activities of incumbent firms. Our results also relate to recent research finding evidence in favor of trade-induced technical change (Bloom et al. (2016), Bernard et al. (2018)) in the U.K. and Denmark, and a negative relationship between import competition and innovation (Autor et al. (2016)) among U.S. firms facing import competition from China. Relatedly, Amiti and Khandelwal (2013) examine the role of import tariffs on product quality upgrading, finding that lower tariffs induce quality upgrading if a country is close to the world technological frontier, but inhibit quality upgrading for countries far from the frontier.[6]

Our focus on heterogeneous responses to trade liberalization across plants within similarly exposed industries is most closely related to Gutierrez and Philippon (2017)), which uses firm-level data from Compustat to show that increased competition due to PNTR induces relative increases in the capital stock among "leaders," defined as firms with high market to book value. Compared to that paper, our contribution is twofold. First, we consider the full population of manufacturing establishments, as opposed to the publicly traded firms present in Compustat. Second, we examine a wider range of firm attributes – such as capital and skill intensity and productivity – that capture other dimensions of "leadership," i.e., consistency with U.S. comparative advantage.

Our findings are also relevant for the literature examining the role of firm characteristics and firm-specific wage premia in explaining increases in inequality in the United States. Song et al. (2015), for example, show that two-thirds of the increase in the variance of worker-level earnings in the United States in recent years is due to increases in between-firm variance, and Card et al. (2013) show that higher dispersion in firm-specific wage premia has increased inequality in Germany. If firms that are initially more productive, skill-intensive and capital-intensive pay higher wage premia, and if investment at these firms is relatively stronger with trade liberalization, these heterogeneous responses may increase the component of inequality associated with across-firm wage dispersion. Furthermore, heterogeneous investment responses among establishments within an industry may affect the re-employment prospects of workers initially displaced by increased import competition. For example, if investment increases at some firms within an industry, offsetting declines at other firms, re-allocation of displaced workers may be easier, as their industry-specific skills can be transferred to expanding firms. Such reallocation may be further facilitated by the geographic clustering of industries, as workers will not have to move to different labor markets to make use of these skills.

Finally, our results speak to policymakers, who are often concerned with how changes in policy will affect firms with certain characteristics,

[2] In prior research (Pierce and Schott (2016a)), we show that goods more exposed to PNTR exhibit substantial relative increases in U.S. imports from China as well as the number of U.S. firms that import from China, the number of Chinese firms that export to the United States, and the number of U.S.-Chinese firm pairs engaged in a trading relationship. One interpretation of these outcomes is that they reflect investment in trading relationships that was unleashed by the elimination of cost uncertainty.

[3] Pierce and Schott (2012b) and Asquith et al. (2017) show that industries with greater exposure to PNTR exhibit relatively higher job destruction due to plant and firm exit and relatively lower job creation due to suppressed plant and firm entry.

[4] Empirically, Bloom et al. (2007) show that publicly traded UK firms' investment is negatively associated to the standard deviation of their stock returns, a potential manifestation of demand uncertainty.

[5] We note, that by eliminating the possibility of tariff increases, the granting of PNTR both decreased the range of potential tariff rate outcomes, while also lowering expected tariff rates. In this sense, the policy change differs from a hypothetical reduction in uncertainty that only decreases the variance of potential outcomes while leaving the expected outcome unchanged.

[6] Aghion et al. (2005) provide a theoretical setting in which these firm-level innovative activities vary based a country's distance from the technological frontier and the level of competition present within the country.

Table 1
PNTR and industry-level capital stock.

	Average Investment Per Plant ('000 USD)			Average investment as a percent of capital (K) stock			Share of establishments with positive investment		
	Total	Structures	Equipment	Total	Structures	Equipment	Total	Structures	Equipment
1992	905	138	767	11%	2%	10%	87%	44%	86%
1997	970	132	838	15%	2%	13%	89%	55%	89%
2002	790	113	676	13%	1%	12%	93%	38%	92%
2007	954	146	808	16%	2%	14%	90%	54%	90%

Notes: Table reports summary statistics related to manufacturing establishments' investment in Census of Manufactures years. All investment and capital stock data are deflated using the price indexes in the NBER-CES Manufacturing Industry Database. Sample excludes adminstrative records. Source: U.S. Census Bureau's Census of Manufactures.

especially small firms.[7] We do not find size – whether measured by employment or value added – to be an important determinant of heterogeneous investment responses to trade liberalization. However, our finding that firms that were already in line with U.S. comparative advantage, by virtue of high labor productivity, skilled-labor intensity, and capital intensity, have investment levels that hold up better in response to trade liberalization is relevant for policymakers considering effects of these policy changes on national welfare.

Finally, we contribute to the relatively small number of empirical studies associated with the large theoretical literature on investment under uncertainty (Pindyck (1993); Rob and Vettas (2003)). Finding plausibly exogenous shocks to uncertainty is an important challenge in these studies and several papers, including Guiso and Parigi (1999), Schwartz and Zozaya-Gorostiza (2003), and Bloom et al. (2007), have estimated such shocks using surveys, cost data for specific information technology investments, or detailed information from firms' annual reports. Here, PNTR provides a large and plausibly exogenous shock to establishments' cost uncertainty, and we identify effects on investment that are broadly consistent with Bloom et al. (2007). Also within this literature, Handley (2014) and Handley and Limao (2017) study the impact of uncertainty on trade, including effects due to PNTR.

The paper proceeds as follows: Section 2 describes the data, Section 3 describes our empirical strategy and presents industry-level results, Section 4 presents the establishment-level analysis, and Section 5 concludes.

2. Data

2.1. Establishment- and industry-level investment data

Establishment-level investment and capital stock data are drawn from the U.S. Census Bureau's confidential Census of Manufactures (CM) and Annual Survey of Manufactures (ASM). In both cases, the Census Bureau asks manufacturing establishments to break down their capital expenditures into two categories – structures and equipment – as well as to report their total capital expenditures. The CM collects this information, as well as data on other establishment attributes, including employment, shipments and value added, on every U.S. manufacturing establishment (i.e., plant) quinquennially in years ending in two and seven. In all of our analyses using the CM, we follow standard practice in excluding all administrative records, i.e., observations for which most of the key variables of interest are imputed.[8]

Table 1 summarizes real investment (i.e., real capital expenditures) among U.S. manufacturing establishments appearing in our regression sample below.[9] Each row of the table reports results for a different Census year, while each panel focuses on a different measure of investment: average investment per plant, average investment as a share of establishments' capital stocks, and average share of establishments with positive investment. In each case, we report figures for total investment and its components, investment in structures and investment in equipment.

As indicated in the table, total investment averages 905 thousand dollars across establishments in 1992, versus 954 thousand dollars in 2007. As a share of the capital stock, these levels of investment range from 11% in 1992 to 16% in 2007. Furthermore, the table reveals that investment in equipment accounts for roughly 85% of total capital expenditures, with the remaining 15% accounted for by investment in structures. Finally, the table indicates that most plants invest in each Census year, with 87% of establishments reporting positive capital expenditures in 1992 and 90% reporting investment in 2007. Investments in equipment are much more common than investment in structures, with the latter occurring at 44% of establishments in 1992 and 54% of establishments in 2007.

For the portion of our analysis where we investigate attributes of investment that must be estimated across time – e.g., the standard deviation of investment or average investment per year – we require higher-frequency data than are available in the CM. We therefore augment the CM data with annual data from the ASM. However, because the ASM collects information from only a subset of plants, we must restrict our analysis to the establishments that are surveyed in every year across our 1992 to 2007 sample period.[10] While this sample is restricted, these long-lived plants typically account for a disproportionately large share of activity in the manufacturing sector.

Our industry-level analysis makes use of the publicly available NBER-CES Manufacturing Industry Database assembled by Becker et al. (2013), which can be downloaded from the NBER website. This dataset tracks many of the same outcomes contained in the CM and ASM across six-digit North American Industry Classification (NAICS) categories, including employment, nominal investment and the real capital stock, including separate data for real stocks of equipment and structures. We deflate the nominal investment in both these data and the CM and ASM using industry-specific investment deflators contained in the database.[11] Because investment is not broken out by equipment versus structures in the NBER-CES database, we construct this breakdown ourselves using publicly available versions of the Census of Manufactures (CM) and Annual Survey of Manufactures (ASM) available on the Census Bureau's website.[12]

[7] For example, the U.S. Small Business Administration is actively considering the effects of changes in the North American Free Trade Agreement on small businesses (see https://www.sba.gov/advocacy/advocacy-host-nafta-modernization-meeting-small-businesses-milwaukee).

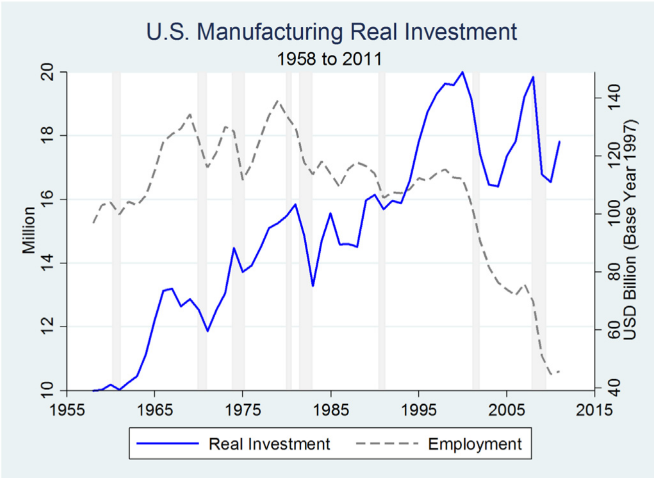
[8] White et al. (2018) also discuss the implications of imputed data for establishments that are not administrative records.

[9] We discuss the deflators used in the computation of real investment below.

[10] This restriction arises from changes in the sampling frame for the ASM that occur every five years, which prevent tracking some plants consistently over time. Furthermore, while some plants are sampled with certainty in the ASM, the threshold used for selecting these "certainty cases" changed several times over the period we consider.

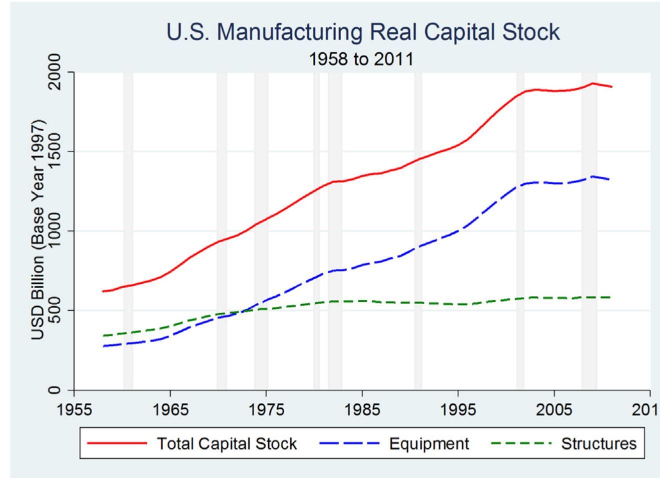
[11] Becker et al. (2013) convert the nominal information on total capital expenditures for each industry collected in the CM and ASM into real expenditure data using investment deflators produced by the Federal Reserve Board. They then construct industry-level real capital stocks using a perpetual inventory equation in conjunction with depreciation rates for each industry also developed by the Federal Reserve Board.

[12] For instances in which publicly available data from the ASM are available only at levels of aggregation higher than the six-digit NAICS industries used in our analysis, we employ industry detail derived by a RAS procedure developed by the Federal Reserve Board to allocate investment to six-digit NAICS industries. Further detail is available from the authors upon request.



Source: NBER-CES Manufacturing Industry Database.

Fig. 1. Manufacturing employment versus real investment.



Source: NBER-CES Manufacturing Industry Database. Total capital stock is the sum of equipment and structures.

Fig. 2. Manufacturing capital stock.

Fig. 1 shows that total real investment by U.S. manufacturing firms in equipment and structures rises faster than trend in the late 1990s before falling substantially in the early 2000s. Indeed, the decline in manufacturing investment from 1999 to 2003 is roughly equal to the decline experienced during the much-deeper Great Recession. As a result, the manufacturing real capital stock fell from 2003 to 2004, the first time it had registered a decline since the data have been tracked (Kurz and Morin (2016)). This decline can be seen in Fig. 2, which also reveals that most of the increase in manufacturing capital stock since the 1970s is in equipment versus structures.

We consider the relationship between the granting of PNTR and both investment flows and the capital stock. Each of these measures has the potential to provide relevant information on the way that firms adjust their behavior in response to trade liberalization. Investment flows respond quickly to changes in competition induced by trade liberalization and therefore might be the first measure to exhibit a response to a change in policy, a fact noted by Dix-Carneiro et al. (2017) when they considered the effects of trade liberalization in Brazil on proxies for regional investment and capital. At the establishment-level, however, measured investment may be measured noisily, and Gutierrez and Philippon (2017) note that it can be influenced by changes in depreciation rates.[13] Therefore, we consider and report the estimated relationships between PNTR and both measures to provide as complete an accounting of investment and capital responses as possible. We do note, however, that the measures of both investment and capital that we employ are for physical structures and machinery, and do not include investment in intangibles.

Changes in investment and employment are highly correlated, suggesting that understanding investment responses to trade liberalization may also provide insights into employment adjustments. Fig. 3 plots scatter diagrams of industry-level changes in employment on changes in real investment for the periods 1990 to 2000 (left panel) and 2000 to 2007 (right panel) using the publicly available data from Becker et al. (2013). Correlation coefficients are 0.62 for the first period, and 0.74 for the second period. The second period, corresponding to the period after the change in U.S. policy, also exhibits a wider range of investment and employment growth rates.

