Chinese Imports and U.S. Innovation: Evidence from the US-China Permanent Normal Trade Relation*

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Abstract

In this paper, we examine the United States' conferral of Permanent Normal Trade Relations (PNTR) on China—a policy eliminating the uncertainty of future tariff increase associated with Chinese goods—on U.S. business activities from the perspective of innovation. We find a significant increase in the number of patents and patent citations for U.S. firms that are affected by PNTR relative to firms that are not affected. Overall, our evidence is consistent with the view that Chinese imports induce U.S firms to invest more in innovative technology that is more consistent with U.S. comparative advantage.

Keywords: Permanent Normal Trade Relation; Innovation; Patents; Import; China

JEL Classification: G38; O31

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1. Introduction

In October 2000, the U.S. Congress decided to grant Permanent Normal Trade Relations (PNTR) to China, which became effective upon China's accession to the World Trade Organization (WTO) at the end of 2001. Conferral of PNTR was unique in that it did not change the import tariff rates the United States actually applied to Chinese goods over this period. U.S. imports from China had been subject to the relatively low NTR tariff rates reserved for WTO members since 1980.[1] But for China, these low rates required annual renewals that were uncertain and politically contentious. Without renewal, U.S. import tariff on Chinese goods would have jumped to the higher non-NTR tariff rates assigned to non-market economies, which were originally established under the Smoot-Hawley Tariff Act of 1930. PNTR removed the uncertainty associated with these annual renewals by permanently setting U.S. duties on Chinese imports at NTR levels.

We expect PNTR to foster innovation in U.S. firms, because it decreases the profitability of using low-skilled technology and boosts the attractiveness in high-skilled technology that is more consistent with U.S. comparative advantage over China.

We empirically test the effect of PNTR on corporate innovation using a panel of 6,209 U.S. public firms from 1995 to 2005 and a difference-in-differences approach. We find that the PNTR leads to a significant increase in innovation outputs. On average, firms that are affected by PNTR experience an increase in the number of patents by 38% and an increase in the number of patent citations by 49%, relative to firms that are unaffected by PNTR.

The identifying assumption central to the difference-in-differences estimation is that treated and control firms share parallel trends prior to the PNTR. Our tests show that their pre-treatment trends are indeed indistinguishable. Moreover, most of the impact of PNTR on innovation occurs several years after the PNTR takes effect.

[1] Normal Trade Relations is a U.S. term for Most Favored Nation.

However, it is possible that our results are likely to be driven by industry conditions that in turn increase firms' innovation. To mitigate this concern, we additionally control for industry characteristics such as: 1) industry skill intensity and capital intensity to account for the potential concern that the increase in innovation might be correlated with an increase in the competitiveness of U.S. technology-intensive industries not due to the change in trade policy; 2) contract intensity measured by the proportion of intermediate inputs that require relationship-specific investments to control for China's barriers to foreign investment; and 3) advanced technology products to control for the bursting of the U.S. tech "bubble" and the subsequent recovery. Furthermore, we explicitly control for industries' NTR rates. Our inferences are largely unchanged.

In further tests, we exploit the fact that Chinese goods arrive at the west coast of U.S. first, before they are shipped to other parts of the U.S. By comparing treated firms in west coast to their peers in the same industry but other parts of U.S., we can better identify how much of the observed innovation change is due to Chinese imports rather than other shocks to industry business conditions. When we difference away changes in industry business conditions by focusing on treated firms in the west coast and same-industry peers outside west coast, we continue to find a significant increase in firms' innovation after PNTR. These results suggest that the observed increase in innovation following PNTR is not driven by industry economic shocks.

To provide further evidence that the effects of PNTR on innovation are indeed tied to Chinese goods in the U.S. market, we apply a double difference-in-differences approach to examine heterogeneous treatment effects. We find that the treatment effects are stronger for industries that experience a greater increase in Chinese goods following PNTR. These cross-sectional variations in the treatment effects further increase our confidence that the impact of PNTR on innovation is indeed related to Chinese imports.

Finally, we implement placebo tests to investigate the possibility that our results are purely driven by chance. In particular, we randomly select a group of firms as pseudo treated firms and the rest of firms as pseudo control firms. We repeat this procedure for 5,000 times. The results indicate that the effects of PNTR on innovation documented in our main tests are unlikely to be spurious: the maximum coefficient in magnitude estimated in the placebo test is substantially smaller than the actual coefficient estimate from the main test.

This paper provides at least two major contributions to existing literature. First, our paper adds to the literature that examines the drivers of innovation. This strand of literature is important for the economy as innovation is widely believed to be crucial for sustainable growth and economic development (Solow (1957); Romer (1986)). Our paper suggests that reducing political uncertainty and better integrating US-China economy have a significant impact on corporate innovation for U.S. firms.

Second, our study sheds light on the real consequences of PNTR. As pointed out by Pierce and Schott (2016), PNTR has a significant effect on U.S. manufacturing firms, leading to a massive layoff of these firms. They find that the number of workers in U.S. manufacturing industry plunge 18 % from 2001 to 2007 and this decline in employment is attributed to PNTR. Complementing to their work, our paper provides evidence on the bright side of PNTR: it promotes innovation.

The remainder of the paper is organized as follows. Section 2 reviews the background on PNTR and Section 3 develops our hypothesis. Section 4 describes our sample and key variable construction. Section 5 presents the empirical results. We conclude in Section 6.

2. Background on PNTR

We use the passage of PNTR as a natural experiment to study the effect of Chinese imports on U.S. corporate innovations. Since the Smoot-Hawley Tariff Act of 1930, U.S. imports from non-market economics including China have been subject to high "non-NTR" tariff rates, which are significantly larger than "NTR" rates offered to WTO members. The U.S. Trade Act of 1974 gives the U.S. President power to grant NTR tariff rates to non-market countries, and U.S. started granting the low tariff rates to China annually in 1980. However, this granting is subject to annual approval by the U.S. Congress. This created uncertainty about whether the low tariff rates would be maintained in the future, and could be easily influenced by political contention. Indeed from 1990 to 2001, the U.S. House of Representatives voted on legislation to revoke China's temporary NTR status every year and the votes were successful in 1990, 1991 and 1992. According to Pierce and Schott (2016), the average House vote against annual NTR renewal was 38%. Even if the probability that U.S. withdraws NTR status from China may be small, the consequences would be catastrophic if it did occur for many U.S. companies since tariff rates could easily jump by 60 percentage point, such as toy industry.

There is a large body of literature on investment under uncertainty that highlights that uncertainty increases the value of waiting before undertaking sunk investments and firms are more likely to undertake irreversible investments as uncertainty decreases (e.g., McDonald and Siegel (1986); Pindyck (1993); Schwartz and Zozaya-Gorostiza (2003)). In particular, Schwarts and Zozaya-Gorostiza (2003) find that uncertainty lowers incentives to invest in new information technology.

