Machines could not compete with Chinese labor: Evidence from U.S. firms' innovation

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Abstract

We study how an improvement in contracting institutions due to the 1999 U.S.-China bilateral agreement affects U.S. firms' innovation. We show that U.S. firms operating in China decrease their process innovations—innovations that improve firms' own production methods—following the agreement. We obtain the same result using the inter-temporal variation in ownership restrictions on foreign investment in China across industries. These findings suggest that a better ability to source labor cheaply across borders affects the types of technologies that are being developed—less process innovation aimed at reducing production cost. More broadly, a decrease in the effective price of labor due to the removal of frictions affects the direction of corporate innovation.

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Manufacturers who had been automating U.S. and European factories to shave labor costs stopped once they set up in China. (WSJ, 11/23/2015)

1 Introduction

Multinational companies use foreign direct investments (FDI) to increase productivity and create value. One of the main strategies of multinationals is to produce at lower costs, especially to save on labor cost by relying on production taking place at subsidiaries located in low-wage countries. Multinationals also account for about 75% of overall innovation amongst publicly listed U.S. firms in 2010, which allows them to substitute between different production techniques by changing the mix of production factors. Such innovation, aka process innovation, captures cost-reducing technologies which allows firms to lower their production costs by automating.

In this paper, we ask whether multinational firms' ability to lower cost of production through FDIs alters their innovation strategies. Our hypothesis is that there are two main ways U.S. multinationals can lower their production costs: substituting relatively cheaper offshore labor for U.S. labor and investing in the development of cost-reducing production technologies. When substituting offshore for U.S. labor becomes relatively more attractive, firms decrease their R&D investments in developing cost-reducing technologies. In simple terms, better contracting with "cheap" offshore labor ("more globalization") creates incentives for firms to alter their investment policy by directing R&D away from devising new production methods that save costs ("less technological change").

For our analysis, we create a novel measure of process innovation, which refers to inventions of new methods or processes to be used in production (Scherer, 1982, 1984; Eswaran and Gallini, 1996). The basis for the measure is textual analysis of claims of patents issued by United States Patent and Trademark Office (USPTO). Section 101 of the Patent Statute recognizes four categories of patentable inventions, of which one is a new process. The category of the invention is explicitly mentioned in the first section of each patent claim—a claim preamble—in a direct and unambiguous way. We machine-read patent claims and distinguish claim preambles that identify process claims from the other three claim categories. Our main measure of process innovation counts the share of process claims to all claims contained in patents filed by a firm in each year and captures the firm's R&D expenditure and innovation efforts aimed at improving its production methods.

Among the U.S. listed firms, the share of process innovations has increased from 26% in 1975 to 37% in 2010. Notably, a steady increase in the share of process innovations over more than a decade leading to 1999 is followed by an apparent flattening afterwards. This distinct pattern over time is driven by manufacturing firms.[1] This evidence suggests that, in the aggregate, technology adoption by firms since mid-1980s documented in the literature is accompanied by a shift of R&D expenditure toward improvements of the firms' production methods. The turning point of this trend in 1999 coincides with signing of the bilateral agreement between the U.S. and China that improved contracting institutions for U.S. multinational firms in China. The agreement allowed U.S. multinationals better utilize "cheap" Chinese labor and reap the benefits of lower production costs by having operations in China. Since, on average over the 25 years starting in mid-1980s, 64% of U.S. multinationals are manufacturing firms and U.S. multinationals account for 67% of patents awarded to U.S. public firms, it may be that the change in the direction of innovation we document in the aggregate may partially be due to a change in innovation strategy of U.S. multinationals. We hypothesise that U.S. multinationals stopped shifting R&D expenditure toward inventing technologies that lower firms' production costs post-1999, due to the agreement.

After opening-up of China started in early 1980s, China gradually became a prime opportunity for U.S. firms to save production costs due to the size of labor force and low wages.[2] U.S. firms operating in China, however, could not capture all the benefits

[1] See Internet Appendix Figure IA-A3.