2.2. Industry and firm exposure to PNTR

Our analysis makes use of a plausibly exogenous change in U.S. trade policy – the U.S. granting of PNTR to China in October 2000 – that effectively liberalized U.S. imports from China. This impact can be understood by considering the two sets of tariff rates that comprise the U.S. tariff schedule. The first set of tariffs, known as NTR tariffs, are generally low and are applied to goods imported from other members of the World Trade Organization (WTO). The second, known as non-NTR tariffs, were set by the Smoot-Hawley Tariff Act of 1930 and are often substantially higher than the corresponding NTR rates. Imports from non-market economies such as China generally are subject to the higher non-NTR rates, but U.S. law allows the President to grant these countries access to NTR rates on a year-by-year basis, with the President's decision subject to potential overruling by Congress.

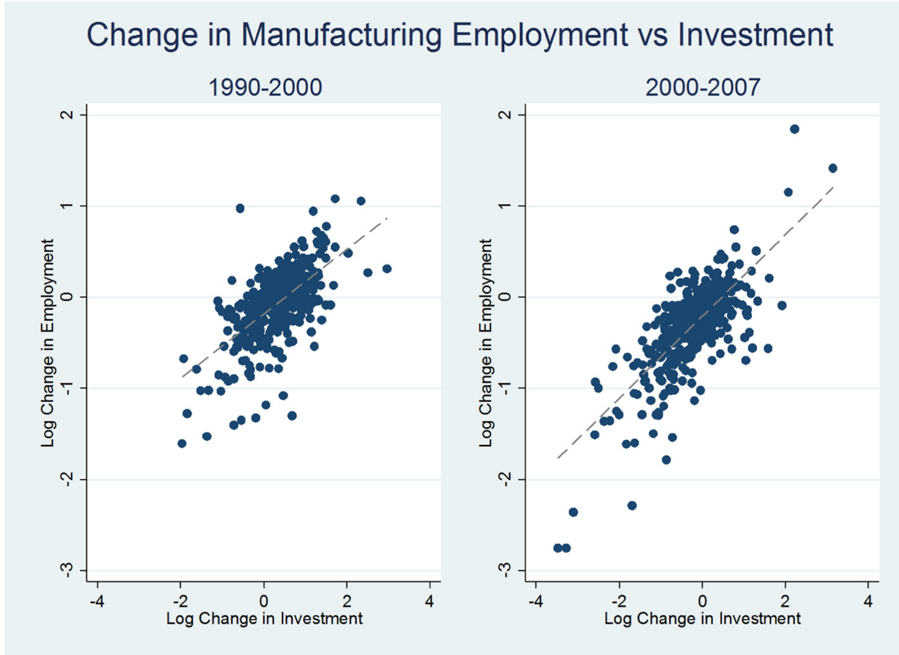
U.S. Presidents granted China such a waiver every year starting in 1980, but Congressional votes over annual renewal became politically contentious and less certain of passage following the Chinese government's crackdown on Tiananmen Square protests in 1989 and other flashpoints in U.S.-China relations during the 1990s such as China's transfer of missile technology to Pakistan in 1993 and the Taiwan Straits Missile Crisis in 1996. The annual threat of substantial tariff increases served as a disincentive to firms considering sourcing goods from China, whether by finding a Chinese supplier or by offshoring U.S. production to China, a fact discussed extensively in the media and in Congress during this time (Pierce and Schott, 2016a). However, uncertainty over China's access to NTR tariff rates and the associated disincentive to U.S. China trade ended with Congress passing a bill granting PNTR status to China in October 2000, which formally took effect upon China's entry into the WTO in December 2001.

We follow Pierce and Schott, 2016a in measuring the impact of PNTR as the rise in U.S. tariffs on Chinese goods that would have occurred in the event of a failed annual renewal of China's NTR status prior to PNTR,

$$NTRGap_j = NonNTRRate_j - NTRRate_j. \quad (1)$$

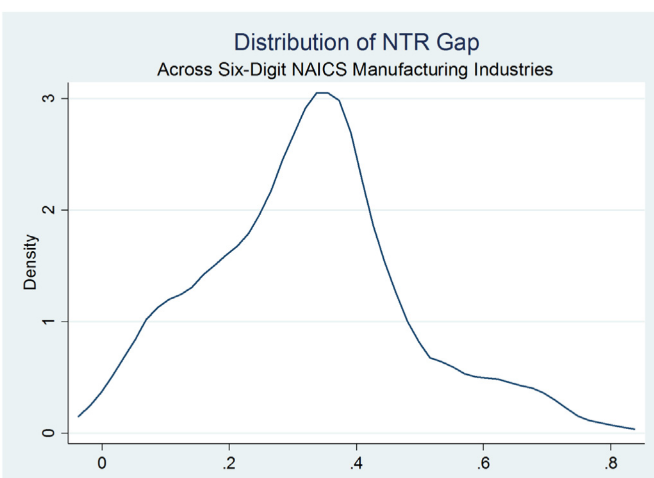
We refer to this difference as the NTR gap, and compute it for each NAICS industry j using *ad valorem equivalent* tariff rates provided by Feenstra et al. (2002) for 1999, the year before passage of PNTR. As indicated in Fig. 4, which reports the distribution of NTR gaps across six-digit NAICS industries, NTR gaps vary widely, with a mean and standard deviation of 30 and 14 percentage points, respectively, and an interquartile range of 0.21 to 0.40. Analysis of the underlying NTR and non-NTR rates in Pierce and Schott (2016a) reveals that 79% of the variation in the NTR gap across industries is due to variation in non-NTR rates, set 70 years prior to passage of PNTR. This feature of non-NTR rates effectively rules out reverse causality that would arise if *non-NTR rates* were set to protect industries with declining employment or surging imports. Furthermore, to the extent that NTR rates were set to

[13] We also explicitly examine the timing and lumpiness of establishments' investment behavior in Section 4.3.



Source: NBER-CES Manufacturing Industry Database.

Fig. 3. Log change in manufacturing employment versus real investment.



Source: Feenstra et al. (2002) and authors' calculations.

Fig. 4. Distribution of industry-level NTR gaps.

protect industries with declining employment prior to PNTR, these higher NTR rates would result in lower NTR gaps, biasing our results away from finding an effect of PNTR.

2.3. Other policy variables

Our empirical analysis includes controls for a wide range of additional factors that may affect U.S. manufacturing investment, with the details of the calculation of each variable discussed in Appendix D. First, we allow for the possibility that the relationship between certain industry-level characteristics and investment may have changed around the time of PNTR's passage. For example, a decline in the competitiveness of labor-intensive industries in the United States or the decline of unions may have disproportionately affected certain industries. We control for these explanations by including interactions of a post-PNTR indicator with initial values of industry capital and skill intensity and the industry-level share of union membership in 1990 (Hirsch and Macpherson, 2003).

We also control for changes in Chinese domestic and trade policies related to its accession to the WTO. These changes include reductions in export licensing requirements, production subsidies and import tariff rates. Our controls draw on data from work on export licensing requirements by Bai et al. (2015), on production subsidies from Khandelwal et al., 2013, and on Chinese import tariff rates from Brandt et al. (2017). To account for the fact that reductions in barriers to foreign investment in China also declined at this time, we control for the share of industry inputs requiring relationship-specificity from Nunn (2007).

Finally, we control for other policy and macroeconomic shifts occurring in the U.S. around 2000. The first of these changes is the bursting of the 1990s tech bubble, which we control for with the interaction of the post-PNTR indicator with an indicator for whether the industry is engaged in the production of advanced technology products, as defined by the International Trade Commission. In addition, we control for the elimination of quotas associated with the phasing out of the global Multi-Fiber Arrangement (Khandelwal et al. (2013)).

3. PNTR and industry-level investment

As indicated in the large literature on the impact of competition on innovation and investment (e.g., Aghion et al. (2005)), the relationship between PNTR and investment is theoretically ambiguous. Some establishments might increase investment in their U.S. operations in an effort to increase competitiveness *vis a vis* rising imports, while others might choose to exit the market, or cease domestic production in favor of production abroad. In this section, we examine the net impact of these establishment- and firm-level decisions on investment at the industry level.

Our baseline difference-in-differences (DID) specification examines whether industries with higher NTR gaps (first difference) experience differential changes in investment after the change in U.S. trade policy (second difference) versus before,

$$y_{jt} = \theta Post\ PNTR_t \times NTRGap_j + \beta \mathbf{X}_{jt} + \gamma Post\ PNTR_t \times \mathbf{X}_j + \delta_j + \delta_t + \varepsilon_{jt}. \quad (2)$$

Table 2
PNTR and industry-level investment.

	Investment								
	$\ln(\text{Total}_{jt})$	$\ln(\text{Total}_{it})$	$\ln(\text{Total}_{it})$	$\ln(\text{Struct}_{it})$	$\ln(\text{Struct}_{it})$	$\ln(\text{Struct}_{it})$	$\ln(\text{Equip}_{it})$	$\ln(\text{Equip}_{it})$	$\ln(\text{Equip}_{it})$
Post x NTR Gap_j	−0.744***	−1.121***	−0.566***	−1.412***	−1.436***	−0.811***	−0.871***	−1.255***	−0.705***
	0.301	0.240	0.180	0.401	0.300	0.267	0.286	0.253	0.179
Post x $\ln(\text{K/Emp}_j]$		−0.117**	−0.195***		−0.002	−0.108**		−0.121***	−0.191***
		0.052	0.034		0.057	0.048		0.051	0.036
Post x $\ln(\text{NP/Emp}_j)$		0.3***	0.377***		0.267***	0.384***		0.19**	0.291***
		0.079	0.068		0.096	0.090		0.085	0.065
Post x Contract Intensity_j			0.037			0.012			0.039
			0.167			0.238			0.159
Post x ΔChina Import Tariffs_j			−0.006***			−0.006**			−0.007***
			0.001			0.003			0.002
Post x ΔChina Subsidies_j			0.685***			0.746***			0.648***
			0.105			0.147			0.101
Post x ΔChina Licensing_j			−0.525**			−0.442			−0.387
			0.249			0.372			0.253
Post x l{Advanced Technology_j}			−0.002			0.005			−0.048
			0.084			0.092			0.088
Post x U.S. Union Membership_j			0.002			0.006			0.002
			0.002			0.004			0.002
MFA Exposure_{jt}			−0.029***			−0.027***			−0.027***
			0.005			0.007			0.006
NTR_{jt}			−0.084			−0.492			0.153
			0.485			0.626			0.488
Observations	8280	8280	8280	8280	8280	8280	8280	8280	8280
R-squared	0.94	0.95	0.95	0.88	0.88	0.88	0.95	0.95	0.95
Fixed effects	j,t	j,t	j,t	j,t	j,t	j,t	j,t	j,t	j,t
Implied impact of PNTR	−0.140	−0.211	−0.106	−0.265	−0.270	−0.152	−0.164	−0.236	−0.133

Notes: Table reports results of unweighted OLS generalized difference-in-differences regressions. The dependent variable is the log of investment (total, structures, or equipment) in indusry j in year t and the independent variable representing the effect of PNTR is the interaction of the NTR gap and a post-PNTR indicator. Additional controls include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese import tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 union membership rate. Data span 1990 to 2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year(t) and industry fixed effects as well as the constant are suppressed. Final row reports implied impact on dependent variable of an interquartile shift in indusry exposure to PNTR. *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

The sample period for the industry analysis is 1990 to 2007. The dependent variable, y_{jt}, represents an outcome in industry j in year t, which in this industry-level analysis is either the log of investment or the capital stock for one of three categories, equipment, structures, and total. The first term on the right hand side is the DID term of interest, an interaction of the NTR gap and an indicator for the post-PNTR period, i.e., years from 2001 forward. The second term on the right-hand side of Eq. (2) captures the impact of time-varying industry characteristics, such as exposure to MFA quota reductions and the NTR tariff rate. The third term on the right hand side is an interaction of the post-PNTR dummy variable and time-invariant industry characteristics, such as initial industry capital and skill intensity, the degree to which industries encompass high-technology products and the extent of initial union membership in the industry. These interactions allow for the possibility that the relationship between employment and these characteristics changes in the post-PNTR period in ways that might spuriously be related to the trade liberalization. δ_j, δ_t and α represent industry and year fixed effects and the constant.

An attractive feature of this DID identification strategy is its ability to isolate the role of the change in U.S. trade policy. While industries with high and low NTR gaps are not identical, comparing outcomes within industries over time isolates the differential impact of China's change in NTR status.

The first three columns of Table 2 report results for total investment, with standard errors clustered at the industry level. The first column reports a specification with only the DID term, the second column adds interactions of the post-PNTR indicator with industry capital intensity and skill intensity, and the third column includes the full set of controls described in Section 2.3. As indicated in the table, we find negative and statistically significant coefficients on the DID term in all three cases, indicating that industries more exposed to PNTR's trade liberalization experienced relative reductions in investment.[14] We assess the economic significance of the estimated DID coefficients in terms of the effect on the dependent variable of an interquartile shift in an industry's NTR gap (from 0.214 to 0.402, or 0.188). The coefficients indicate that, for the third column, when all covariates are included, an interquartile shift in industry exposure to PNTR is associated with a relative decline in total investment of −0.106 log points (e.g., −0.566*0.188). The next six columns report analogous results for investment in structures and equipment. We find a negative and significant relationship between exposure to PNTR and each of these types of investment in all three specifications.