Two decades later in October 2000, the U.S. Congress passed a bill granting PNTR status to China following the November 1999 agreement between U.S. and China in related to China's entry into WTO. PNTR became effective upon China's entry into WTO and was finally implemented on January 1, 2002. This effectively ended the uncertainty associated with annual renewals of NTR status to China.

Conferral of PNTR status to China had effects on U.S. corporate innovation through at least three ways. First, it led to a substantial reduction in expected U.S. import tariff rates on Chinese goods. Second, it invited directed foreign competition from Chinese producers. Third, it reduced the profitability of using low-skilled technology and boosted the attractiveness in high-skilled technology that is more consistent with U.S. comparative advantage. Therefore, we expect that U.S. firms that are affected by the passage PNTR to invest more in innovative technologies.

To quantify the effect of PNTR, we define the "NTR gap" as the difference between the non-NTR rates to which tariff rates would have jumped if annual renewal had failed and the NTR rates locked in by PNTR. On average, the non-NTR rate is 37% and NTR rate is 4% in 1999. Therefore, the NTR gap averages 34%. More importantly perhaps, it has a large cross-sectional variation across different industries, as indicated by a standard deviation of 14%. The impact of PNTR is larger in industries with higher NTR gaps, and we expect the responses from firms would be larger as well.

One paramount advantage of this natural experiment is its exogeneity to corporate innovation activities after PNTR. Firstly, the conferral of PNTR status was unique in that it did not change the import tariff rates that were actually applied to Chinese imports over this period, which effectively rules out the concern that tariff rate changes might be influenced by policy considerations and corporate lobbying activities, pertinent in studies that use import tariff rate reductions as shocks to look at outcomes in real economy and changes in corporate polices. Secondly, according to Pierce and Schott (2016), over 79% of the variation in the NTR gap comes from variation in non-NTR rates, which were set under Smoot-Hawley Tariff Act of 1930. This makes it highly unlikely that corporate innovation could influence the setting of non-NTR rates seven decades ago. Thirdly, tariff rates are normally set higher to protect domestic industries. Following this logic, if higher NTR tariff rates were set to protect domestic production, it would result in lower NTR gaps, which would bias against us to find an effect of PNTR.

3. Hypothesis Development

Suppose that a U.S. firm can use two types of technology to produce: a low-skill technology to produce a conventional product or a high-skill technology to produce an innovating product. The profitability of these two technologies is P_L and P_H. The firm will choose to innovate if P_H is greater than P_L, and produce conventional product otherwise. We expect the PNTR to foster U.S. firms to innovate for the following two reasons.

First, compared to U.S., Chinese manufacturing firms have significant wage advantages for low-skilled workers. According to Amiti and Freund (2010), despite a dramatic shift in its export composition over the last two decades, China continues to specialize in low-wage, labor-intensive goods once we account for processing trade, i.e. the activity of assembling intermediate inputs and re-exporting the finished products after processing. The comparative advantage of U.S. lies in industries involving a high percentage of high-skilled labor and a low percentage of low-skilled labor (Keesing (1966)). It therefore follows from the prediction of the Heckscher–Ohlin comparative advantage model that the capital-abundant country (U.S.) will import labor-intensive good from the labor-abundant country (China).

After the PNTR eliminates the tariff uncertainty faced by Chinese manufacturing firms, a U.S. firm faces greater competitions for conventional products in the U.S. domestic market, leading to a significant decrease in P_L.With the U.S. granting of PNTR to China and the ensuing elimination of trade policy uncertainty, Chinese export has boomed significantly (Berger and Martin (2011); Handley and Limão (2013)). Import competition from low-wage countries like China exerts downward pressure on the price and therefore, the profitability of conventional products, $P_{L,}$ in the U.S. (Krugman (1979); Dollar (1986); Auer and Fischer (2010)). Given the high relative wages, it is unlikely that U.S. firms continue to earn profits from the labor-intensive low-skill-content products. As a consequence, they respond to the pressure from import competition by altering their product mix (Bernard, Jensen and Schott (2006)).

Second, uncertainty increases the value of waiting before undertaking sunk investments and firms are more likely to undertake irreversible investments after ambiguity decreases (e.g., McDonald and Siegel (1986); Pindyck (1993); Dixit and Pindyck (1994); Schwartz and Zozaya-Gorostiza (2003)). The conferral of PNTR eliminates the tariff uncertainty for U.S. manufacturing firms, which boosted the attractiveness of investment in capital- or skill-intensive production innovations

Based on the discussion above, we expect a positive effect of PNTR for innovation in U.S. manufacturing firms, because PNTR is likely to decrease the profitability of using low-skilled technology to produce conventional product but increase the profitability of producing high-skilled innovative products.

4. Sample Formation and Variable Construction

We start with all U.S. public firms in Compustat during the 1995-1998 and 2002-2005 periods. Following Pierce and Schott (2016), we then construct our sample of manufacturing firms that have SIC codes between 2000 and 3999. Our final sample consists of 6,209 firm-year observations.

We define a firm as in the treated group if the firm belongs to the industries that are in the top tercile of NTR Gap values, and in the control group if the firm is in the industries that are in the bottom tercile of NTR Gap values. We calculate NTR gaps as the difference of *ad valorem* equivalent tariff rates between Normal Trade Relation (NTR) country and non-NTR country, obtained from Feenstra, Romalis and Schott (2002). We further define an indicator variable *Post*, which takes the value of one for the 2002-2005 period (i.e. post-PNTR period), and zero for the 1995-1999 period (i.e., pre-PNTR period). The U.S. Congress passed the bill granting PNTR status to China in October 2000 after the November 1999 agreement governing China's eventual entry into WTO PNTR became effective in December 2001 and was implemented on January 1, 2002. To alleviate any confounding effects, we drop the years 1999, 2000 and 2001, as PNTR was foreseeable in 1999 and was eventually implemented in 2002.

We collect patent information from the National Bureau of Economic Research (NBER) Patent Citations Date File (Hall, Jaffe and Trajtenberg (2005)). This database provides detailed information on more than three million patents granted by the United States and Trademark Office from 1976 to 2006. For each patent, this patent database also provides information regarding the number of citations received by the patent. However, considering the average of a two-year lag between patent application and patent grant, and that the latest year in the NBER patent database is 2006, patents applied for from 2005 to 2006 may not appear in the database. To address this concern, we supplement the information for patents grated over the period of 2007-2010 from the Harvard Business School (HBS) U.S. Patent Inventor Database (Li, Lai, D'Amour, Doolin, Sun, Torvik, Amy and Fleming (2014)).[2]

We mainly use two measures for innovation output. The first measure is the number of patent applications filed in a year that are eventually granted. This measure captures the quantity of innovation output. Our second measure of innovation is the sum of citation counts across all patents filed by the firm in a given year, which captures the significance of the patent outputs. Because citations are received for many years after a patent is created, patents created near the end of the sample period have less time to accumulate citations. To address

[2] The HBS patent database is constructed in a similar manner as the NBER patent database, and has more recent patent data and more details about patent inventors.

this truncation bias, we follow the recommendations of Hall Jaffe and Trajtenberg (2001, 2005) and scale the citation count of each patent by the average citation count of all firms' patents that are filed in the same year. The use of patenting to measure a firm's innovativeness has been widely used in the literature since Scherer (1965) and Griliches (1981).