[2] "*China's average manufacturing wages, at about \$0.25 per hour, are about one-fifth as great as Mexico's, and about one-fiftieth as much as total compensation for manufacturing workers in*

of low wages because contractual incompleteness allowed Chinese partners, mainly, joint venture counterparts, suppliers, and distributors, to capture a share of the profits of U.S. firms' subsidiaries in China (Antràs, 2005, 2014). For example, one of the key methods to exercise control over the production processes is the U.S. firms' ownership of Chinese assets. Since Chinese government imposed ownership limits on foreign-owned subsidiaries and typically required majority ownership by local joint venture counterparts, U.S. firms' production in China was subject to hold-ups and distortions.[3]

We use the *1999 U.S.-China bilateral agreement* to identify the effect of U.S. firms' improved ability to access cheap and abundant offshore labor on their investment in cost-reducing technologies. The agreement, which was largely unanticipated due to the turbulent political landscape, made using Chinese labor easier for U.S. firms by lifting restrictions on doing business in China, such as: the withdrawal of ownership restrictions on foreign investment, the compliance with the WTO Trade Related Investment Measures agreement, the removal of local content and export performance requirements, the withdrawal of the requirement to use domestic suppliers, and the liberalization of distribution services. As the agreement expanded the space of applicable contracts, the hold-up problems were substantially alleviated. Overall, the agreement secured that China is moving toward the "rule of law" and will be held accountable for the contracts that it makes (U.S. Trade Representative Charlene Barshefsky, 18 November 1999). While a large share of the profits of U.S. firms' Chinese subsidiaries accrued to Chinese partners before 1999, the agreement increased the share of the profits the U.S. firms capture post-1999, effectively reducing their labor cost.

We start by showing that the 1999 U.S.-China bilateral agreement indeed benefited the

the United States. China's labor force is 18 times that of Mexico and five times that of the United States" (CSR Report for Congress, 2000).

[3]In *Poorly Made in China*, Midler (2011) describes how Chinese suppliers extract surplus from Western companies by manipulating prices and quality, and argues that solutions like relationship contracting were not effective in the case of China. Antràs (2014) highlights the nature of incomplete contracts in China by citing a Chinese old saying: "*signing a contract is simply a first step in negotiations*".

subsidiaries of U.S. multinationals that had already operations in China. Using a sample of manufacturing subsidiaries in China with foreign ownership, which we match to U.S. publicly listed firms in Compustat, we show that the subsidiaries matched to U.S. parent firms scale up their operations in China, increasing their employment and their investment in production-specific assets, and become more profitable, following the agreement, as compared to the rest of the Chinese subsidiaries with foreign ownership. All subsidiaries in our analysis have been established in China prior to 1999. Moreover, we show that U.S. firms that had entered China prior to 1999 have a first-mover advantage and are those who largely expand their footprint in China following the agreement, consistent with the idea that fixed costs of relocating production mitigates the benefits of the agreement for those not already in China. This analysis guides our main identification strategy, where we define treated firms to be U.S. multinationals with a subsidiary in China prior to 1999.

We, thus, examine the effect of the 1999 U.S.-China bilateral agreement on U.S. parent firms' innovation strategies comparing U.S. firms with a subsidiary in China prior to the agreement (treated) with two sets of control groups: i) U.S. multinational firms with a subsidiary in a low-wage country but not China, and ii) U.S. firms with operations abroad except China. We find that, after 1999, treated firms' share of process innovations is lower by 10%-12% relative to the median ratio, depending on the control group and the specification. In our regressions, we control for time-invariant firm characteristics by including firm fixed effects, time-varying industry characteristics by including interacted industry and year fixed effects, or time-varying firm characteristics by including firm-level controls. Our key identifying assumption is that, conditional on these controls, the assignment of firms into the treated versus control group is "as good as random". Although the identifying assumption is practically untestable, we support it in a number of ways. First, we find no significant effect of the agreement in pre-treatment years, while the effect appears after 1999. Second, when we control for potential differential trends between the treated and control firms by interacting the value of the dependent variable in 1997 with a full set of year dummies, our results continue to hold. Third, we conduct a placebo test by generating "pseudo" treated groups and re-estimating our baseline specifications: we conclude that the regression coefficients we estimate in our main tests are results that cannot occur mechanically in our data.