For the decline in investment to be attributable to PNTR, the NTR gap should be correlated with investment after PNTR, but not before. To determine whether there is a relationship between these variables in the years before 2001, we replace the *PostPNTR* indicator used in Eq. (2) with interactions of the NTR Gap and the full set of year dummies,

$$y_{jt} = \sum_{y=1991}^{2007}\left(\theta_y 1\{y=t\} \times NTR\,Gap_j\right) + \sum_{y=1991}^{2007}\left(\lambda_y 1\{y=t\} \times \mathbf{X}_j\right) + \beta \mathbf{X}_{jt} + \delta_j + \delta_t + \alpha + \varepsilon_{it}. \quad (3)$$

These estimations include the full set of controls noted above. Results are reported visually in Fig. 5. The upper left panel of this figure displays the 95% confidence intervals for the impact on total investment of an interquartile shift in industry exposure to PNTR implied by the estimated difference-in-differences coefficients θ_y. As indicated in that panel, the

[14] When we add interactions of the full set of three-digit NAICS dummies with the post-PNTR indicator to these specifications, coefficient estimates for the DID terms remain negative and statistically significant at the 5% level for regressions examining either total or equipment investment. For structures investment, the DID coefficient remains negative but loses statistical significance at conventional levels (p-value of 0.16).

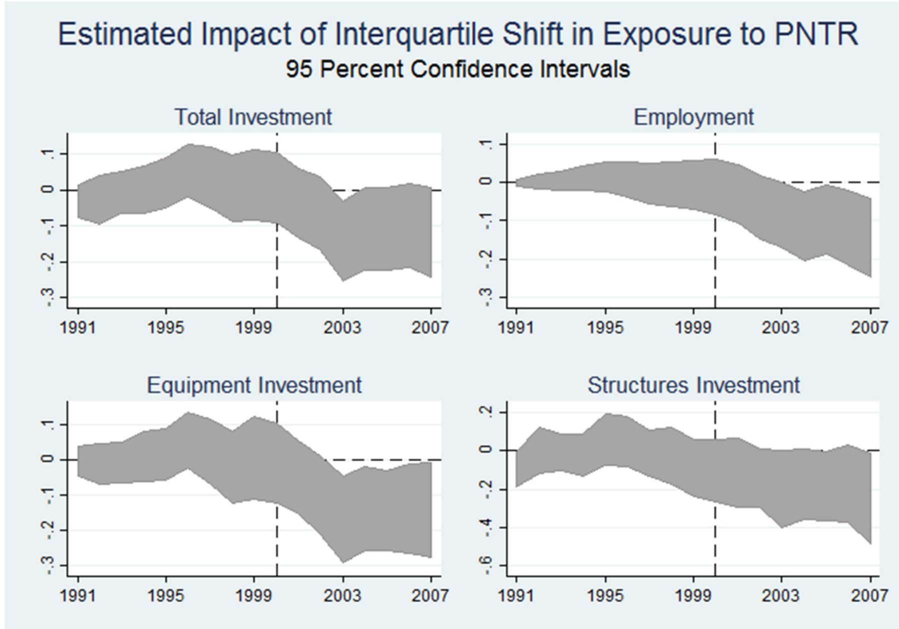


Fig. 5. PNTR and industry-level investment.

point estimates shift down noticeably following the change in policy, though coefficient estimates of the individual differences-in-differences coefficients for total investment are estimated less precisely than the single baseline DID coefficient for Eq. (2), with the estimates statistically insignificant at the 5% level for most post-PNTR years. The bottom panel of the figure reports results separately for the two constituents of total investment, equipment and structures. As shown in the lower left panel, the relationship with PNTR is most pronounced for equipment investment, for which the estimated impact of PNTR is negative and statistically significant at the 5% level starting in 2002. For comparison, the upper right panel displays results when the log of manufacturing employment is used as the dependent variable. As indicated in the figure, the relationship between manufacturing employment and exposure to PNTR is negative and statistically significant in years following the policy change.

Next, we examine whether the decline in investment associated with PNTR in Table 2 is also apparent in capital stocks. As indicated in Table 3, we find that the relationships between PNTR and the three categories of the capital stock are not statistically significant.[15]

One potential reason for the lack of a relationship between PNTR and the capital stock, unlike for investment, is that the capital stock adjusts slowly to changes in investment flows.[16] A second potential reason is a shift in the mix of investment goods being purchased by firms, with different types of investment goods yielding different responses in the capital stock due to, for example, variation in depreciation rates across different types of capital goods (e.g. computers vs. structures). Lastly, if investments in intangible capital feed through to changes in the physical capital stock, our inability to observe the former may obscure the relationship between PNTR and physical capital.

Our results with respect to capital here also differ from those reported in Gutierrez and Philippon (2017), who find relative declines in capital stocks in response to PNTR among publicly traded U.S. manufacturing firms. There are several potential reasons for this divergence in results. First, our analysis captures the universe of manufacturing establishments, while the Compustat data analyzed in Gutierrez and Philippon (2017) is restricted to publicly traded companies. Second, our analysis is conducted at the establishment level, while theirs focuses on firms. Finally, unlike the information analyzed in Gutierrez and Philippon (2017), our dataset covers only investment in physical equipment and structures among manufacturing establishments, and therefore excludes investments in intangible capital like intellectual property or goodwill. It also excludes investment at any nonmanufacturing establishments that might be part of the firms that own the manufacturing plants. Both of these investments are included in the balance sheet information examined by Gutierrez and Philippon (2017). Indeed, recent research by Fort et al. (2018) shows that U.S. manufacturing firms during our sample period added non-manufacturing establishments even as they closed manufacturing establishments. This research, combined with the results in Gutierrez and Philippon (2017), suggests that such investments may be significant.

An interesting question for further study is whether the relative weakening in investment we document above may help explain the persistence of the reduction in manufacturing employment associated with PNTR (Pierce and Schott (2016a)). That is, while increases in investment may lead to subsequent rebounds in employment, declines in investment driven by establishment exit may have a long-run dampening effect on job creation.[17]

4. PNTR and establishment-level investment

In this section, we use the CM and ASM to examine the investment behavior of *continuing* establishments before and after PNTR. We first set a baseline by examining establishment-level responses to PNTR without controlling for the substantial heterogeneity of establishments within industries. Next, we explicitly estimate how establishment heterogeneity–

[15] These results are consistent with Pierce and Schott (2016a), who find no statistically significant relationship between exposure to PNTR and industry-level capital stock. The analysis in the latter differs from that presented here in that it is based on an aggregation of establishment-level data from the Census of Manufactures to the industry-level, and therefore only uses data for years in which the CM is available, namely 1992, 1997, 2002, and 2007. Pierce and Schott (2016a) do not examine the relationship between PNTR and investment.

[16] Some support this idea is present in Appendix Figure 9, which plots figures analogous to those presented in Figure 5 for overall capital as well as equipment and structures capital. As indicated in the figure, the impact of PNTR is estimated with substantial noise, though the estimated impact of an interquartile shift in exposure for equipment capital shifts down in the mid-2000s.

[17] Fort et al. (2018) show that 85% of the decline in manufacturing employment between 1977 and 2012 is due to net establishment death.

Table 3
PNTR and industry-level capital stock.

	Capital stocks		
	$\ln(\text{Total}_{jt})$	$\ln(\text{Equipment}_{jt})$	$\ln(\text{Structures}_{jt})$
Post x NTR Gap_j	0.083	0.038	−0.033
	0.087	0.095	0.081
Post x $\ln(\text{K/Emp}_{j,1990})$	−0.093***	−0.118***	−0.07***
	0.016	0.017	0.016
Post x $\ln(\text{NP/Emp}_{j,1990})$	0.161***	0.13***	0.076***
	0.036	0.036	0.026
Post x Contract Intensity_j	0.105	0.048	−0.007
	0.078	0.080	0.054
Post x ΔChina Import Tariffs_j	−0.002**	−0.002**	−0.003***
	0.001	0.001	0.001
Post x ΔChina Subsidies_j	0.276***	0.395***	0.135***
	0.048	0.044	0.036
Post x ΔChina Licensing_j	−0.05	−0.14	0.071
	0.119	0.125	0.121
Post x I{Advanced Technology_j}	0.138***	0.14***	0.111*
	0.047	0.055	0.065
Post x U.S. Union Membership_j	−0.003***	−0.001	−0.002**
	0.001	0.001	0.001
MFA Exposure_{jt}	−0.009***	−0.011***	−0.004***
	0.001	0.001	0.001
NTR_{jt}	0.139	0.244	0.166
	0.314	0.382	0.373
Observations	8280	8280	8280
R-squared	0.99	0.99	0.99
Fixed effects	j,t	j,t	j,t
Weighting	K	K	K
Implied impact of PNTR	0.016	0.007	−0.006

Notes: Table reports results of OLS generalized difference-in-differences regressions. The dependent variables are the log of industry-year capital stock and its constituents, the log of the stock of equipment and structures. The independent variable representing the effect of PNTR is the interaction of the NTR gap and a post-PNTR indicator. Additional controls include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese import tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 union membership rate. Data span 1990 to 2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and industry fixed effects as well as the constant are suppressed. Observations are weighted by 1990 industry capital stock. Final row reports implied impact on dependent variable of an interquartile shift in indusry exposure to PNTR. *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

along dimensions including size, productivity, capital and skill intensity, and trade status–affects establishments' responses to the trade liberalization. Finally, we examine the extent to which PNTR has effects on the average size and "lumpiness" of establishments' investments.

4.1. Baseline plant-level estimates

As mentioned above, we begin by examining the average investment responses of plants to PNTR without including terms that might account for within-industry heterogeneity. We use establishment-level data from the CM, which cover the population of manufacturing establishments and are available every five years. Our sample is composed of observations from the 1992, 1997, 2002 and 2007 CMs and the baseline specification is as follows,

$$y_{pt} = \theta Post\ PNTR_t \times NTR\ Gap_j + \gamma Post\ PNTR_t \times \mathbf{X}_j + \beta \mathbf{X}_{jt} + \delta_p + \delta_t + \alpha + \varepsilon_{pt}. \quad (4)$$

where p indexes continuing establishments, j indexes industries, t indexes years, and establishments' exposure to PNTR is based on that of their primary six-digit NAICS industry, j. The dependent variable is one of three real investment shares – total investment (i.e., total capital expenditures), investment in equipment, or investment in structures, where each is divided by the establishment's capital stock – or the log value of the capital stock. Note that, unlike in the industry-level regressions, where the natural log of investment was used as the dependent variable, this choice of dependent variable in the establishment-level regressions allows for the presence of years in which an individual establishment's investment is zero. The first term on the right-hand side is the DID term representing the effect of PNTR, and it consists of the interaction of a $Post PNTR_t$ indicator and the time-invariant $NTR Gap_j$. The next two terms represent the additional control variables used in Eq. (2). The remaining terms represent plant and year fixed effects and the constant. We note that this specification yields within-plant estimates of the relationship between exposure to PNTR and capital expenditures, but does not account for changes in investment driven by establishment entry and exit.

The first two columns of Table 4 report the results of estimating Eq. (4), first with only the DID term of interest and the fixed effects required for its identification (column 1), and then with the full set of covariates (column 2). We find that while the relationship between exposure to PNTR and total investment is negative, as in the industry-level estimates discussed above, it is not statistically significant at conventional levels. The next six columns indicate similar negative but mostly statistically insignificant relationships for the two broad categories of investment shares – equipment and structures – as well as for the log real book value of capital.[18] The overall message of Table 4 is that the relationship between exposure to PNTR and investment within continuing plants is not precisely estimated.

The differences between results at the establishment- and industry-levels underscore the importance of establishment exit in the relationship between PNTR and investment. That is, in the establishment-level regressions, which achieve identification from variation over time *within continuing establishments*, we do not find an association between exposure to PNTR and investment, on average. The industry-level regressions, which exploit variation from within-establishment changes in investment as well as establishment entry and exit, reveal a statistically significant relationship.[19] As discussed in further detail in Appendix B, the differences in the magnitudes of the coefficients are due to the different scales of the different dependent variables used in the establishment-level regressions (where the dependent variable is investment divided by capital stock) versus the industry-level regressions (where the dependent variable is the natural log of investment).[20]

4.2. Plant-level results allowing for heterogeneous responses

To assess the importance of plant heterogeneity within industries in determining responses to PNTR, we augment Eq. (4) with an additional covariate that interacts the DID term with one of ten normalized initial plant attributes: plant size, as measured by employment or value added; plant productivity, as measured by TFP, value added (VA) per worker or shipments per worker; plant capital and skill intensity; indicators for firm importer and establishment exporter status; and plant age,

$$\begin{aligned} y_{pt} = {} & \theta_1 Post\ PNTR_t \times NTR\ Gap_j + \theta_2 Post\ PNTR_t \times NTR\ Gap_j \\ & \times Estab\ Char_p + \varphi_1 Post\ PNTR_t \times Estab\ Char_p + \beta \mathbf{X}_{jt} \\ & + \gamma Post\ PNTR_t \times \mathbf{X}_j + \delta_p + \delta_t + \alpha + \varepsilon_{pt} \end{aligned} \quad (5)$$

[18] Pierce and Schott (2016a) also find a statistically insignificant relationship between exposure to PNTR and the total capital stock using establishment-level data from the CM.

[19] The samples for the two levels of analysis also differ in two ways. First, the use of establishment fixed effects in the establishment-level regressions implies that only establishments present in both the pre- and post-PNTR periods contribute to identification. Second, the establishment-level regressions are restricted to years in which the Census of Manufactures is available – 1992, 1997, 2002 and 2007 – while the industry-level sample includes data for every year from 1990 to 2007.