We control for a vector of firm and industry characteristics that may affect a firm's innovation productivity, and these controls are motivated by prior literature (e.g., Aghion, Bloom, Blundell, Griffith and Howitt (2005)). These variables include firm size, firm age, asset tangibility, leverage, cash holding, R&D expenditures, capital expenditures, ROA, Tobin's *Q*, and industry concentration (the Herfindahl index based on sales) and the squared Herfindahl index (which controls for non-linear effects of product market competition on innovation outputs). All these control variables are lagged by one year. To minimize the effect of outliers, we winsorize all variables at the 0.5^{th} and 99.5^{th} percentiles. Detailed variable definitions are provided in the Appendix.

Table 1 Panel A provides summary statistics. On average, firms in our sample have 8 patents filed (and subsequently granted) per year and receive 33 total citations. Our average sample firms have a book value of total assets of $2.11 billion, and are 17 years old. The average R&D and capital expenditure account for 5.4% and 5.1% of total assets, respectively. The average firms are moderately levered with a book leverage ratio of 18.9%, and tangible assets account for 26% of total assets in the average firms. In terms of performance, sample firms perform well with an average ROA of 6.2% and Tobin's Q of 2.15.

5. Empirical Results

5.1 Univariate Tests

We examine the before-after effect of the change in innovation in firms that are affected by PNTR (the treatment group) compared to the before-after effect in firms that are unaffected from such a policy (the control group). Table 2 reports the univariate test. For each firm, we compute change in the number of patents as:

$$\sum\nolimits_{2002}^{2005} LnPat - \sum\nolimits_{1995}^{1998} LnPat.$$

As shown in column (1), change in the number of patents is 0.408 for treated firms, which is almost six times that of control firms (0.073). This difference is significant at the 5% level.

In column (2), we define change in the number of patent citations as:

$$\sum\nolimits_{2002}^{2006} LnCit - \sum\nolimits_{1995}^{1998} LnCit.$$

We find that change in the number of patent citations is 0.494 for treated firms and is -0.037 for control firms. The difference is also significant at the 1% level.

Overall, the univariate test shows that treated firms become more innovative after PNTR, compared to the control firms. This result indicates that PNTR has a significantly positive effect on corporate innovation.

5.2 Baseline Regression

We implement a standard difference-in-differences test through the following regression:

$$Innovation = \alpha + \beta_1 Treat \times Post + Firm\ Characteristics + Industry\ FE + Year\ FE + \varepsilon. \qquad (1)$$

The dependent variable is a proxy for innovation performance. The indicator variable *Treat* takes the value of one for the treated firms, and zero for control firms. The indicator variable *Post* takes the value of one for the 2002-2005 period (i.e. post-PNTR period), and zero for the 1995-1999 period (i.e., pre-PNTR period). We include industry and year fixed effects, as well as a set of firm-level control variables that could affect firms' innovation output, as discussed in Section 3. Because we control industry fixed effects and year fixed effect in the regression, we do not include *Treat* and *Post* in the regression due to collinearity problem. Given that our treatment is defined at the industry level, we cluster standard errors by industry.

The coefficient of interest in this model is the β_1 coefficient, which captures the innovation differences in treated firms before and after PNTR as opposed to similar before-after differences in control firms.

It is helpful to consider an example. Suppose we want to estimate the effect of the PNTR on innovation. We can subtract the number of innovations in the pre-PNTR period from the number of innovations in the post-PNTR period for firms affected by PNTR. However, economy-wide shocks may occur at the same time and affect corporate innovations. To difference away such factors, we calculate the same difference in innovations in firms that are unaffected by PNTR. Finally, we calculate the difference between these two differences, which represents the incremental effect of PNTR on treated firms compared to control firms.

Table 3 presents the regression results. The coefficient estimates on the *PNTR* are positive and statistically significant in all columns. The dependent variable in column (1) is Ln(1+patents) and we include *Treat*×*Post*, industry fixed effects and year fixed effects in the regression. We find that the coefficient estimate on *Treat*×*Post* is positive and significant at the 1% level, suggesting a positive effect of PNTR on corporate innovations.

Examining Ln(1+citations) as the dependent variable in column (2), we find that the coefficient on the *Treat*×*Post* indicator is also positive and is significant at the 1% level, which implies that PNTR leads to an decrease in the quality of patents.

In columns (3) and (4), we additionally control for a long list of firm characteristics, and we continue to find a positive effect of PNTR on innovation. The economic magnitude is also sizeable. For example, the coefficient on *Treat*×*Post* is 0.32 in column (3) and is significant at the 1% level, indicating that PNTR leads to an increase in the number of patents by approximately 38% $(= \mathrm{e}^{0.32} - 1)$. When examining patent citation in column (4), the coefficient on *Treat*×*Post* is a significant 0.403, indicating that the number of patent citations increases by 49% $(= \mathrm{e}^{0.403} - 1)$ following PNTR.

With regards to control variables, larger firms, older firms, cash-rich firms, firms with higher R&D and capital expenditures, firms with more intangible assets, firms with low leverage, and firms with higher growth potential are more innovative. These results are broadly consistent with prior literature (e.g., Aghion, Bloom, Blundell, Griffith and Howitt (2005)).

Taken together, these results indicate a positive effect of PNTR on innovation outputs in terms of both quantity and quality.

5.3 The Pre-treatment Trends

The validity of difference-in-differences estimation depends on the parallel trends assumption: absent PNTR, treated firms' innovation would have evolved in the same way as that of control firms. We present the results that investigate the pre-trend between the treated group and control group in Table 4. In particular, we estimate the following regression:

$$Innovation = \alpha + \beta_1 Treat \times Year1996 + \beta_2 Treat \times Year1997 + \beta_3 Treat \times Year1998 + \beta_4 Treat \times Year2002 + \beta_5 Treat \times Year2003 + \beta_6 Treat \times Year2004 + \beta_7 Treat \times Year2005 + Firm\ Characteristics + Industry\ FE + Year\ FE + \varepsilon.$$

(2)

We define seven dummies, *Year1996*, *Year1997*, *Year1998*, *Year2002*, *Year2003*, *Year2004*, and *Year2005*, to indicate the corresponding years, respectively. Year 1995 is the baseline year.

The coefficients on $Treat \times Year1996$, $Treat \times Year1997$, and $Treat \times Year1998$ indicators are especially important because their significance and magnitude indicate whether there is any difference in innovation trend between the treatment group and the control group prior to PNTR. The coefficients on both variables are small in magnitude and not statistically significant in both columns. These results suggest that the parallel trend assumption of the difference-in-differences approach is not violated.