To provide evidence that the change in process innovation is due to the labor channel, we examine subgroups of treated firms where we expect to observe a differential effect. To this end, we exploit cross-sectional variation in the pre-treatment share of wages in Chinese subsidiaries normalized by the costs of production of the U.S. parent company. We find that the treatment effect is more pronounced for those firms with a larger share of production cost in China, as those firms will likely benefit the most from the agreement. Moreover, we show that the extent of foreign ownership plays a role. U.S. firms with a large equity stake in the subsidiary pre-treatment could alleviate hold-up problems more easily before the agreement. As such, we show that the treatment effect is attenuated for firms whose Chinese subsidiaries have a larger share of foreign capital pre-treatment.

These findings suggest that an improvement in contracting institutions that leads to a better ability to source labor cheaply across borders affects firms' innovation decisions. Specifically, our findings suggest that a decrease in the effective price of labor input due to the removal of frictions in an international setting affects the types of technologies that are being developed—less process innovation aimed at reducing production cost. As a result, the agreement allowed U.S. firms operating in China to allocate their resources more efficiently. Consistent with this intuition, we find that treated firms in our sample exhibit higher total factor productivity following the agreement, as compared to multinational firms in the control groups.

We discuss and rule out several alternative explanations. First, it may be that our estimates capture the effect of Chinese import competition on U.S. firms' innovation (Autor et al., 2020). To address this concern, we show that Chinese import competition has no differential effect on the share of process innovations of treated firms after 1999. Moreover, we look at the aggregate data and examine whether Chinese competitive pressure appears to be a determinant of the flattening of the process ratio that motivated our analysis. We split the sample of all Compustat firms by measures that capture Chinese competition and find no correlation between Chinese competitive pressure and the flattening of the share of process innovation around 1999, suggesting that this is not likely the primary factor driving the shift of firms away from process innovations.

Second, it may be that our estimates capture changes in U.S. firms' patenting practices around 1999, such as U.S. firms transferring their R&D centers to China, trade secrets substituting for patenting of process innovations, or, relatedly, secrecy incentives affecting patent quality. We find no support for these explanations. Third, our process innovation measure does not capture firms' overall investments in production costs saving as it does not include improvements in production processes that occur due to innovations embodied in capital goods that firms purchase from suppliers. To examine the importance of such externally sourced innovations, we include in our regressions a control variable capturing this channel. We show that our results are unchanged, which suggests that our findings cannot be explained by the substitution between internally produced process innovations (captured by our measure) and externally sourced innovations. More generally, we show that the differences in intensities with which treated and control firms are involved in different technological fields of innovation are not biasing our results.

Finally, we provide additional evidence that our findings are due to the alleviation of contracting frictions U.S. firms face in China. Specifically, we use the variation across industries and over time in ownership restrictions imposed by the Chinese government on foreign investments in China. We extract this information from the Foreign Investment Industry Catalogues issued six times in the 1995-2011 period. Consistent with the 1999 agreement being fundamental in China's opening towards the world, we observe most of the liberalization happening between the 1997 and 2002 catalogues. The staggered loosening of ownership restrictions implied by the catalogues changes the split of the profits of Chinese subsidiaries in favor of U.S. firms, effectively reducing their labor costs. We find that the loosening of ownership restrictions decreases the share of process innovations for firms with subsidiaries in China as compared to those with subsidiaries in other (low-wage) countries. This evidence further supports our findings that the improvement in contracting institutions that lead to a better ability to source labor cheaply across borders affects corporate innovation.