[20] For regressions examining the relationship between PNTR and the capital stock, the dependent variable is the natural log of the capital stock in both establishment- and industry-level regressions. However, because the dependent variable for the industry-level regressions is the log of the sum of the establishment-level capital stocks–as opposed to the sum of the logged capital stocks–even regressions using the same specification at the establishment- and industry-level would not yield identical results.

These terms, which we refer to as "plant heterogeneity terms," and which we include one-at-a-time in separate regressions, appear as the triple interaction in the second line of Eq. (5). The normalization divides the 1992 plant attribute by the average of that attribute across all plants in the same industry in 1992, therefore explicitly accounting for heterogeneity within industries, rather than differences across industries.[21] The third term in Eq. (5) represents the interaction of the plant heterogeneity term with the $Post\ PNTR_t$ indicator required to identify the triple interaction. We do not simultaneously include all plant heterogeneity terms in a single regression given their high correlation.[22]

Tables 5 to 8 report results for each of four successive dependent variables–the three measures of investment as a share of capital stock and the log of capital stock. In each table, results are separated by horizontal lines into four panels. The top panel of each table reports the coefficient estimates and standard errors for the two DID terms of interest, θ_1 and θ_2, with the particular plant attribute used in the triple difference noted in the top row of the second panel.[23] The third panel of each table reports the estimated impact and standard error of an interquartile shift in the NTR gap for plants with "low" and "high" values of the noted noted attributes, as well as for the difference in the estimated impact for plants with high and low attributes. A low value is defined as the attribute's mean less one standard deviation, where both moments are computed across plants in all years for each industry. Likewise, a high value reflects the mean plus one standard deviation. The final panel of each table reports these estimates as a share of the 1997 value of each dependent variable, respectively.

As indicated in the top panel of Table 5, we find that the main PNTR DID terms, θ_1, are *negative* and statistically significant at conventional levels for regressions in which TFP, either measure of labor productivity, skill and capital intensity, and age are included as heterogeneity terms, indicating that for the average plant, higher exposure to PNTR is associated with relatively lower total investment. The plant heterogeneity DID terms, θ_2, by contrast, are *positive* and statistically significant for these same attributes, with the exception of TFP and age, where the relationship is also positive but statistically insignificant. These positive coefficients indicate that, for a given level of exposure to PNTR, plants with higher values of these attributes exhibit relatively higher levels of equipment investment after the change in trade policy, relative to those with lower values of the attributes.

Turning to results for the components of investment– equipment and structures– that are displayed in Tables 6 and 7, we find that this relationship between PNTR and establishment-level investment is driven by reactions in equipment investment. As shown in Table 6, when equipment investment as a share of the capital stock is used as the dependent variable, coefficient estimates for the main DID terms θ_1 and θ_2 are very similar in terms of both sign and significance to those for in Table 5. By contrast, when structures investment as a share of the capital stock is used as the dependent variable– as shown in Table 7– coefficient estimates are typically statistically insignificant, as they also are when the capital stock is used as the dependent variable (Table 8).

As mentioned above, we examine the economic significance of these results– and the heterogeneous effects across plants with differing attributes–by calculating the effect of an interquartile shift in exposure to PNTR on plants with low and high values of each attribute. The first two rows of the bottom panel of Table 6 show the impact of this interquartile shift on the dependent variable, represented as a percentage of the mean equipment investment share in 1997 (0.129), the prior year closest to the change in trade policy. As indicated in that panel, an interquartile shift in exposure to PNTR is associated with relative reductions in the equipment investment share that range from 3.4% of the 1997 average (for size based on employment) to 9.8% (for value added productivity). Responses of plants with high values of the attributes are not statistically significantly different from zero.

Finally, we test whether the responses of high- and low-attribute plants are statistically different from one another, as opposed to the just-discussed tests of whether they are statistically different from zero. The final row of Table 6 reports the estimated differential impact of an interquartile shift in high- relative to low-attribute plants as a share of the 1997 level. Two of these estimates – for the labor productivity terms – are positive and statistically significant at the 5% level, and two – for skill and capital intensity – are statistically significant at the 10% level, indicating that plants with high values of each of these attributes respond to PNTR by decreasing their investment less than those with low values. To facilitate comparison of these estimates across attributes for a given type of investment, and across investment types, Fig. 6 reports the 95% confidence intervals of the differential response of establishments with high versus low attributes. As indicated in the figure, plants with high and low values of the attributes we examine do not adjust their structures investment in statistically different ways in response to PNTR. However, given that equipment investment makes up the bulk of U.S. manufacturing investment, the estimated impacts for overall investment generally mirror those for equipment investment, though with slightly less precision.

In sum, we find that most of the establishment-level investment response to PNTR occurs via equipment investment, and that it is concentrated among plants that had low initial values of labor productivity, capital intensity, and skill intensity. Establishments with high initial values of those attributes–which correspond to traditional views of U.S. advantage–do not experience statistically significant declines in investment in response to PNTR. For plant size, TFP, age, and trade status, by contrast, we find that the differences between low- and high-attribute plants are relatively small. These results are broadly consistent with those reported in Gutierrez and Philippon (2017), who find that while investment in property, plant and equipment is relatively lower for publicly traded firms after PNTR versus before, investment increases at "leader" firms, defined as firms whose market-to-book value of capital is above the median.

The relatively stronger investment performance of plants with initially high labor productivity and capital and skill intensity could represent trade-induced technological change of the type discussed in Bloom et al. (2016). Alternatively, it could reflect capital expenditures used to upgrade product quality (Schott (2003, 2004)) or switch production towards goods more in line with U.S. comparative advantage (Bernard et al., 2006, 2011; Khandelwal, 2010).

4.3. Responses in the timing and frequency of investment

One of PNTR's unique features was that it had effects via the elimination of potential tariff increases–and the associated uncertainty about future tariff rates–rather than changes in applied tariff rates. Therefore, it creates an opportunity for contributing to the relatively small empirical literature that considers the implications of the larger theoretical literature on investment under uncertainty.[24] As mentioned above, Bloom et al. (2007) show that UK firms' investment is negatively related

[21] Given the fixed effects, plants are included in the regression only if they span 1997 and 2002. For plants that are not present in 1992, we divide their 1997 attribute by the relevant industry attribute in 1992.

[22] One potential concern with our regression specification is that plants with different values of initial characteristics may have been on different trends prior to the PNTR, and that these trends may drive the relationship between the policy change and the plant heterogeneity terms. In unreported but available results, we control for this possibility by augmenting equation 5 with interactions of year dummies and the plant characteristic being examined. Results are virtually identical to those described below.

[23] To conserve space, we do not report estimates for the other control variables included in the regression (i.e., those reported in Table 4) or the fixed effects. The former are available upon request.

[24] As mentioned above, we note that PNTR lowered expected tariffs while also shrinking the range of potential tariff outcomes, meaning that it should not be confused with a theoretical reduction in uncertainty that lowers the standard deviation of potential outcomes, while leaving the expected outcome unchanged.

Table 4
PNTR and establishment-level investment.

	Investment as a share of capital stock						Capital stock	
	$Total_{tp}$	$Total_{tp}$	$Struct_{tp}$	$Struct_{tp}$	$Equip_{tp}$	$Equip_{tp}$	$Total_{tp}$	$Total_{tp}$
Post x NTR Gap_j	−0.0442	−0.0173	−0.0138*	−0.0033	−0.0304	−0.014	−0.1162	0.0704
	0.028	0.015	0.008	0.004	0.021	0.013	0.172	0.171
Post x $\ln(K/Emp_{j,1990})$		−0.0098***		0.0005		−0.0103***		−0.0124
		0.003		0.001		0.002		0.036
Post x $\ln(NP/Emp_{j,1990})$		0.0242***		0.003*		0.0212***		0.07
		0.005		0.002		0.005		0.070
Post x Contract $Intensity_j$		−0.0119		−0.0021		−0.0098		0.0978
		0.013		0.004		0.010		0.152
Post x ΔChina Import $Tariffs_j$		−0.021		−0.0005		−0.0205**		0.4753***
		0.013		0.005		0.010		0.176
Post x ΔChina $Subsidies_j$		0.0454***		0.0095***		0.0359***		0.2388***
		0.008		0.002		0.007		0.098
Post x ΔChina $Licensing_j$		0.0492*		0.0078		0.0414*		0.8632***
		0.028		0.006		0.024		0.351
Post x l{Advanced $Technology_j$}		−0.0003		0.0005		−0.0008		−0.1017
		0.008		0.002		0.007		0.103
Post x Union $Memperships_j$		0.0003		0.000		0.0003***		−0.0059***
		0.0002		0.0000		0.0001		0.0021
MFA $Exposure_{jt}$		−0.0009***		−0.0001		−0.0008***		−0.0188***
		0.0002		0.0001		0.0002		0.0029
NTR_{jt}		0.0184		−0.0167		0.035		0.5473
		0.057		0.019		0.048		0.978
Observations	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000
R-squared	0.46	0.46	0.38	0.39	0.46	0.46	0.46	0.90
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Table reports results of plant-level OLS generalized difference-in-differences regressions. The dependent variables are total investment as a share of the capital stock (book value), investment in structures as a share of the capital stock, investment in equipment as a share of the capital stock, and the natural log of the capital stock. The independent variable representing the effect of PNTR is the interaction of the NTR gap and a post-PNTR indicator. Additional controls include time varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. Data span 1990 to 2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

Table 5
PNTR and heterogeneity in establishment-level total investment.

	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}	Inv/K_{pt}
Post x NTR Gap_j	−0.0233	−0.0238	−0.0668*	−0.0453***	−0.0484***	−0.0451**	−0.06**	−0.0252	−0.0215	−0.0379*
	0.0156	0.0167	0.0387	0.0186	0.0196	0.0214	0.0273	0.0176	0.0161	0.0203
x $Attribute_p^{1992}$	0.0014	0.0008	0.0475	0.0234**	0.0272**	0.0175*	0.0524*	0.0034	0.0027	0.0215
	0.0016	0.0024	0.0360	0.0116	0.0124	0.0102	0.0278	0.0052	0.0031	0.0137
Attribute =	Emp	VA	TFP	VA/L	Ship/L	K/L	Skill/L	Importer	Exporter	Age
Observations	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000
R-squared	0.46	0.46	0.46	0.47	0.46	0.47	0.46	0.46	0.46	0.46
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Implied impact, low attribute	−0.0046	−0.0048	−0.0044	−0.0129***	−0.0102***	−0.0088**	−0.0065**	−0.0056	−0.0055	−0.0059*
Standard error	0.003	0.004	0.003	0.005	0.004	0.004	0.003	0.004	0.004	0.003
Implied impact, high attribute	−0.0035	−0.0037	−0.0025	0.0057	0.0033	−0.0003	0.0034	−0.0024	−0.0014	−0.0012
Standard error	0.003	0.003	0.003	0.005	0.004	0.003	0.004	0.003	0.003	0.003
Implied impact, high vs low	0.0011	0.0011	0.0019	0.0186**	0.0135**	0.0085*	0.0099*	0.0032	0.0042	0.0048
Standard error	0.001	0.003	0.001	0.009	0.006	0.005	0.005	0.005	0.005	0.003
Mean dependent Var (1997)	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152	0.152
Implied impact as % dependent variable										
Low attribute	−3	−3.1	−2.8	−8.4***	−6.6***	−5.7**	−4.2**	−3.6	−3.6	−3.8*
High attribute	−2.3	−2.4	−1.6	3.7	2.1	−0.1	2.2	−1.5	−0.9	−0.7
Difference	0.6	0.7	1.2	12.2**	8.8**	5.5*	6.4*	2	2.7	3.1

Notes: Table reports results of establishment-level OLS generalized difference-in-differences regressions for noted dependent variable. The independent variables representing the effect of PNTR are the interaction of the NTR gap and a post-PNTR indicator (first covariate), and a triple interaction of that term with one of ten initial (1992) plant attributes, which are normalized by the average of that attribute across all plants in the same industry in 1992. Additional controls included in the regression but whose results are suppressed include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. The third panel of the table reports the estimated impact and standard error of an interquartile shift in the NTR gap for plants with low and high values for the noted attribute, as well as for the difference between high and low plants. Low (high) values are defined as the mean less (plus) one standard deviation. Final panel reports these estimates as a share of the 1997 value of the dependent variable. Data are for the years 1992, 1997, 2002 and 2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

Table 6
PNTR and Heterogeneity in Establishment-Level Equipment Investment.