Overall, Table 4 shows that the treated group and the control group share a similar trend in innovation prior to PNTR, thus supporting the parallel trends assumption associated with the difference-in-differences estimation. Moreover, Table 4 also indicates that most of the impact of PNTR on innovation occurs *after* it is implemented, which suggests a causal effect.

5.4 Confounding Industry Conditions

It is possible that some omitted industry characteristics that are associated with both tariff rate and innovation are driving our results. In this section, we implement two tests to address this issue. In our first test, we additionally control for a set of observable industry characteristics in the regression. In our second test, we difference away unobservable industry characteristics by focusing on treatment firms that are in the west cost of U.S. and firms in the same industry but in other parts of U.S. In both tests, we continue to find a significant increase in innovation after PNTR.

Table 5 presents our first test. In addition to our usual set of explanatory variables used in Table 3, we also account for various time-varying, industry-level variables in our regressions. Specifically, we control for measures of industry capital and skill intensity, contract intensity, advanced technology products, and industries' NTR rates. There is a potential concern that the increase in innovation might be correlated with an increase in the competitiveness of U.S. technology-intensive industries not due to the change in trade policy. To address this issue, we control for industry skill intensity and capital intensity. Skill intensity is measured by the ratio of non-production workers to total employment in one industry, while capital intensity is calculated as the ratio of capital to total employment in one industry. The data come from Bureau of Economic Analysis. An alternative strategy in response to PNTR is to shift operations to China. We control this possibility by including a measure of China's barriers to foreign investment: contract intensity, which is measured by the proportion of intermediate inputs that require relationship-specific investments to capture the nature of contracting in the industry, as China's reduction of barriers to foreign investment may have affected industries differently. The data is obtained from Nunn (2007). To control for the bursting of the U.S. tech "bubble" and the subsequent recovery in our study period, we further control for advanced technology products (ADT), a dummy variable that equals 1 if the industry produces advanced technology products, which is obtained from U.S. Census Bureau. Furthermore, we also include industries' NTR rates.

We find that the PNTR continues to have a positive and (statistically and economically) significant impact on corporate innovation. Compared to Table 3, the coefficient on the *Treat*×*Post* variable is largely unchanged. Also, we find that industry skill intensity and ADT have a positive effect on innovation.

Although the above test accounts for observable industry characteristics, some unobservable industry shocks may be associated with both tariff rate and corporate innovation. In our second test, we examine the change in innovation in the treatment firms in U.S. west coast and firms in the same industry but other part of the U.S. The logic is as follows. Suppose that the effect of PNTR on a given industry is driven by unobserved changes in industry-level business conditions, and that it is these changes, not the PNTR, that spur corporate innovation. Then both firms in the U.S. west coast and other part (but in the same industry) would spuriously appear to react to PNTR. In this case, the change in innovation in treated firms in west coast should be no different from that in the same-industry firms that are located in other parts of U.S. However, if our documented effect is truly due to Chinese import associated with PNTR, the firms in the west coasts should be more affected relative to the firms in the same industry but in different part of the U.S. This is because the majority of Chinese imports need to arrive at U.S. west coast first and then move to other parts of the U.S. Thus, firms in the U.S. west coast face greater pressure from Chinese import. Since we are comparing a firm in treated industry in west coast to a firm in the same industry but different part of the U.S., we thus can difference away any unobservable industry characteristics.

Table 6 presents the results. In columns (1) and (2), we first select the treated firms in the west coast (i.e., the firms headquartered in California, Oregon, and Washington). Then, for each of these firms, we match it to a non-west coast firm that is in the same industry, and with the closest total asset value. The *WestCoast* indicator variable takes the value of one for each treated firm in the west coast, and zero for their matched firms. Thus, we are comparing a firm in treated industry (but close to China) with another firm in the same industry (but further away from China). The coefficient on WestCoast×Post is 0.44 (significant at the 1% level) in column (1) when the dependent variable is LnPat, and is 0.685 (significant at the 1% level) in column (2) when the dependent variable is LnCit. This result indicates that, within the treated industries, firms that are closer to Chinese imports experience greater increase in innovation than the same-industry matched firms that are further away from China. As a placebo test, we repeat the same analysis based on untreated industries in columns (3) and (4), and we find no significant difference in innovation between west coast and other parts of U.S. in untreated industries. Overall, these results suggest that unobserved industry confounds seem unlikely to drive our results.

5.5 Double Difference-in-differences Tests

To provide further evidence that the effects of PNTR on innovation are indeed tied to Chinese import into U.S. market, in this subsection we implement double difference-in-differences tests to examine the heterogeneous treatment effects. Examining heterogeneous treatment effects can further help to alleviate the concern that some omitted variables are driving our results, because such variables would have to be uncorrelated with all the control variables we include in the regression model and they would also have to explain the cross-sectional variation of the treatment effects, which is less likely (Claessens and Laeven (2003); Raddatz (2006)).

If the enhanced innovation after PNTR is truly due to Chinese imports that push U.S. firms to innovate, we expect this treatment effect to be stronger in industries that experience greater increase of Chinese imports. We define the indicator variable *HighPctImportChg*, which takes the value of one if the percentage increase in Chinese import over the 1995-2005 period in a given industry is above the sample median, and zero otherwise. We then re-estimate Equation (1) by adding the interaction *Treat* × *Post* × *HighPctImportChg*. Table 7 presents the results. In column (1), where the dependent variable is *LnPat*, the coefficient on *Treat* × *Post* is 0.265 (significant at the 5% level) and the coefficient on *Treat* × *Post* × *HighPctImportChg* is 0.177 (significant at the 5% level). For firms in industries with a greater increase in Chinese imports, their number of patents increase by 55% ($= e^{(0.265+0.177)} - 1$), while the number of patents increase by 30% ($= e^{0.265} - 1$) for firms in industries with a less increase in Chinese imports.

These results suggest that the impact of PNTR on corporate innovation is indeed tied to Chinese imports and seems not to be spuriously driven by unobserved heterogeneity.

5.6 Placebo Tests

In this section, we implement placebo tests to investigate the possibility that our results are purely driven by chance. In particular, we draw a random sample of 929 firms (the same number of the treated firms) as the treated firms during the sample period and then treat the rest of the pool as "non-treated firms." Consistent with our baseline regression, the dummy variable *Post* assumes the value of one for the 2002-2005 period (i.e. post-PNTR period), and zero for the 1995-1999 period (i.e., pre-PNTR period).Based on these "pseudo" treated and control groups, we re-estimate columns (3) and (4) of Table 3 and save the coefficients on *Treat*×*Post*. We repeat this procedure for 5,000 times.

Panel A of Figure 1 plots the distribution of the coefficients on *Treat*×*Post* when the dependent variable is LnPat. The actual coefficient on *Treat*×*Post* of 0.320 (see column (3) of Table 3) is more than seven times standard deviations (0.043) above the mean (0.004) of the distribution and is even larger than the maximum coefficient estimate (0.141). Panel B plots the distribution of the coefficients on *Treat*×*Post* when the dependent variable is LnCit. The actual coefficient on *Treat*×*Post* of 0.403 (see column (4) of Table 3) is more than six times standard deviations (0.060) below the mean (0.009) of the distribution and is much larger than the maximum coefficient estimate (0.201). These results indicate that our results are unlikely to be driven by chance.