Our paper relates to a longstanding literature in economics which points to the relation from the abundance and price of production factors to innovation (Hicks, 1963). Allen (2009) argues that the scarcity of labor and/or high wages motivate firms to invent new ways to produce and thereby led to the industrial revolution which took place in eighteenth-century Britain. Lewis (2011) documents that immigration waves, which increased the supply of less-skilled labor in certain U.S. regions, are associated with lower investment in machinery by local plants. We instead focus on a different margin that firms can use to adjust their production processes: offshoring to a low-wage country. Unlike immigration waves or other factors determining the supply of low-skilled labor in the local labor markets, offshoring can be decided by individual firms. While only 15% of U.S. publicly listed (Compustat) firms are multinationals as of 2010, these account for 75% of patents filed by Compustat firms that year. We show that firms' ability to source labor on cheap labor markets and incentives to invest in innovation are intertwined, a conclusion that suggests that public policy aimed at lower integration of labor markets globally as a remedy to domestic employment demand might not have the anticipated effects.

Our paper is also related to the literature on the effect of trade with low-wage countries on high-wage country economies. Several papers have shown that Chinese imports have had a negative effect on U.S. employment (Acemoglu et al., 2016; Pierce and Schott, 2016; David et al., 2013) and innovation (Autor et al., 2020). Bernard et al. (2006), Bloom et al. (2016) and Hombert and Matray (2018) instead show that firms in developed countries react to a surge in low-wage country imports by changing their product mix towards more high-tech products. We add to this work by analyzing a novel angle through which the openness of China to the world impacted firms in the West: the ability of multinationals to tap Chinese labor altered U.S. firms' incentives to invent new production methods.

There is also prior work examining the impact of regulatory frictions on international trade and investment (Moran, 2001; Antràs, 2005). More broadly, seminal papers in the corporate finance literature describe how hold-up problems due to contract incompleteness distort investments (Grossman and Hart, 1986; Hart and Moore, 1990; Williamson, 1979). We add to this literature by showing that regulatory changes that allow U.S. firms to benefit more from offshore workers have implications for their R&D investment decisions.

2 Patented process innovation

Our main measure captures the share of firms' innovation activities that are aimed at improving the firms' production processes. Following long-standing literature (Griliches, 1990), we rely on patents to proxy innovation and we use the universe of USPTO utility patents granted in 1975-2010. To identify improvements in production processes, we utilize the fact that Section 101 of the Patent Statute (USPTO 35 U.S.C. §101) recognizes four categories of patentable inventions, of which one is an invention of a new process, defined as "an act, or series of acts or steps".[4] The type of the invention is almost always explicitly mentioned in the first section of each patent claim—a claim preamble—in a direct and unambiguous way.[5] Conceptually, a process innovation describes a new way to produce an existing good, while a non-process innovation typically describes a new good that did not exist before. Economics literature interprets process innovations to be aimed at improving a firm's own production methods in order to lower its production cost (Cohen and Klepper, 1996; Eswaran and Gallini, 1996; Link, 1982; Scherer, 1982, 1984).

We process texts of patent claims using textual analysis to distinguish claim preambles that identify process inventions from the other three invention categories.[6] Our main dependent variable *Share of Process Innovations*$_{it}$ is the ratio of the number of claims

[4]Two other categories of patentable inventions are physical objects, that is, products, and the last category of patentable inventions is defined as a composition of two or more substances. See, for example, "USPTO 35 USC § 101: Statutory Requirements and Four Categories of Invention" available at https://www.uspto.gov/sites/default/files/101_step1_refresher.pdf.

[5]See, for example, the USPTO guide on "Claim Interpretation - Preambles" available at https://www.uspto.gov/sites/default/files/documents/Claim-Interpretation-Preambles-Final-02-18.pdf or the World Intellectual Property Organization (WIPO) guide on "Patent Claim Format and Independent Claims" available at https://www.wipo.int/edocs/mdocs/aspac/en/wipo_ip_mnl_3_18/wipo_ip_mnl_3_18_p_4.pdf.