	Equipment investment as a share of capital stock									
	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$	$Equip/K_{pt}$
Post x NTR Gap_j	−0.022	−0.0201	−0.057*	−0.0432***	−0.0429***	−0.0378**	−0.045**	−0.0179	−0.0196	−0.033*
	0.0135	0.0139	0.0305	0.0154	0.0161	0.0176	0.0214	0.0151	0.0148	0.0175
x $Attribute_p^{1992}$	0.002	0.0008	0.041	0.0243***	0.0252***	0.0149*	0.038*	0.0011	0.0034	0.0199
	0.0016	0.0019	0.0283	0.0089	0.0095	0.0081	0.0213	0.0043	0.0034	0.0128
Attribute =	Emp	VA	TFP	VA/L	Ship/L	K/L	Skill/L	Importer	Exporter	Age
Observations	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000
R-squared	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Implied impact, low attribute	−0.0045*	−0.0041	−0.0037	−0.0127***	−0.0091***	−0.0074**	−0.005*	−0.0036	−0.0056	−0.0051*
Standard error	0.003	0.003	0.002	0.004	0.003	0.003	0.003	0.004	0.004	0.003
Implied impact, high attribute	−0.003	−0.003	−0.002	0.0066	0.0034	−0.0001	0.0022	−0.0026	−0.0003	−0.0007
Standard error	0.002	0.002	0.003	0.004	0.003	0.002	0.004	0.003	0.003	0.003
Implied impact, high vs low	0.0015	0.0011	0.0017	0.0192***	0.0125***	0.0073*	0.0072*	0.001	0.0053	0.0044
Standard error	0.001	0.003	0.001	0.007	0.005	0.004	0.004	0.004	0.005	0.003
Mean dependent Var (1997)	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129	0.129
Implied Impact as % Dependent Variable										
Low attribute	−3.4*	−3.1	−2.8	−9.8***	−7***	−5.7**	−3.8*	−2.8	−4.3	−3.9*
High attribute	−2.2	−2.3	−1.5	5	2.6	−0.1	1.6	−2	−0.2	−0.5
Difference	1.1	0.8	1.2	14.8***	9.6***	5.6*	5.5*	0.8	4.1	3.4

Notes: Table reports results of establishment-level OLS generalized difference-in-differences regressions for noted dependent variable. The independent variables representing the effect of PNTR are the interaction of the NTR gap and a post-PNTR indicator (first covariate), and a triple interaction of that term with one of ten initial (1992) plant attributes, which are normalized by the average of that attribute across all plants in the same industry in 1992. Additional controls included in the regression but whose results are suppressed include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. The third panel of the table reports the estimated impact and standard error of an interquartile shift in the NTR gap for plants with low and high values for the noted attribute, as well as for the difference between high and low plants. Low (high) values are defined as the mean less (plus) one standard deviation. Final panel reports these estimates as a share of the 1997 value of the dependent variable. Data are for the years 1992, 1997, 2002 and 2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

Table 7
PNTR and heterogeneity in establishment-level structures investment.

	Structures investment as a share of capital stock									
	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$	$Struct/K_{pt}$
Post x NTR Gap_j	−0.0013	−0.0037	−0.0098	−0.002	−0.0056	−0.0073	−0.015*	−0.0073	−0.0019	−0.0049
	0.0040	0.0045	0.0124	0.0064	0.0059	0.0063	0.0084	0.0045	0.0051	0.0067
x $Attribute_p^{1992}$	−0.0006	0	0.0065	−0.0008	0.002	0.0026	0.0144	0.0023	−0.0008	0.0017
	0.0005	0.0006	0.0120	0.0043	0.0038	0.0030	0.0096	0.0017	0.0023	0.0057
Attribute =	Emp	VA	TFP	VA/L	Ship/L	K/L	Skill/L	Importer	Exporter	Age
Observations	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000
R-squared	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39	0.39
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Implied impact, low attribute	−0.0001	−0.0007	−0.0007	−0.0002	−0.0011	−0.0014	−0.0015*	−0.002*	0.0001	−0.0008
Standard error	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.001
Implied impact, high attribute	−0.0006	−0.0007	−0.0005	−0.0009	−0.0001	−0.0001	0.0012	0.0002	−0.0011	−0.0005
Standard error	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.002	0.001
Implied impact, high vs low	−0.0004	0	0.0003	−0.0007	0.001	0.0013	0.0027	0.0022	−0.0012	0.0004
Standard error	0.000	0.001	0.000	0.003	0.002	0.001	0.002	0.002	0.004	0.001
Mean dependent Var (1997)	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023
Implied impact as % dependent variable										
Low attribute	−0.6	−3	−3.1	−0.9	−4.9	−6.1	−6.6*	−8.6*	0.2	−3.6
High attribute	−2.5	−3	−2	−3.8	−0.5	−0.6	5.2	0.8	−4.8	−2
Difference	−1.8	0	1.1	−2.9	4.4	5.5	11.8	9.4	−5.1	1.6

Notes: Table reports results of establishment-level OLS generalized difference-in-differences regressions for noted dependent variable. The independent variables representing the effect of PNTR are the interaction of the NTR gap and a post-PNTR indicator (first covariate), and a triple interaction of that term with one of ten initial (1992) plant attributes, which are normalized by the average of that attribute across all plants in the same industry in 1992. Additional controls included in the regression but whose results are suppressed include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. The third panel of the table reports the estimated impact and standard error of an interquartile shift in the NTR gap for plants with low and high values for the noted attribute, as well as for the difference between high and low plants. Low (high) values are defined as the mean less (plus) one standard deviation. Final panel reports these estimates as a share of the 1997 value of the dependent variable. Data are for the years 1992, 1997, 2002 and 2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

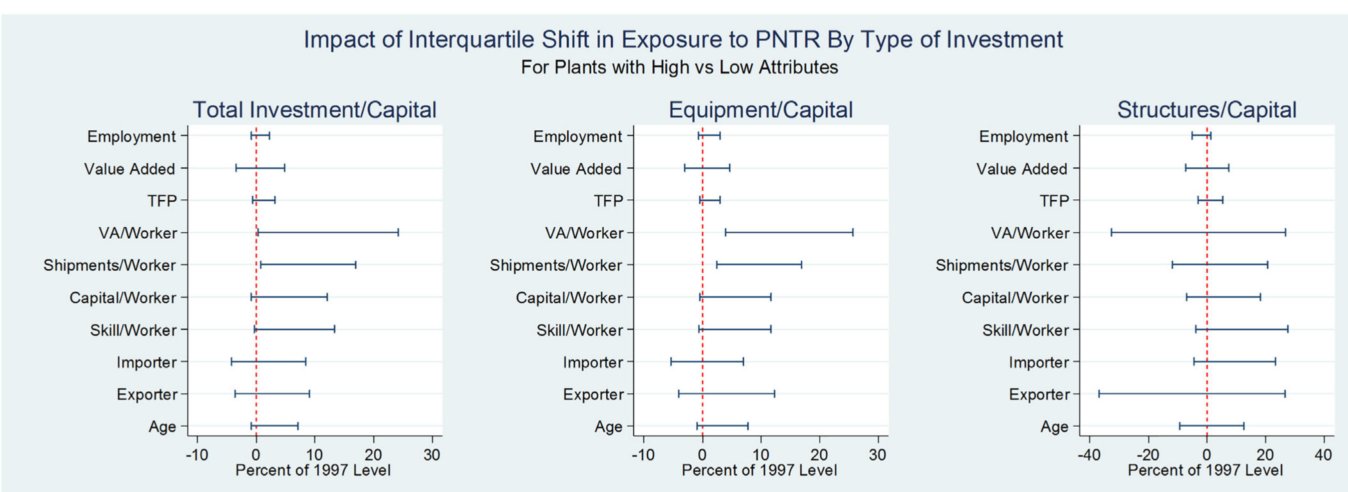
Table 8
PNTR and Heterogeneity in Establishment-Level Capital Stock.

	Log Capital Stock									
	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$	$\log(K_{pt})$
Post x NTR Gap_j	0.0647	0.1347	0.4061	0.1784	0.2106	0.1813	0.0849	0.1322	0.0786	−0.0005
	0.2033	0.1869	0.4980	0.2263	0.2475	0.2608	0.2571	0.2215	0.2075	0.2763
x $Attribute_p^{1992}$	−0.0022	−0.019	−0.3645	−0.0728	−0.0976	−0.0438	−0.0187	−0.0496	−0.0103	0.0754
	0.0295	0.0154	0.4196	0.1033	0.1297	0.1202	0.2241	0.0591	0.0492	0.2082
Attribute =	Emp	VA	TFP	VA/L	Ship/L	K/L	Skill/L	Importer	Exporter	Age
Observations	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000	396,000
R-squared	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Implied impact, low attribute	0.0124	0.0336	0.0139	0.0471	0.0436	0.0348	0.0142	0.0377	0.0205	0.0039
Standard error	0.041	0.038	0.035	0.057	0.051	0.051	0.036	0.053	0.060	0.043
Implied impact, high attribute	0.0108	0.0083	−0.0007	−0.0106	−0.005	0.0134	0.0106	−0.0084	0.0046	0.0206
Standard error	0.033	0.032	0.031	0.047	0.040	0.038	0.041	0.031	0.039	0.036
Implied impact, high vs low	−0.0016	−0.0254	−0.0147	−0.0577	−0.0486	−0.0214	−0.0035	−0.0461	−0.016	0.0167
Standard error	0.022	0.021	0.017	0.082	0.065	0.059	0.042	0.055	0.076	0.046
Mean dependent Var (1997)	7.286	7.286	7.286	7.286	7.286	7.286	7.286	7.286	7.286	7.286
Implied impact as % Dependent variable										
Low attribute	0.1	0.4	0.1	0.6	0.5	0.4	0.1	0.5	0.2	0
High attribute	0.1	0.1	0	−0.1	0	0.1	0.1	−0.1	0	0.2
Difference	0	−0.3	−0.2	−0.7	−0.6	−0.2	0	−0.6	−0.2	0.2

Notes: Table reports results of establishment-level OLS generalized difference-in-differences regressions for noted dependent variable. The independent variables representing the effect of PNTR are the Interaction of the NTR gap and a post-PNTR indicator (first covariate), and a triple Interaction of that term with one of ten initial (1992) plant attributes, which are normalized by the average of that attribute across all plants in the same industry in 1992. Additional controls included in the regression but whose results are suppressed Include time-varying variables – MFA exposure, NTR tariff rates – as well as Interactions of the post-PNTR indicator with time-invariant controls Including the log of 1990 capital and skill intensity, contract Intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. The third panel of the table reports the estimated impact and standard error of an interquartile shift In the NTR gap for plants with low and high values for the noted attribute, as well as for the difference between high and low plants. Low (high) values are defined as the mean less (plus) one standard deviation. Final panel reports these estimates as a share of the 1997 value of the dependent variable. Data are for the years 1992, 1997, 2002 and 2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

to demand uncertainty, as measured by the standard deviation of stock returns. Handley and Limao (2017) show in their theoretical model that investment responses to uncertainty may vary based on heterogeneity in firms' productivity levels. Here, by examining heterogeneous responses along a broad range of dimensions of heterogeneity, our results can provide context to this literature while yielding information relevant to new theories of firm- and establishment-level reactions to changes in uncertainty.

As noted above, the ASM has two drawbacks relative to the CM: it is a survey rather than a census, and the survey sample is re-drawn every five years, complicating one's ability to track individual establishments for a long period of time. Given these limitations, our analysis is limited to the balanced panel of establishments present in every ASM from 1990 to 2007. This selected sample clearly differs from the general population of establishments, as the establishments in our sample are larger, older and more likely to be exporters.



Notes: Panels display the impacts of an interquartile shift in exposure to PNTR on noted investment per capital outcomes for establishments with “high” versus low values of the noted attributes. Impact is expressed as the change in the noted investment share relative to its respective 1997 average across establishments. “Low” is defined as the mean less one standard deviation, while “high” is defined as the mean plus one standard deviation. Each confidence interval uses results from a different column in the bottom panels of Tables 5 to 7. Source: Census of Manufacturers and authors’ calculations.

Fig. 6. Implied impact of PNTR with plant heterogeneity from CM regressions.

Table 9
PNTR and the lumpiness of equipment investment.

	Standard deviation (SD), Average (Avg) and years with positive (Pos) investment								
	$\ln(SD_{pc}^{Total})$	$\ln(Avg_{pc}^{Total})$	$\ln(Pos_{pc}^{Total})$	$\ln(SD_{pc}^{Struct})$	$\ln(Avg_{pc}^{Struct})$	$\ln(Pos_{pc}^{Struct})$	$\ln(SD_{pc}^{Equip})$	$\ln(Avg_{pc}^{Equip})$	$\ln(Pos_{pc}^{Equip})$
Post x NTR 6ap$_j$	−0.3716	-0.2788	0.0043	−0.9465*	−0.9149	−0.1953	−0.3661	−0.205	0.0052
	0.334	0.264	0.010	0.523	0.561	0.197	0.323	0.260	0.013
Post x ln(K/Emp$_{j,1990}$)	−0.1505*	−0.1393*	0.0011	−0.0073	−0.0525	−0.0193	−0.203***	−0.1712***	0.0026
	0.081	0.071	0.002	0.109	0.098	0.024	0.076	0.069	0.002
Post x ln(NP/Emp$_{j,1990}$)	0.3794***	0.4123***	−0.0008	0.2811**	0.245*	0.0672	0.3835***	0.4353***	0.0067
	0.096	0.091	0.005	0.136	0.131	0.055	0.101	0.095	0.008
Post x Contract Intensity$_j$	0.2546	−0.0547	0.0112	0.783	0.554	−0.0565	0.0772	−0.1513	0.0196
	0.335	0.346	0.011	0.522	0.468	0.090	0.314	0.332	0.012
Post x ΔChina Import Tariffs$_j$	−0.2603	−0.3696	−0.0109	−0.2938	−0.5932	−0.4235***	−0.293	−0.3665	0.0082
	0.318	0.295	0.010	0.465	0.483	0.144	0.324	0.295	0.015
Post x ΔChina Subsidies$_j$	0.5715***	0.531***	−0.0104*	0.0629	0.0819	0.0275	0.5999***	0.5568***	−0.0142*
	0.156	0.117	0.006	0.238	0.246	0.097	0.148	0.116	0.007
Post x ΔChina Licensing$_j$	0.9039*	0.7887	0.0239	1.1695	1.0156	0.1253	0.8291	0.8504*	0017
	0.530	0.532	0.020	0.771	0.737	0.173	0.506	0.504	0.019
Post x l{Advanced Technology$_j$}	0.1041	0.1896*	0.0012	0.1368	0.172	0.0406	0.1299	0.1948**	−0.0089
	0.089	0.100	0.006	0.147	0.149	0.052	0.099	0.097	0.011
Post x Union Memepership$_j$	−0.0026	0.002	0	−0.0064	−0.008*	−0.0019	−0.0014	0.0028	−0.0002**
	0.004	0.002	0.000	0.005	0.005	0.003	0.004	0.002	0.000
MFA Exposure$_{jc}$	−0.0108	−0.0138	0.0008	−0.0097	−0.0266*	−0.0181***	−0.0156	−0.016	0.0017
	0.011	0.012	0.001	0.015	0.014	0.006	0.012	0.012	0.002
NTR$_{jc}$	−1.5884	0.4876	0.0802	−1.4264	−0.0671	1.504*	−1.0439	0.7227	0.0975
	1.699	0.844	0.060	2.272	1.708	0.873	1.450	0.769	0.082
Observations	9000	9000	9000	9000	9000	9000	9000	9000	9000
R-squared	0.90	0.95	0.54	0.81	0.84	0.67	0.91	0.95	0.54
Fixed effects	p,t	p,t	p,t	p,t	p,t	p.t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Table reports results of OLS generalized difference-in-differences regressions. The dependent variables are the natural logs of the standard deviation, average, and share of years with positive investment for total investment (columns 1–3), investment in structures (columns 4–6), and investment in equipment (columns 7–9). The independent variable representing the effect of PNTR is the interaction of the NTR gap and a post-PNTR indicator. Additional controls include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill Intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes In Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. Sample includes establishments present in every year from 1990 to 2007, and data are collapsed to two periods, 1990–2000 and 2001–2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

We relate the patterns of establishments' investment to the change in trade policy by collapsing the balanced panel into two periods: a pre-PNTR period encompassing the years 1990 to 2000; and a post-PNTR period comprising 2001 to 2007, meaning that we have two observations for each establishment. A virtue of this sample interval, in addition to its spanning the passage of PNTR, is that each sub-period roughly

Table 10
PNTR and the standard deviation of plant equipment investment.