5.7 Alternative Measures of Innovation

As a robustness check, we employ various alternative measures to examine the effect of PNTR on corporate innovation. Table 8 presents the results. In columns (1) and (2), we normalize the number of patent and citation by the number of employees. In columns (3) and (4), we normalize the number of patent and citation by R&D expenditure. In column (5), we use citation per patent to measure patent quality. We find that the coefficients on *Treat*×*Post* are positive and significant at or below the 5% level across all the five columns.

Overall, Table 8 shows that the positive effect of PNTR on innovation is robust to various alternative innovation measures.

6. Conclusions

In this paper, we examine that United States' conferral of Permanent Normal Trade Relations (PNTR) on China— a policy eliminating the uncertainty of future tariff increase associated with Chinese goods—on U.S. business activities from the perspective of innovation. Using a difference-in-differences approach, we find a significant increase in firms' patents and patent citations for firms affected by PNTR, relative to firms that are unaffected by this policy. In support of a causal interpretation of our findings, our timing tests indicate that there is no difference in pre-treatment trend in innovation between the two groups of the firms, and that the reduction in innovation occurs after the PNTR. Finally, the cross-sectional variation of the treatment effects indicates that the treatment effect is larger for industries with greater increase in Chinese imports. Overall, our findings are consistent with the view that eliminating the possibility of sudden tariff spikes on Chinese imports boosts the attractiveness of technology innovation that is more consistent with U.S. comparative advantage relative to China.

Our paper provides important implications for public policies aimed at facilitating global trading. Our results suggest that such policies can promote corporate innovation for the countries which have comparative advantages at technological innovation rather than cheap labor costs. This effect is nontrivial considering that technological innovation has long been recognized a key factor in economic growth, productivity increase, and competitive advantage of nations and that the U.S. economy is increasingly reliant on innovation.

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Appendix: Variable Definitions

Variable	Definition
Measures of Innovation Output	
Patent	Number of patents that are applied for (and subsequently granted) by a firm in a given year.
LnPat	Natural logarithm of one plus firm's total number of patents filed (and subsequently granted).
Citation	Total number of citations received on the firm's patents filed. To adjust the citation count, each patent's number of citations is divided by the average citation count of all patents applied in the same year.
LnCit	Natural logarithm of one plus firm's total number of citations received on the firm's patents filed.
LnPat/Emp	Natural logarithm of one plus firm's total number of patents filed (and subsequently granted), scaled by the number of the firm's employees.
LnPat/R&D	Natural logarithm of one plus firm's total number of patents filed (and subsequently granted), scaled by its R&D expenditure.
LnCit/Pat	Natural logarithm of one plus firm's average number of citations received on the firm's patents filed. If the firm filed no patents in that year, the missing value of average citation counts is set to zero.
LnCit/Emp	Natural logarithm of one plus firm's total number of citations received on the firm's patents filed (and subsequently granted), scaled by the number of the firm's employees.
LnCit/R&D	Natural logarithm of one plus firm's total number of citations received on the firm's patents filed (and subsequently granted), scaled by its R&D expenditure.
Firm Characteristics	
Treat	A dummy variable that equals 1 if the firm is in the industry that is in the top tercile of NTR Gap and 0 if it is in the bottom tercile.
Post	A dummy variable that equals 1 for the 2002-2005 period, and 0 for the 1995-1998 period.
Total Asset	Book value of total assets.
Firm Size	Number of employees in thousands
Ln(Firm Size)	Natural logarithm of firm size.
Firm Age	Number of years since a firm's first appearance in Compustat.
Ln(Firm Age)	Natural logarithm of firm age.
Cash	Cash and short-term investments normalized by total assets.
R&D	R&D intensity, measured as R&D expenditures normalized by total assets. If R&D expenditures variable is missing, we set the missing value to zero.
ROA	Return on assets, measured as EBITDA (earnings before interest, tax,

	depreciation and amortization) normalized by total assets.
PPE	Property, plant & equipment normalized by total assets.
Leverage	Long-term debt normalized by total assets.
Capex	Capital expenditures normalized by total assets. If capital expenditures variable is missing, we set the missing value to zero.
Tobin's Q	Market value of equity plus book value of total assets minus book value of equity minus balance sheet deferred taxes, normalize by total assets.
WestCoast	A binary indicator variable that equals 1 if the firm is historically headquartered in one of the west coast states (i.e. Washington, Oregon and California). The historical headquarter location is obtained from Compact Disclosure.
HighPctImportChg	A dummy variable that equals 1 if the firm belongs to the high-percentage-change-in-Chinese-import industry, where the percentage Chinese import change is computed as the percentage change in import from China from the level in 1995 level to that in 2005 and classified as high-percentage-change-in-Chinese-import industry if the percentage change is greater than or equals to the sample median. The Chinese import data is obtained from the U.S. import and export data assembled by Robert Feenstra.
Industry Characteristics	
Herfindahl index	Sum of squared sales-based market shares of all firms in a two-digit SIC industry.
Skill Intensity	The ratio of non-production workers to total employment in one industry, which is obtained from Bureau of Economic Analysis.
Capital Intensity	The ratio of capital to total employment in one industry, which is obtained from Bureau of Economic Analysis.
ADT	A dummy variable that equals 1 if the industry produces advanced technology products, which is obtained from U.S. Census Bureau's website.
Contract Intensity	The proportion of intermediate inputs that require relationship-specific investments to capture the nature of contracting in the industry, as China's reduction of barriers to foreign investment may have affected industries differently. The data is obtained from Nunn (2007).
NTR Gap	NTR Gap measures the intensity of industry-level PNTR shock, which is the difference of *ad valorem* equivalent tariff rates between Normal Trade Relation (NTR) country and non-NTR country, obtained from Feenstra, Romalis and Schott (2002).

Table 1: Summary Statistics

The sample consists of 6,209 firm-year observations from 1995-2005, excluding 1999-2001. We obtain patent information from NBER patent database and HBS patent database, and financial information from Compustat. Definitions of all variables are detailed in the Appendix. All continuous variables are winsorized at the 0.5^{th} and 99.5^{th} percentiles. Panel A reports summary statistics and Panel B reports the distribution of NTRGAP value across each industry.