[6]We obtain full texts of patent claims, claims-to-patents links, and other patent-level characteristics from the 'PatentsView by USPTO' project available at https://patentsview.org/.

with explicit reference to process invention category in the claim preamble—the number of ‘process claims’—to all claims contained in patents applied for (and eventually granted) by firm i in year t. To assign patents to firms in Compustat we use the firm name string matching procedure from Bena et al. (2017). We assume that the claim count is zero for firm-years with missing USPTO information. The ratio is defined for firm-years with at least one patent. We also define the levels of $\textit{Process Innovations}_{it}$ and $\textit{Non-process Innovations}_{it}$ as the number of process and non-process claims, respectively, included in patents applied for (and eventually granted) by firm i in year t. As an alternative, we define these process innovation variables using independent claims only. An independent claim stands on its own, while a dependent claim has meaning only when combined with a claim (in the same patent) it refers to. Internet Appendix Section A describes details of our methodology.

We provide two examples to illustrate the construction of our variables. Patent US 8317964 B2 titled “Method of manufacturing a vehicle” applied for on January 11, 2007 by Ford Motor Company has 11 process claims to protect a method of manufacturing a vehicle (Internet Appendix Figure IA-A1). The wording of claim 1 begins: “1. A method of manufacturing a vehicle comprising...”. The wording of claim 2 begins: “2. The method of claim 1 wherein the step of assembling the upper portion further comprises...”. We code claims 1 and 2 to be process claims, wherein claim 1 is an independent and claim 2 is a dependent claim. In contrast, patent US 7535468 B2 titled “Integrated sensing display” applied for on June 21, 2004 by Apple Inc. has 22 non-process claims to protect the invention of an integrated sensing display (Internet Appendix Figure IA-A2). The wording of claim 1 begins: “1. A device comprising a display panel...”. The wording of claim 2 begins: “2. The device of claim 1, wherein the image elements are located in a ...”. We code claims 1 and 2 to be non-process claims, wherein claim 1 is an independent claim and claim 2 is a dependent claim.

We also define the process innovation variables using patents instead of claims. We classify a patent as a ‘process patent’ if the first patent’s claim is a process claim and as a 'non-process patent' if the first patent's claim is a non-process claim.[7] Alternatively, we classify a patent as a 'pure process patent' if all claims in the patent are process claims and as a 'pure non-process patent' if all patent's claims are non-process claims. In robustness tests, we weight the share of process innovations variable constructed based on (pure) process patents using the number of citations received by patents and we adjust the levels of process (non-process) innovations variables constructed based on patents using technological class-by-time period specific means (Bena and Li, 2014). All variable definitions are provided in the Appendix.

Internet Appendix Figure IA-A3 plots the evolution of the share of process innovations among all U.S. listed firms in 1975-2010. On average, 32% of innovations are new processes. The share varies by the sector of the economy and over time. Process innovations account for a relatively higher share of innovations in the primary sector, reflecting that industrial processing of natural resources is the main activity in this sector. The share of process innovations started to increase sharply in the manufacturing and services sectors in late 80s/early 90s, which coincides with the polarization patterns of the U.S. labor market largely attributed to the wide adoption of technology (e.g., Autor et al., 2003; Autor, 2010). The share of process innovations has increased by 8.8 percentage points in the manufacturing sector and by 20.3 percentage points in the services sector over 35 years since 1975. Since manufacturing firms account for the majority of patents, the aggregate trend in the share of process innovations coincides with the trend in manufacturing.

Internet Appendix Figure IA-A4 plots the evolution of the share of process innovations by fields of technology and labor intensity. The share is high and steady in Cooperative Patent Classification (CPC) Sections B (Performing operations; Transporting) and C (Chemistry; Metallurgy), and it is increasing in the two CPC Sections with the highest fractions of all patents—G (Physics) and H (Electricity)—that reflect the Information and Communication Technologies (ICT) revolution in the patenting space. Panel (b) of Internet Appendix Figure IA-A4 shows that the share of process innovations has been sharply and

[7]The first claim listed on a patent is always an independent claim and describes the principal invention of the patent.

steadily increasing over the last four decades especially in labor-intensive industries, with the notable exception of 1999-2003 period. Over 35 years since 1975, the share of process innovations has increased by 22.3 percentage points among firms with above-median labor-to-capital ratio, while it increased by 4.8 percentage points among firms with below-median labor-to-capital ratio. In Internet Appendix Section A, we provide additional analysis documenting a positive association of process innovation with subsequent capital intensity and a negative association with the share of production workers. Overall, this evidence suggests that process innovation acts primarily as a labor-saving technology in our sample.