	Log standard deviation of equipment investment									
	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$	$StdDev_{pt}$
Post x NTR Gap$_j$	−0.4549	−0.5123	−1.6802*	−1.0377**	−0.9941**	−0.4146	−0.276	−0.6585	−0.8222**	−1.0492
	0.3531	0.3629	0.8635	0.4555	0.4847	0.3849	0.5924	0.4647	0.4140	0.7027
x Attribute$_p^{1992}$	0.0099	0.0164	1.2359*	0.5356***	0.5205***	0.0243	−0.0991	0.179	0.2953**	0.6307
	0.0195	0.0169	0.6848	0.1984	0.2193	0.0684	0.4591	0.1264	0.1489	0.4734
Attribute =	Emp	VA	TFP	VA/L	Ship/L	K/L	Skill/L	Importer	Exporter	Age
Observations	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
R-squared	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Implied impact, low attribute	−0.0867	−0.103	−0.0756	−0.156**	−0.142*	−0.0845	−0.0603	−0.138	−0.202**	−0.0922
Standard error	0.068	0.072	0.057	0.075	0.076	0.084	0.078	0.095	0.094	0.068
Implied impact, high attribute	−0.0694	−0.0627	−0.028	0.0266	0.0275	−0.0507	−0.0764	0.05	0.1	−0.0098
Standard error	0.060	0.058	0.054	0.055	0.054	0.070	0.058	0.073	0.100	0.058
Implied impact, high vs low	0.0173	0.04	0.0476*	0.182***	0.17***	0.0338	−0.016	0.188	0.302**	0.0824
Standard error	0.034	0.041	0.026	0.068	0.071	0.095	0.074	0.133	0.152	0.062

Notes: Table reports results of establishment-level OLS generalized difference-in-differences regressions for noted dependent variable. There are two observations for each establishment, one computed over investment in the years before PNTR and the other comupted over the years after PNTR. The independent variables representing the effect of PNTR are the interaction of the NTR gap and a post-PNTR indicator (first covariate), and a triple interaction of that term with one of ten initial (1992) plant attributes, which are normalized by the average of that attribute across all plants in the same industry in 1992. Additional controls included in the regression but whose results are suppressed include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. The third panel of the table reports the estimated impact and standard error of an interquartile shift in the NTR gap for plants with low and high values for the noted attribute, as well as for the difference between high and low plants. Low (high) values are defined as the mean less (plus) one standard deviation. Final panel reports these estimates as a share of the 1997 value of the dependent variable. Sample includes establishments present in every year from 1990 to 2007, and data are collapsed to two periods, 1990–2000 and 2001–2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

Table 11
PNTR and mean plant equipment investment.

	Log average equipment investment									
	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$	$Average_{pt}$
Post x NTR Gap_j	−0.1908	−0.1498	−0.5907	−0.346	−0.2616	−0.1902	−0.1078	−0.2115	−0.4647	−0.2638
	0.2964	0.2924	0.6406	0.3334	0.3545	0.2893	0.4927	0.3586	0.3041	0.5866
x $Attribute_p^{1992}$	−0.0118	−0.019	0.3301	0.1126	0.047	−0.0025	−0.1188	−0.0055	0.1635*	0.0516
	0.0223	0.0158	0.5269	0.1431	0.1692	0.0539	0.4067	0.0937	0.0927	0.4186
Attribute =	Emp	VA	TFP	VA/L	Ship/L	K/L	Skill /L	Importer	Exporter	Age
Observations	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
R-squared	0.54	0.54	0.54	0.54	0.54	0.54	0.54	0.55	0.55	0.55
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Implied impact, low attribute	−0.0336	−0.0198	−0.0467	−0.0567	−0.0449	−0.0348	−0.0307	−0.0391	−0.113*	−0.0408
Standard error	0.058	0.059	0.047	0.056	0.057	0.063	0.063	0.073	0.066	0.055
Implied impact, high attribute	−0.0543	−0.0664	−0.034	−0.0183	−0.0296	−0.0382	−0.0499	−0.0448	0.0537	−0.0341
Standard error	0.048	0.047	0.048	0.051	0.054	0.060	0.051	0.058	0.071	0.052
Implied impact, high vs low	−0.0207	−0.0466	0.0127	0.0384	0.0153	−0.0034	−0.0192	−0.0057	0.167*	0.0067
Standard error	0.039	0.039	0.020	0.049	0.055	0.075	0.066	0.098	0.095	0.055

Notes: Table reports results of establishment-level OLS generalized difference-in-differences regressions for noted dependent variable. The independent variables representing the effect of PNTR are the interaction of the NTR gap and a post-PNTR indicator (first covariate), and a triple interaction of that term with one of ten initial (1992) plant attributes, which are normalized by the average of that attribute across all plants in the same industry in 1992. Additional controls included in the regression but whose results are suppressed include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. The third panel of the table reports the estimated impact and standard error of an interquartile shift in the NTR gap for plants with low and high values for the noted attribute, as well as for the difference between high and low plants. Low (high) values are defined as the mean less (plus) one standard deviation. Final panel reports these estimates as a share of the 1997 value of the dependent variable. Sample includes establishments present in every year from 1990 to 2007, and data are collapsed to two periods, 1990–2000 and 2001–2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.

coincides with a full business cycle, beginning around the time of a recession peak and continuing through the start of the next recession.

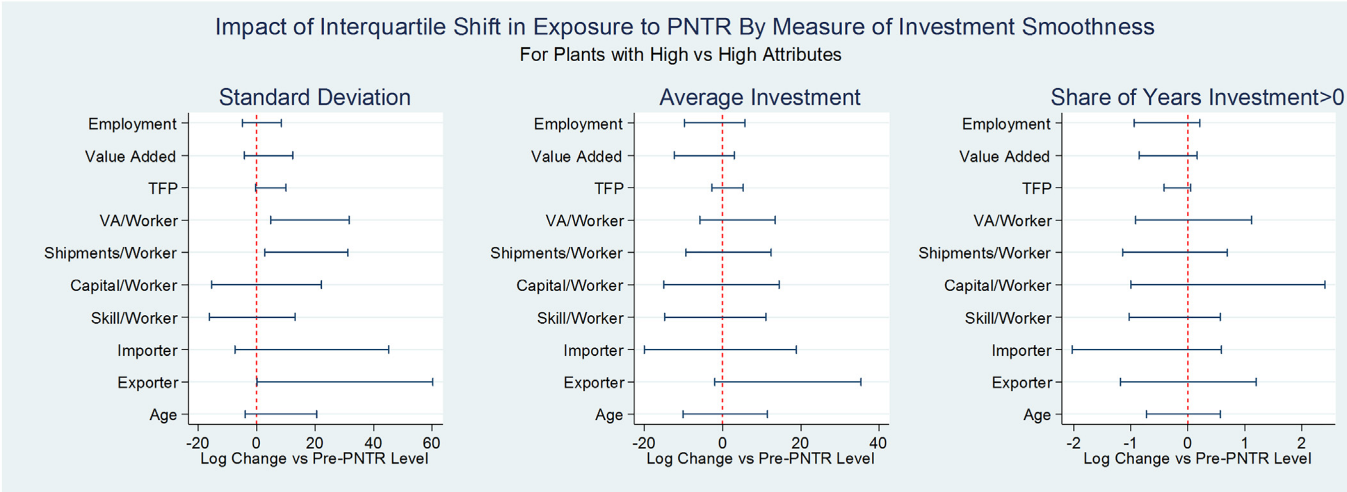
For each period, we calculate three plant-level measures of investment activity. The first measure is the log of the standard deviation of investment, within plants, across the years in each period. This measure captures changes in the lumpiness of plants' investment behavior. The second measure is the log of the average size of establishments' investments, defined as the sum of plant p's investment for period c, divided by the number of years in the period. This measure provides a useful comparison to our results above. The third measure is the log of the share of years in each period with positive investment, a measure that captures the frequency with which establishments invest. In practice, as noted in Table 1, a high share of establishments invest each year, though the share is lower for structures investment. With these measures, we estimate the following equation:

$$\ln\left(y_{pc}\right) = \theta Post\,PNTR_c \times NTR\,Gap_j + \beta \mathbf{X}_{jc} + \gamma Post\,PNTR_c \times \mathbf{X}_j + \delta_p + \delta_c + \alpha + \varepsilon_{pc}, \quad (6)$$

Table 12
PNTR and the share of years with positive equipment investment.

	Log share of years with positive equipment investment									
	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$	$PosShare_{pt}$
Post x NTR Gap_j	0.02	0.0149	0.0544*	−0.0005	0.0135	−0.0079	0.0164	0.0151	0.0046	0.0114
	0.0139	0.0140	0.0319	0.0235	0.0231	0.0177	0.0233	0.0166	0.0153	0.0298
x $Attribute_p^{1992}$	−0.0021	−0.0014	−0.048	0.0029	−0.007	0.0051	−0.0144	−0.0068	0.0001	−0.0062
	0.0017	0.0010	0.0301	0.0151	0.0143	0.0062	0.0249	0.0063	0.0059	0.0250
Attribute =	Emp	VA	TFP	VA/L	Ship/L	K/L	Skill/L	Importer	Exporter	Age
Observations	9000	9000	9000	9000	9000	9000	9000	9000	9000	9000
R-squared	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Fixed effects	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t	p,t
K stock weighted	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Implied impact, low attribute	0.0041	0.0034	0.0009	0.0001	0.0019	−0.0029	0.0018	0.0034	0.0008	0.0011
Standard error	0.003	0.003	0.002	0.004	0.003	0.005	0.003	0.003	0.003	0.003
Implied impact, high attribute	0.0004	−0.0001	−0.0009	0.0011	−0.0003	0.0041	−0.0005	−0.0038	0.0009	0.0003
Standard error	0.003	0.003	0.003	0.004	0.003	0.005	0.004	0.005	0.004	0.003
Implied impact, high vs low	−0.0037	−0.0035	−0.0019	0.001	−0.0023	0.007	−0.0023	−0.0072	0.0001	−0.0008
Standard error	0.003	0.003	0.001	0.005	0.005	0.009	0.004	0.007	0.006	0.003

Notes: Table reports results of establishment-level OLS generalized difference-in-differences regressions for noted dependent variable. The independent variables representing the effect of PNTR are the interaction of the NTR gap and a post-PNTR indicator (first covariate), and a triple interaction of that term with one of ten initial (1992) plant attributes, which are normalized by the average of that attribute across all plants in the same industry in 1992. Additional controls included in the regression but whose results are suppressed include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with time-invariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products, and the 1990 percentage of union membership. The third panel of the table reports the estimated impact and standard error of an interquartile shift in the NTR gap for plants with low and high values for the noted attribute, as well as for the difference between high and low plants. Low (high) values are defined as the mean less (plus) one standard deviation. Final panel reports these estimates as a share of the 1997 value of the dependent variable. Sample includes establishments present in every year from 1990 to 2007, and data are collapsed to two periods, 1990–2000 and 2001–2007. Robust standard errors adjusted for clustering at the industry (j) level are displayed below each coefficient. Estimates for the year (t) and plant (p) fixed effects as well as the constant are suppressed. Observations are weighted by capital stock (book value). *, ** and *** represent statistical significance at the 10, 5 and 1% levels.