Panel A

	Mean	SD	P25	Median	P75
Patent	8.070	44.882	0.000	0.000	2.000
Citation	33.493	211.404	0.000	0.000	3.200
Total Asset (in billion $)	2.114	7.341	0.035	0.154	0.864
Firm Size (in 1000s)	6.193	15.809	0.185	0.991	4.400
Firm Age (in years)	17.516	14.282	7.000	12.000	26.000
Cash	0.177	0.213	0.022	0.088	0.255
R&D	0.054	0.095	0.000	0.016	0.067
ROA	0.062	0.232	0.048	0.119	0.175
PPE	0.260	0.187	0.116	0.215	0.362
Leverage	0.189	0.172	0.024	0.164	0.308
Capex	0.051	0.048	0.021	0.038	0.066
Tobin's Q	2.153	1.882	1.152	1.558	2.371
H-index	0.054	0.038	0.040	0.044	0.049
H-index^2	0.004	0.010	0.002	0.002	0.002

Panel B

Industry	SIC	NTRGAP
Rubber And Miscellaneous Plastics Products	30	0.581
Apparel And Other Finished Products Made From Fabrics And Similar Materials	23	0.578
Miscellaneous Manufacturing Industries	39	0.507
Leather And Leather Products	31	0.490
Textile Mill Products	22	0.462
Electronic And Other Electrical Equipment And Components, Except Computer Equipment	36	0.455
Measuring, Analyzing, And Controlling Instruments; Photographic, Medical And Optical Goods; Watches And Clocks	38	0.414
Furniture And Fixtures	25	0.411
Fabricated Metal Products, Except Machinery And Transportation Equipment	34	0.405
Chemicals And Allied Products	28	0.381
Lumber And Wood Products, Except Furniture	24	0.349
Industrial And Commercial Machinery And Computer Equipment	35	0.319
Tobacco Products	21	0.232
Stone, Clay, Glass, And Concrete Products	32	0.209
Primary Metal Industries	33	0.209
Transportation Equipment	37	0.185
Food And Kindred Products	20	0.160
Paper And Allied Products	26	0.130
Printing, Publishing, And Allied Industries	27	0.055
Petroleum Refining And Related Industries	29	0.052

Table 2: Univariate Tests

This table reports the univariate tests that examine the impacts of the passage of a U.S. trade policy that grants Permanent Normal Trade Relations (PNTR) to China on corporate innovation. Treat firms are firms that belong to the industries that are in the top tercile of NTR Gap values, and controls firms are those that are in the bottom tercile of NTR Gap. Variable definitions are provided in Appendix. All continuous variables are winsorized at the 0.5th and 99.5th percentiles. The superscript ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	$\sum_{2002}^{2005} LnPat - \sum_{1995}^{1998} LnPat$	$\sum_{2002}^{2005} LnCit - \sum_{1995}^{1998} LnCit$
Treat firms (1)	0.408	0.494
Control firms (2)	0.073	-0.037
Difference-in-differences test (*p*-value of t-test: (1)=(2))	0.020**	0.004***

Table 3: Baseline Regression

This table reports the difference-in-differences tests that examine the impacts of the passage of a U.S. trade policy that grants PNTR to China on corporate innovation. The dependent variable in columns (1) and (3) is LnPat, defined as the natural logarithm of one plus the number of patents. The dependent variable in columns (2) and (4) is LnCit, defined as the natural logarithm of one plus number of citations. The indicator variable *Treat* takes the value of one if the firm belongs to the industry that is in the top tercile of NTR Gap values and zero if it belongs to the industry that is in the bottom tercile of NTR Gap. The indicator variable *Post* takes the value of one for the 2002-2005 period, and zero for the 1995-1998 period. Variable definitions are provided in Appendix 1. All continuous variables are winsorized at the 0.5^{th} and 99.5^{th} percentiles. T-statistics based on robust standard errors clustered by SIC 2-digit industries are in parentheses. The superscript ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) LnPat	(2) LnCit	(3) LnPat	(4) LnCit
Treat × Post	0.230***	0.284***	0.320***	0.403***
	(2.897)	(3.516)	(3.740)	(4.650)
Ln(Firm Size)			0.309***	0.403***
			(6.560)	(5.886)
Ln(Firm Age)			0.189***	0.201**
			(3.640)	(2.572)
Cash			0.515***	0.951***
			(2.893)	(3.369)
R&D			0.941***	1.580***
			(3.213)	(4.198)
ROA			0.076	0.214*
			(0.815)	(1.706)
PPE			-0.401*	-0.547*
			(-1.855)	(-1.847)
Leverage			-0.348***	-0.376**
			(-3.130)	(-2.430)
Capex			1.441***	2.170***
			(3.827)	(3.222)
Tobin's Q			0.057***	0.075***
			(5.087)	(6.070)
H-index			-2.214	-0.807
			(-1.222)	(-0.271)
$H\text{-index}^2$			5.709	5.108
			(1.069)	(0.600)
Constant	0.625***	0.898***	0.161	0.201
	(28.683)	(30.740)	(1.009)	(0.922)
Observations	6,209	6,209	6,209	6,209
R-squared	0.060	0.067	0.306	0.273
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Table 4: Pre-treatment Trend

This table investigates the pre-treatment trends between the treated group and control group. The dependent variable in column (1) is LnPat, defined as the natural logarithm of one plus the number of patents. The dependent variable in column (2) is LnCit, defined as the natural logarithm of one plus number of citations. The indicator variable *Treat* takes the value of one if the firm belongs to the industry that is in the top tercile of NTR Gap values and zero if it belongs to the industry that is in the bottom tercile of NTR Gap. The indicator variables, Year1996-Year2005, flag year 1996-2005, respectively. Year 1995 is the baseline year. Variable definitions are elaborated in the Appendix. All continuous variables are winsorized at the 0.5^{th} ^{and} 99.5^{th} percentiles. T-statistics based on robust standard errors clustered by SIC 2-digit industry are in parentheses. The superscript ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) LnPat	(2) LnCit
Treat ×Year1996	0.054	0.107
	(0.481)	(0.704)
Treat ×Year1997	0.069	0.180
	(0.531)	(0.987)
Treat ×Year1998	0.061	0.117
	(0.519)	(0.710)
Treat ×Year2002	0.316**	0.413***
	(2.640)	(2.870)
Treat ×Year2003	0.351**	0.485***
	(2.579)	(2.873)
Treat ×Year2004	0.357**	0.434***
	(2.555)	(2.938)
Treat ×Year2005	0.353**	0.494***
	(2.604)	(3.818)
Ln(Firm Size)	0.309***	0.403***
	(6.542)	(5.871)
Ln(Firm Age)	0.190***	0.203**
	(3.682)	(2.618)
Cash	0.515***	0.950***
	(2.899)	(3.361)
R&D	0.938***	1.571***
	(3.156)	(4.113)
ROA	0.074	0.211*
	(0.792)	(1.685)
PPE	-0.393*	-0.531*
	(-1.836)	(-1.822)
Leverage	-0.351***	-0.382**
	(-3.201)	(-2.499)
Capex	1.435***	2.156***
	(3.867)	(3.256)
Tobin's Q	0.057***	0.075***
	(5.050)	(6.052)
H-index	-2.314	-1.018
	(-1.289)	(-0.343)
H-index^2	6.057	5.902
	(1.156)	(0.699)
Constant	0.162	0.200
	(0.995)	(0.902)
Observations	6,209	6,209
R-squared	0.306	0.273
Industry FE	Yes	Yes
Year FE	Yes	Yes