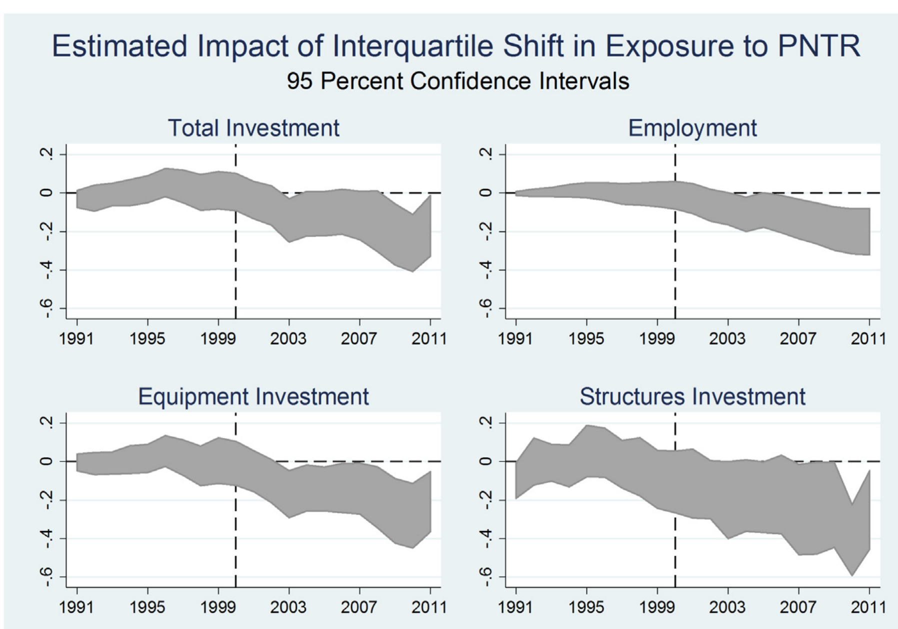
Notes: Panels display the impacts of an interquartile shift in exposure to PNTR on noted pattern of investment outcomes in the pre- (1990 to 2000) versus post- (2001 to 2007) periods for establishments with "high" versus "low" values of the noted attributes (e.g., employment). Impact is expressed as the change in the noted investment characteristic relative to its respective 1997 average across establishments. "Low" is defined as the mean less one standard deviation, while "high" is defined as the mean plus one standard deviation. Each pair of bars is computed using estimated coefficients from a separate difference-in-differences (DID) regression (equation 6) that contains a plant heterogeneity DID term corresponding to the noted attribute (e.g., employment). These estimates appear in Tables 10 through 12. Source: ASM, CM and authors' calculations.

Fig. 7. Implied impact of PNTR on smoothness of plant equipment investment.

where p indexes establishments and j indexes industries, as before, and c indexes the two time periods. The dependent variable $ln(y_{pc})$ is one of the three measures of investment behavior for plant p in period c noted above, and the DID term and control variables are identical to those in Eq. (2), with the exception that in Eq. (6), time-varying control variables are averaged over each period.

As in Section 4.1, Table 9 sets a baseline by reporting coefficient estimates and standard errors from estimating Eq. (6) without controls for plant heterogeneity. The first three columns of the table display results for total investment, the next three columns for investment in structures, and the final three columns for investment in equipment.

Results indicate that higher industry-level exposure to PNTR – and therefore a larger reduction in tariff rate uncertainty – is associated with smaller average investment sizes, a smaller standard deviation of investment across years, and a higher share of years with positive investment. Though the signs for the latter two variables generally are in line with the predictions from Bloom et al., 2007, in that larger reductions in uncertainty lead to investments that are less lumpy (standard deviation) and more frequent (share positive), these relationships are generally not



Notes: Figure display the 95 percent confidence intervals associated with an interquartile shift in industry exposure to PNTR on industry-level investment (upper left panel) and employment (upper right panel). Bottom panels report results separately for equipment and structures investment. Source: Authors' calculations based on data from the NBER-CES Manufacturing Industry database.

Fig. 8. Implied industry-level impact of PNTR, 1991–2011.

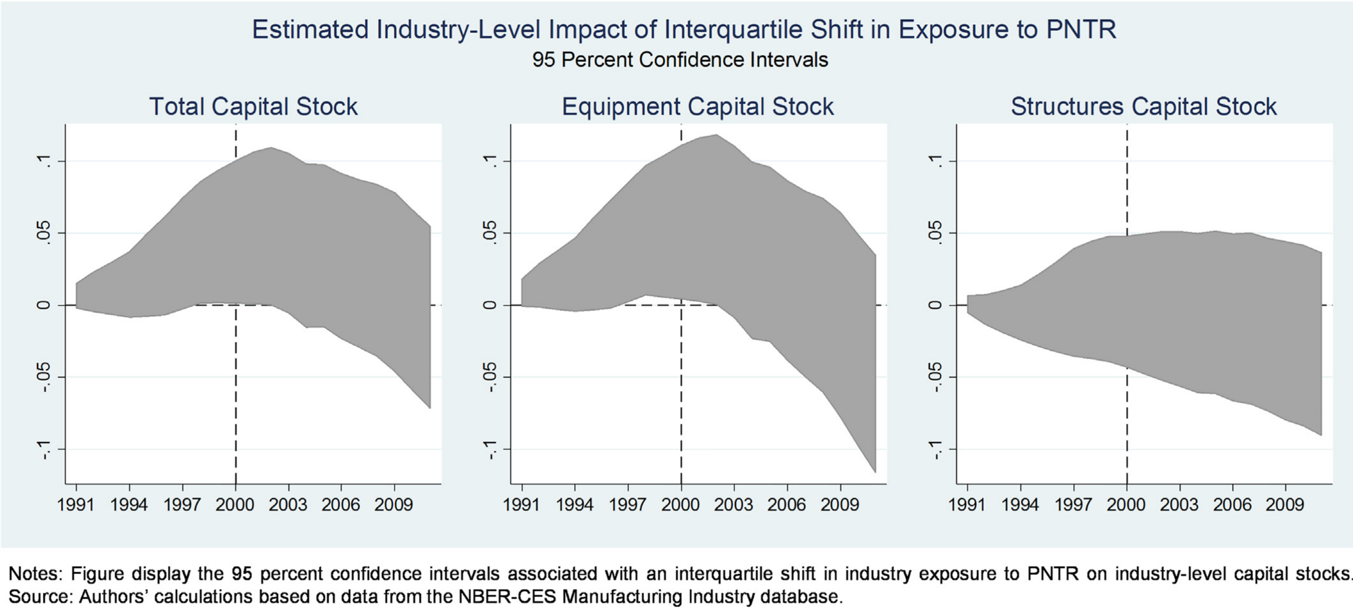


Fig. 9. Implied industry-level impact of PNTR, 1991–2011.

statistically significant at conventional levels. One potential explanation for the lack of significance–in addition to our lack of controls at this stage for establishment heterogeneity–may be that our data are at a relatively infrequent annual frequency, thereby masking variation in the timing of investments within calendar years (Bloom et al. (2007)).

However, as in Section 4, when we augment Eq. (6) with plant heterogeneity terms, these relationships become clearer. As in the previous section, we focus our discussion on equipment investment. Results from this augmented specification are displayed in Tables 10 to 12, which take the same format as Tables 5 to 8. Analogous tables for total and structures investment are not reported here, but are available upon request.

The bottom panel of each table reports the estimated log change in the dependent variable associated with an interquartile shift in the NTR gap for plants with low and high values of the noted attributes. As indicated in Table 10, we find that plants with low levels of each attribute exhibit relative declines in the standard deviation of investment after the change in trade policy, versus before, though these responses are statistically significant at conventional levels only with respect to labor productivity and plants that are non-exporters. For plants with low levels of these attributes, the standard deviation of investment is estimated to decline by 0.14 to 0.20 log points, in relative terms. By contrast, none of the estimated estimated impacts for plants with high levels of the noted attributes are statistically significant. As a result, as illustrated in left panel of Fig. 7, the 95% confidence interval for the estimated differential impact of high- versus low-attribute plants is statistically significantly greater than zero only for regressions examining labor productivity and export status.

Results for average investment and the share of years in positive investment, in Tables 11 and 12, and the right two panels of Fig. 7, reveal no substantial relationships with PNTR except for a marginally significant association for log average investment and non-exporters.

In sum, we find in this section that plants with low values of labor productivity and non-exporters experience less lumpy investment behavior in response to PNTR. For plants with high values of these attributes, however, there is no statistically significant change in the lumpiness of investment. One potential explanation for these results can be found by considering the expectations of high-productivity establishments prior to passage of PNTR. If these establishments viewed their productivity level as being sufficiently high to continue operating even if tariffs increased substantially, their investment activity may not have been suppressed by uncertainty in the pre-PNTR period. As a result, less of a response to the timing of these establishments' investment following passage of PNTR might be expected. Low-productivity establishments, by contrast, may have viewed their continued operation as being in jeopardy prior to PNTR, leading to lumpier investment. After PNTR, when the probability of survival had increased, investment activity at these plants became smoother.

5. Conclusion

This paper estimates the investment responses of U.S. manufacturing industries and establishments to the elimination of the possibility of tariff increases occurring with the U.S. granting of PNTR to China in October 2000. We use a differences-in-differences approach to examine how variation in exposure to PNTR is associated with changes in manufacturing investment and capital stock after the policy change, relative to before.

At the industry-level, we find that industries more exposed to PNTR experience relative declines in manufacturing investment, with the results most precisely estimated for investment in equipment, though the relationship between exposure to PNTR and the capital stock is not statistically significant. Examining a flexible specification that makes no assumptions about the timing of the effects of PNTR, we find that the decline in investment lines up closely with the timing of the granting of PNTR.

At the establishment-level, we find that there is heterogeneity within industries in terms of how establishments respond to PNTR's trade liberalization. While the average effect of PNTR is to lower investment, for establishments with higher initial levels of labor productivity and of capital and skilled labor intensity, higher exposure to PNTR's trade does not yield a statistically significant decline in investment. This relatively stronger performance of investment for high-attribute plants may be evidence of trade-induced technical change, product-upgrading, or other activities that differentiate U.S. production from import-competing products.

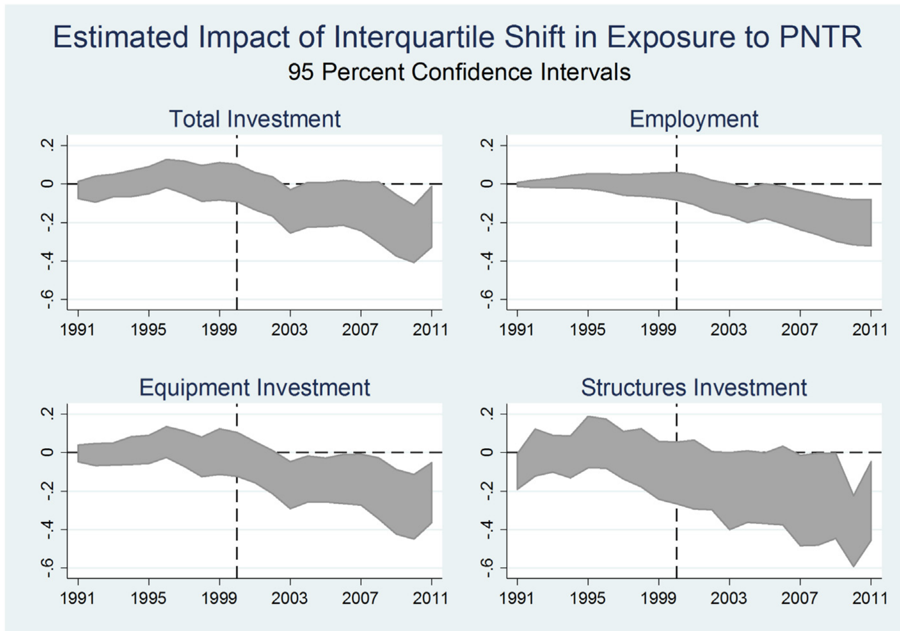
Examining the timing, frequency, and lumpiness of establishments' investment behavior, we find that larger reductions in uncertainty associated with PNTR are associated declines in the lumpiness of investment, with less of a change in behavior for establishments with high initial productivity levels and for exporters.

In sum, the findings in this paper indicate that while increased import competition is associated with relative declines in investment, initial characteristics play a role in determining how individual establishments respond to trade liberalization.

Appendix A. Appendix

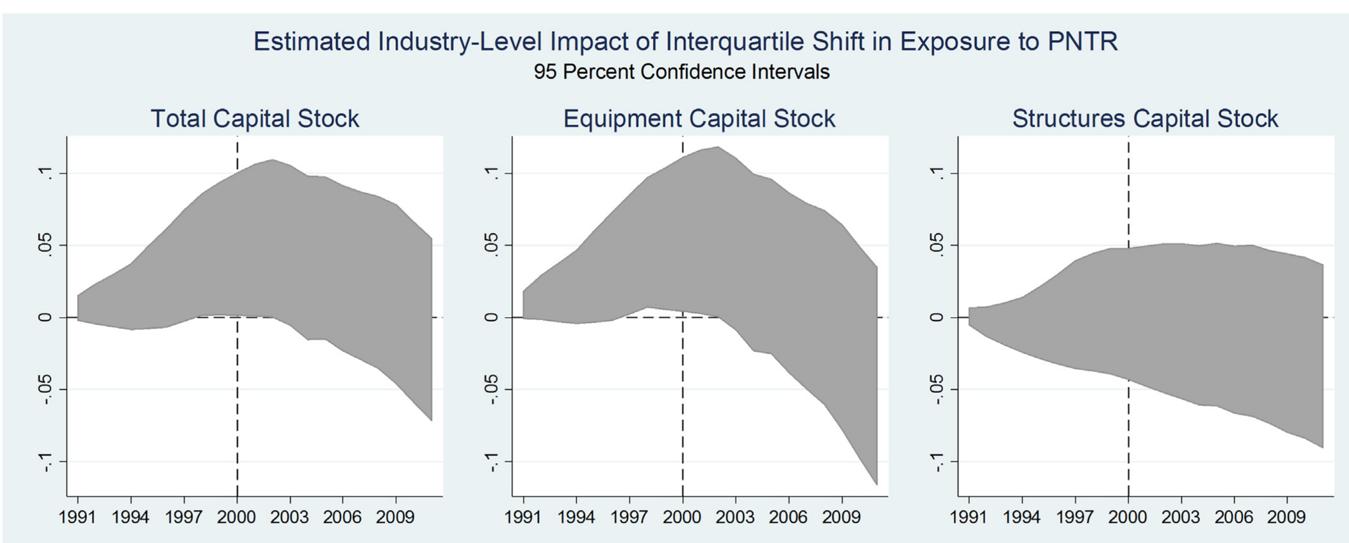
A.1. Industry results through 2011

The regression sample in the main text extends through 2007 in order to avoid the Great Recession. For comparison, Fig. 8 reports results for industry-level investment and for the industry-level investment deflators using Eq. (3) for 1990 to 2011, the limit of the NBER-CES Manufacturing Productivity Database. Fig. 9 presents analogous results for industry capital stocks.