Table 5: Controlling for Observable Industry Characteristics

This table reports the difference-in-differences tests that examine the impacts of the US granting PNTR status to China on corporate innovation with additional controls for observable industry characteristics. The dependent variable in column (1) is LnPat, defined as the natural logarithm of one plus the number of patents. The dependent variable in column (2) is LnCit, defined as the natural logarithm of one plus number of citations. The indicator variable *Treat* takes the value of one if the firm belongs to the industry that is in the top tercile of NTR Gap values and zero if it belongs to the industry that is in the bottom tercile of NTR Gap. The indicator variable *Post* takes the value of one for the 2002-2005 period, and zero for the 1995-1998 period.Variable definitions are provided in Appendix. All continuous variables are winsorized at the 0.5^{th} and 99.5^{th} percentiles. T-statistics based on robust standard errors clustered by SIC 2-digit industries are in parentheses. The superscript ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) LnPat	(2) LnCit
Treat × Post	0.328***	0.410***
	(3.367)	(4.043)
Skill Intensity	0.979**	1.142*
	(2.118)	(1.811)
Capital Intensity	-0.001	-0.001
	(-1.096)	(-1.251)
ADT	0.409***	0.522***
	(3.865)	(3.463)
Contract Intensity	-0.259	-0.218
	(-0.856)	(-0.640)
NTR	0.096	-0.248
	(0.106)	(-0.186)
Ln(Firm Size)	0.329***	0.430***
	(6.511)	(5.985)
Ln(Firm Age)	0.172***	0.179**
	(3.018)	(2.050)
Cash	0.535***	0.989***
	(3.112)	(3.588)
R&D	0.537***	1.094***
	(3.536)	(6.137)
ROA	0.015	0.141
	(0.152)	(1.084)
PPE	-0.047	-0.121
	(-0.217)	(-0.393)
Leverage	-0.206**	-0.190
	(-2.062)	(-1.286)
Capex	1.268***	1.990**
	(3.121)	(2.660)
Tobin's Q	0.059***	0.078***
	(4.770)	(5.489)
H-index	-2.762	-1.380
	(-1.089)	(-0.367)
H-index^2	9.175	8.697
	(1.179)	(0.753)
Constant	-0.161	-0.231
	(-0.502)	(-0.493)
Observations	5,542	5,542
R-squared	0.319	0.280
Industry FE	Yes	Yes
Year FE	Yes	Yes

Table 6: Controlling for Unobservable Industry Shocks

This table addresses the concern of unobservable industry characteristics. The dependent variable in columns (1) and (3) are LnPat, defined as the natural logarithm of one plus the number of patents. The dependent variable in columns (2) and (4) are LnCit, defined as the natural logarithm of one plus number of citations. The indicator variable *WestCoast* takes the value of one if the firm is historically headquartered in one of the west coast states (Washington, Oregon and California) and zero otherwise. The indicator variable *Post* takes the value of one for the 2002-2005 period, and zero for the 1995-1998 period. In columns (1) and (2), treat firms are firms that belong to the industries that are in the top tercile of NTR Gap values, and in columns (3) and (4), controls firms are those that are in the bottom tercile of NTR Gap. Variable definitions are provided in Appendix. All continuous variables are winsorized at the 0.5$^{th\ and}$ 99.5th percentiles. T-statistics based on robust standard errors clustered by SIC 2-digit industries are in parentheses. The superscript ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) LnPat	(2) LnCit	(3) LnPat	(4) LnCit
	Treat Firm		*Control Firm*	
WestCoast × Post	0.440***	0.685***	0.123	0.182
	(3.211)	(4.753)	(1.296)	(1.522)
Ln(Firm Size)	0.527***	0.698***	0.185**	0.255*
	(26.313)	(30.010)	(2.251)	(2.129)
Ln(Firm Age)	-0.052	-0.202**	0.151*	0.165*
	(-0.888)	(-2.938)	(1.877)	(1.878)
Cash	0.932***	1.623***	-0.624**	-0.720**
	(8.282)	(7.389)	(-2.568)	(-2.398)
R&D	0.243	0.541	2.197	2.681
	(0.943)	(1.425)	(0.870)	(0.758)
ROA	-0.296***	-0.166	0.448	0.509
	(-3.861)	(-1.602)	(1.606)	(1.477)
PPE	-0.815***	-0.859**	0.130	0.266
	(-3.020)	(-2.651)	(0.463)	(0.646)
Leverage	-0.628***	-0.706**	-0.351	-0.431
	(-3.536)	(-2.849)	(-1.040)	(-0.991)
Capex	2.102***	3.468***	1.427	1.951
	(3.920)	(3.961)	(1.385)	(1.423)
Tobin's Q	0.021**	0.040***	0.110*	0.158*
	(2.345)	(3.223)	(2.045)	(1.958)
H-index	17.411	27.147*	107.835	129.168*
	(1.398)	(2.123)	(1.775)	(1.991)
H-index^2	-121.590	-189.588**	-1,066.525	-1,362.113*
	(-1.571)	(-2.386)	(-1.741)	(-2.144)
Constant	0.822	1.278**	-3.196**	-3.860**
	(1.544)	(2.472)	(-2.369)	(-2.373)
Observations	1,674	1,674	462	462
R-squared	0.379	0.314	0.492	0.507
Year FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes

Table 7: Heterogeneous Treatment Effects based on China's Influence

This table reports the double difference-in-differences tests to examine the relative impacts of the passage of PNTR on innovation in firms with high and low influence by Chinese imports. The dependent variable in column (1) is LnPat, defined as the natural logarithm of one plus the number of patents. The dependent variable in column (2) is LnCit, defined as the natural logarithm of one plus number of citations. The indicator variable *Treat* takes the value of one if the firm belongs to the industry that is in the top tercile of NTR Gap values and zero if it belongs to the industry that is in the bottom tercile of NTR Gap. The indicator variable *Post* takes the value of one for the 2002-2005 period, and zero for the 1995-1998 period. The indicator variable *HighPctImportChg* takes the value of one if the firm is a member of the industry that experiences high percentage in Chinese import over the 1995-2005 period, and zero otherwise. Variable definitions are elaborated in Appendix. All continuous variables are winsorized at the 0.5^{th} and 99.5^{th} percentiles. T-statistics based on robust standard errors clustered by SIC 2-digit industries are in parentheses. The superscript ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

	(1) LnPat	(2) LnCit
Treat × Post	0.265**	0.285**
	(2.269)	(2.261)
Treat × Post × HighPctImportChg	0.177**	0.384***
	(2.362)	(4.117)
Ln(Firm Size)	0.308***	0.402***
	(6.545)	(5.873)
Ln(Firm Age)	0.189***	0.201**
	(3.660)	(2.591)
Cash	0.508***	0.935***
	(2.782)	(3.228)
R&D	0.938***	1.574***
	(3.157)	(4.071)
ROA	0.077	0.218*
	(0.827)	(1.722)
PPE	-0.414*	-0.576*
	(-1.895)	(-1.914)
Leverage	-0.349***	-0.377**
	(-3.147)	(-2.445)
Capex	1.473***	2.239***
	(3.913)	(3.301)
Tobin's Q	0.057***	0.075***
	(5.142)	(6.117)
H-index	-2.974*	-2.455
	(-1.687)	(-0.870)
H-index^2	5.997	5.734
	(1.173)	(0.721)
Constant	0.207	0.301
	(1.285)	(1.325)
Observations	6,209	6,209
R-squared	0.307	0.275
Industry FE	Yes	Yes
Year FE	Yes	Yes

Table 8: Alternative Innovation Measures

This table examines the effects of the passage of PNTR on corporate innovation with alternative innovation measures. The regression specification is the same as that in Table 3. The dependent variables are natural logarithm of one plus the value of firm's number of patents and citations scaled by the number of the firm's employees, by its R&D expenditure, and the firm's number of citations scaled by its number of patens in columns (1)-(5), respectively. The indicator variable *Treat* takes the value of one if the firm belongs to the industry that is in the top tercile of NTR Gap values and zero if it belongs to the industry that is in the bottom tercile of NTR Gap. The indicator variable *Post* takes the value of one for the 2002-2005 period, and zero for the 1995-1998 period. All the control variables used in Table 3 are also included in this regression. Variable definitions are provided in the Appendix. All continuous variables are winsorized at the 0.5^{th} and 99.5^{th} percentiles. Robust standard errors clustered by SIC 2-digit industry are in parentheses. Superscripts ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

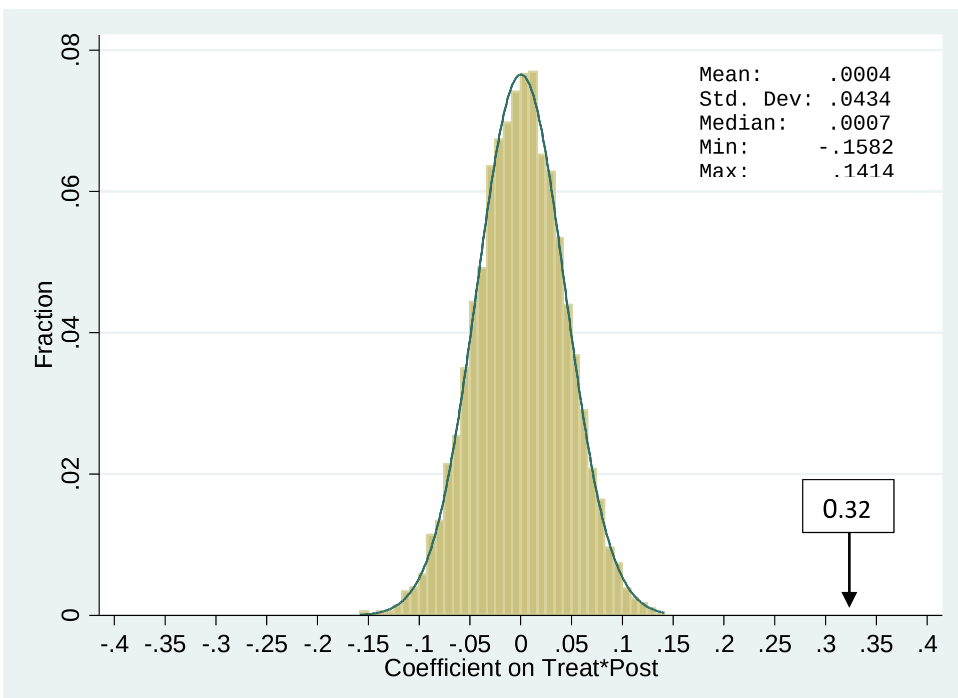
	(1) LnPat/Emp	(2) LnCit/Emp	(3) LnPat/R&D	(4) LnCit/R&D	5 LnCit/Pat
Treat × Post	0.148***	0.162***	0.061**	0.114**	0.111***
	(4.545)	(3.054)	(2.595)	(2.726)	(3.110)
Ln(Firm Size)	0.081***	0.167***	0.015***	0.073***	0.129***
	(4.235)	(3.769)	(5.249)	(10.412)	(6.465)
Ln(Firm Age)	-0.021	-0.036	0.009	-0.021	0.055
	(-0.726)	(-0.616)	(0.678)	(-0.544)	(1.552)
Cash	0.941***	1.393***	0.102***	0.446***	0.504***
	(3.207)	(3.499)	(3.050)	(5.553)	(3.641)
R&D	1.407***	2.108***	-0.575***	-0.543**	0.802***
	(4.545)	(5.246)	(-4.502)	(-2.346)	(6.077)
ROA	0.235***	0.406***	-0.084***	-0.035	0.183***
	(3.207)	(4.282)	(-2.983)	(-0.724)	(3.779)
PPE	-0.048	-0.163	0.004	-0.106	-0.224**
	(-0.396)	(-0.890)	(0.041)	(-1.188)	(-2.041)
Leverage	-0.234**	-0.258**	-0.209***	-0.354***	-0.104
	(-2.523)	(-2.067)	(-7.099)	(-5.295)	(-1.510)
Capex	0.934	1.721*	0.339*	1.070**	0.956**
	(1.552)	(1.780)	(1.804)	(2.109)	(2.395)
Tobin's Q	0.031***	0.049***	0.015***	0.031***	0.028***
	(4.088)	(5.395)	(7.122)	(10.796)	(7.068)
H-index	1.101	3.770	3.001	4.351	0.920
	(0.856)	(1.495)	(1.602)	(1.345)	(0.660)
H-index^2	-4.328	-8.022	-9.179	-6.941	-1.577
	(-1.151)	(-1.167)	(-1.495)	(-0.656)	(-0.382)
Constant	0.261**	0.264*	0.098	0.249	0.116
	(2.622)	(1.936)	(1.183)	(1.624)	(1.297)
Observations	6,209	6,209	4,109	4,109	6,209
R-squared	0.205	0.198	0.065	0.090	0.192
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Figure 1 Placebo Test

The figure reports the placebo tests to investigate the possibility that our results are purely driven by chance. In particular, we draw a random sample of 929 firms (the same number of the treated firms) as the treated firms during the sample period and then treat the rest of the pool as "non-treated firms." Consistent with our baseline regression, the dummy variable Post assumes the value of one for the 2002-2005 period (i.e. post-PNTR period), and zero for the 1995-1999 period (i.e., pre-PNTR period). Based on these "pseudo" treated and control groups, we re-estimate columns (3) and (4) of Table 3 and save the coefficients on Treat×Post. We repeat this procedure for 5,000 times.

Panel A of Figure 1 plots the distribution of the coefficients on Treat×Post when the dependent variable is LnPat, whilePanel B plots the distribution of the coefficients on Treat×Post when the dependent variable is LnCit.

Panel A. LnPat as dependent variable



Panel B. LnCit as dependent variable