Notes: Figure display the 95 percent confidence intervals associated with an interquartile shift in industry exposure to PNTR on industry-level investment (upper left panel) and employment (upper right panel). Bottom panels report results separately for equipment and structures investment. Source: Authors' calculations based on data from the NBER-CES Manufacturing Industry database.

Fig. 8. Implied industry-level impact of PNTR, 1991–2011.



Notes: Figure display the 95 percent confidence intervals associated with an interquartile shift in industry exposure to PNTR on industry-level capital stocks. Source: Authors' calculations based on data from the NBER-CES Manufacturing Industry database.

Fig. 9. Implied industry-level impact of PNTR, 1991–2011.

Appendix B. Reconciling industry and plant results

Table 13
Aggregating plant results to industry results.

	Investment	Investment	Investment Share	Investment Share
	$\ln(Total_{it})$	$\ln(Total_{it})$	$TotInv/K_{it}$	$TotInv/K_{jt}$
Post x NTR Gap_j	−0.5419***	−03819*	−0.025***	−0.0297***
	0.191	0.229	0.009	0.013
Post x $\ln(K/Emp_j)$	−0.1065	−0.1598***	0.0044	−0.0027
	0.068	0.039	0.004	0.002
Post x $\ln(NP/Emp_j)$	0.1441	0.2708***	0.0048	0.0051
	0.145	0.087	0.006	0.005
Post x Contract $Intensity_j$	−0.2433	0.0779	0.0006	−0.0029
	0.174	0300	0.008	0.013
Post x ΔChina Import $Tariffs_j$	0.1981	−03961	−0.0037	0.0131
	0.130	0367	0.006	0.017
Post x ΔChina $Subsidies_j$	0.9238***	03385***	0.0043	0.0054
	0.256	0.114	0.012	0.007
Post x ΔChina $Licensing_j$	0.0025	0.6489	0.0001	0.0016
	0.002	0.400	0.000	0.026
Post x 1{Advanced $Technology_j$}	−0.0558	0.0009	0.0004	−0.0054
	0.039	0.087	0.002	0.006
MFA $Exposure_{jt}$	0.3801***	−0.0384***	0.0013	−0.0002**
	0.070	0.004	0.003	0.000
NTR_{jt}	−0.0233***	0.9459	−0.0001	0.0481
	0.005	0.764	0.000	0.053
Post x U.S. Union $Membership_j$	−0.2133	0.0024	0.0232	0.0003***
	0.833	0.002	0.031	0.000
Observations	2000	2000	2000	2000
R-squared	0.95	0.96	0.54	0.68
Weighting	No	K_j	No	K_j
Fixed effects	j,t	j,t	j,t	j,t
Implied impact of PNTR	−0.102	−0.072	−0.005	−0.006

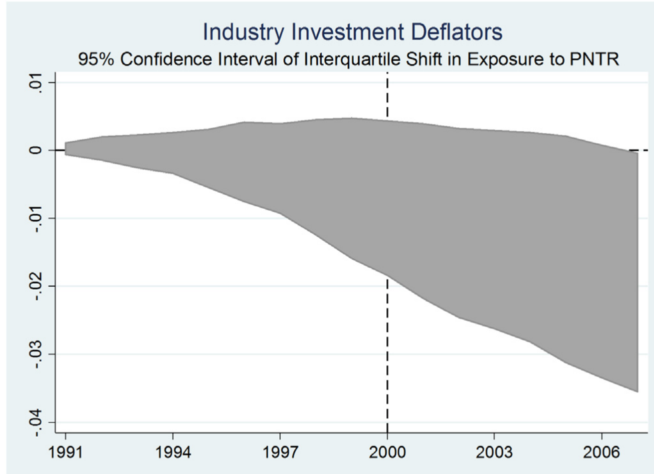
Notes: Table reports results of OLS generalized difference-in-differences regressions. The dependent variable in the first two columns is the log of industry-year total investment and the independent variable representing the effect of PNTR is the interaction of the NTR gap and a post-PNTR indicator. The dependent variable in the last two columns is total investment divided by capital stock. Columns one and three are unweighted while columns two and four are weighted by the initial value of the capital stock. Additional controls include time-varying variables – MFA exposure, NTR tariff rates – as well as interactions of the post-PNTR indicator with timeinvariant controls including the log of 1990 capital and skill intensity, contract intensity (Nunn, 2007), changes in Chinese tariffs, changes in Chinese production subsidies, changes in Chinese export licensing requirements, an indicator for whether the industry produces advanced technology products and the 1990 union membership rate. The sample is constructed by aggregating the establishment-level sample employed in Table 4 to the industry-year level. Sample includes census years 1992, 1997, 2002 and 2007. Robust standard errors adjusted for clustering at the industry (i) level are displayed below each coefficient. Estimates for the year (t) and industry fixed effects as well as the constant are suppressed. Final row reports implied impact on dependent variable of an interquartile shift in indusry exposure to PNTR.

As discussed in Section 4.1, we obtain differing results in establishment-level regressions versus industry-level regressions. These differences arise from several causes. First, the sources of variation in the data that are exploited for identification are different in the two analyses. Specifically, because the establishment-level regression includes establishment fixed effects, it only uses variation within continuing establishments over time to generate coefficient estimates. By contrast, the industry-level regressions will capture the effect of changes in industry-level investment due to establishment entry and exit. Second, the dependent variables used to examine the relationship between PNTR and investment differ across the two approaches. In the industry-level regressions, the dependent variable is the natural log of investment, while in the establishment-level regressions, the dependent variable is the ratio of investment to the total capital stock. The different scales of these dependent variables will yield different magnitudes for coefficient estimates. Third, the samples for the two analyses differ somewhat, as only establishments that are present in both the pre- and post-PNTR periods contribute to identification in the establishment-level regressions. Furthermore, the establishment-level regressions–because they use Census of Manufactures data–only use data for the years 1992, 1997, 2002 and 2007, while the industry-level regressions are based on data for all years from 1990 to 2007.

Table 13 illustrates that the differences between industry- and establishment-level results largely disappear when they are aggregated to the same level–allowing identification from the same sources of variation–and consider the same same dependent variable. Specifically, the first column of the table reports results of estimating Eq. (2) after starting with the establishment-level sample, aggregating to the industry-level, and using the natural log of total investment as the dependent variable. Comparing the coefficient estimate for the DID term in column 1 of Table 13 to the analogous estimate in column 3 of Table 2 indicates that both are negative and statistically significant, and of nearly identical magnitudes. Alternatively, when we estimate Eq. (2) with the same sample as column one of Table 13, but use the dependent variable from the establishment-level regressions–investment divided by capital stock–we again find that the magnitude of the DID coefficient estimate is similar to the analogous establishment-level results from column 2 of Table 4. The coefficient in this *industry*-level analysis is statistically significant, likely because it captures changes in investment associated with net plant exit, which the establishment-level regressions do not. Columns 2 and 4 of Table 13 provide results weighted by capital stock, for comparison.

Appendix C. Investment deflators

We examine the relationship between the change in U.S. trade policy and investment deflators using Eq. (3) in Fig. 10. As indicated in the figure, we find that industries with greater exposure to PNTR exhibit greater declines in their investment deflators. One potential explanation for this relationship relates to impact of net plant death on investment highlighted in the main text, complemented by the Pierce and Schott (2016a) finding that plants with greater exposure to the change in policy are relatively more likely to shut down. If these closures increase the supply (on the secondary market) of the capital goods used to produce in that industry, their price might fall.



Notes: Figure display the 95 percent confidence intervals associated with an interquartile shift in industry exposure to PNTR on industry-level investment deflators. Source: Authors' calculations based on data from the NBER-CES Manufacturing Productivity database.

Fig. 10. PNTR and industry investment deflators.

Appendix D. Calculation of control variables

This section describes the calculation of each of the control variables included in eqs. 2 and 3. We separate the variables according to whether they are time-varying at the industry-year-level or time-invariant at the industry-level. Time-invariant variables are interacted with either the post-PNTR indicator (Eq. (2)) or year dummies (Eq. (3)).

D.1. Time-varying control variables

NTR Rates: This variable is the average at the industry-year-level of the U.S. normal trade relations tariff rate across eight-digit HS codes. These HS-level tariff rate data are from Feenstra et al. (2002) and are matched to six-digit NAICS industries using concordances provided in Pierce and Schott (2012a). Because Feenstra et al. (2002) does not report tariff rates for years after 2001, we assume that tariff rates are constant after that year, through 2007. Pierce and Schott (2016a) examine "revealed" tariff rates from public U.S. import data over this time period and find that this assumption is reasonable, without relying on the smaller set of industries for which revealed tariff data are available.

MFA Exposure: We calculate industries' exposure to elimination of the MFA in two steps. In the first step, as in Khandelwal et al. (2013) we calculate the extent to which MFA quotas in industry i and phase *p* were binding as the average fill rate of the industry's constituent import products in the year before they were phased out, $FillRate_{jp}$.[25] Specifically, for each phase, we measure an industry's exposure to MFA expiration as its average quota fill rate across products in the year prior to the phase's expiration. Industries with higher pre-expiration average fill rates faced more binding quotas and are therefore more exposed to the end of the MFA. In the second step, the industry-year-level control variable of interest, $MFAExposure_{ct}$, is calculated as the cumulated fill rates as each phase of expiration takes place. Additional background information on the MFA is provided in Pierce and Schott (2016b).

D.2. Time-invariant control variables

Changes in Contract Intensity: As part of China's accession to the WTO, China agreed to eliminate differential treatment of foreign-owned enterprises, which may increase the incentive for U.S. firms to offshore production to China. To the extent that this policy change affected all industries identically, it will be captured in the year fixed effects. However, it may be possible that this policy change had a larger affect on industries in which relationship specificity in contracting over inputs is more important. Therefore, we include as a control Nunn's (2007) measure of industries' contract intensity, which rises with the share of intermediate inputs requiring relationship-specific investment.[26]

Changes in Chinese Import Tariffs: Because we do not have access to Chinese import tariff data for all years of our sample, we use six-digit HS product-level data on Chinese import tariffs for 1996 to 2005 from Brandt et al. (2017) to compute the average change across those years in Chinese import tariffs across products within each U.S. industry. Six-digit HS product-level tariff data are matched to industries using the concordances from Pierce and Schott (2012a).

Changes in Chinese Production Subsidies: We use data from the Annual Report of Industrial Enterprise Statistics compiled by China's National Bureau of Statistics (NBS), which reports the subsidies provided to responding firms. The NBS data encompass a census of state-owned enterprises (SOEs) and a survey of all non-SOEs with annual sales above 5 million Renminbi (~$600,000). The version of the NBS dataset available to us from Khandelwal et al. (2013) spans the period 1998 to 2005. Following Girma et al. (2009) and Aghion et al. (2015) we use the variable "subsidy" in this dataset and compute the change in the subsidies to sales ratio for each NAICS industry between 1998 and 2005 using concordances provided by Dean and Lovely (2010) and Becker et al. (2013).

Changes in Chinese Export Licensing Requirements: As discussed in detail in Bai et al., 2015, China agreed to phase out export licensing requirements by 2003 as part of its accession to the WTO (Bai et al. (2015)). Bai et al. (2015) reports the share of Chinese producers in each four-digit CIC industry that were eligible to export in 1999. We concord these shares to ISIC and then U.S. NAICS industries using concordances provided by Dean and Lovely (2010), Becker et al. (2013), and the United Nations, available at http://unstats.un.org/unsd/cr/registry/regot.asp.

[25] As discussed in Brambilla et al. (2010), fill rates are defined as actual imports divided by allowable imports under the the quota. MFA products for which there were no restrictions on imports are assigned fill rates of zero.

[26] These data are available from Nunn's website at http://scholar.harvard.edu/nunn/pages/data-0.

Indicator for Advanced Technology Products: An indicator for the presence of advanced technology products is set equal to one if the industry contains a ten-digit HS product classified by the U.S. International Trade Commission as being an advanced technology products. These ten-digit HS product codes are matched to NAICS industries using the concordances from Pierce and Schott (2012a). Lists of product codes and descriptions are available here: http://www.census.gov/foreign-trade/reference/codes/atp/.

Initial Union membership: We control for initial-year (1990) union membership at the industry-level using data from the website www.unionstats.com – assembled by Hirsch and Macpherson (2003) – which publishes information on the share of workers that are members of a union by Current Population Survey (CPS) industry classification and year. We match CPS industries to NAICS codes using the concordances posted at unionstats.com. We note that union membership is often defined at higher levels of industry aggregation than the six-digit NAICS level.

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