3 1999 U.S.-China bilateral agreement

The bilateral agreement signed between the U.S. and China in November 1999 was a landmark in the economic relations of the two countries, and it paved the way to China's entry into the World Trade Organization (WTO). The agreement involved significant concessions from China, mainly the elimination of a number of restrictions on investment by U.S. firms.

The agreement was unexpected due to turbulent political relations between the two countries. In mid-1997, the U.S. puts aside multilateral negotiations with China and starts bilateral talks instead—a decision driven mainly by political reasons. In 1998, little progress is being made due to the Clinton-Lewinsky scandal. A milestone in the talks is the visit of Premier Zhu Rongji in the U.S. in April 1999, when he made—for the first time—significant concessions. No agreement was signed however, and the negotiations were seriously threatened a few weeks later when the U.S. mistakenly bombed the Chinese embassy in Belgrade. The agreement was finally signed on November 15, 1999 when the U.S. Trade Representative (USTR) Charlene Barshefsky visited China. To emphasize the uncertainty surrounding the negotiations, it is worth mentioning that USTR threatened to leave China three times and the negotiations were completed only after she decided to stop at the Chinese trade ministry on her way to the airport (Devereaux and Lawrence, 2004).

Historically, U.S. firms operating in China faced numerous restrictions and regulatory interventions. They had to work with Chinese partners, mainly, joint-venture counterparts, suppliers, distributors, and local governments, which led to hold-up problems and disruptions of firms' operations, and thereby lower profits. Hold-up problems stem from contact incompleteness—a predominant feature of international contracts (Antràs, 2014; Rodrik, 2000).

The hold-up problems were substantially alleviated by the agreement. China lifted ownership restrictions on foreign investment and agreed to comply with the WTO Trade Related Investment Measures agreement. The agreement thus expanded the space of applicable contracts, most importantly, it allowed U.S. firms to side step working with Chinese partners. China ceased to impose trade and foreign exchange balancing requirements, local content requirements, which require foreign firms to use domestic materials and parts for production, and export performance requirements. China committed that U.S. firms are not required to work with domestic suppliers or distributors, and withdrew requirements of any kind such as offsets, transfer of technology, production processes, or the conduct of R&D in China. Furthermore, China committed to ensure fair competition between private and state-invested enterprises and liberalize distribution services. Overall, the agreement increased the share of the profits from Chinese operations accruing to U.S. firms, effectively reducing U.S. firms' labor cost.

3.1 Effect of the U.S.-China bilateral agreement on Chinese subsidiaries

The data for Chinese subsidiaries are from Annual Surveys of Industrial Production by the Chinese government's National Bureau of Statistics. The Annual Survey of Industrial Production—'Chinese Industrial Survey' (CIS) data—covers firms in manufacturing, mining, and public utilities and it is a census of all nonstate firms with more than 5 million yuan in revenue plus all state-owned firms. This data is available since 1998 and was used in prior work on growth and productivity of manufacturing firms in China (Hsieh and Klenow, 2009; Song et al., 2011). We access CIS data through the RESSET Database. From CIS data, we create a sample of firms that have foreign ownership in at least one reporting year. Although CIS data provides details on the type of foreign ownership, it does not provide information about the country of domicile or the identity of the parent firm. We manually go through all company names in CIS data and hand-match it to U.S. publicly listed firms in Compustat. To the best of our knowledge, the match between Chinese subsidiary data and U.S. publicly listed parent firms is unique to our paper and a distinct contribution to the literature.

Chinese subsidiaries span a wide range of manufacturing industries, as shown in Internet Appendix Figure IA-B1, with clothing and textile manufacturing industries representing 9% and 7% of the subsidiaries, respectively, followed by electrical machinery (6.4%), general machinery manufacturing (5.8%) and chemical raw materials manufacturing (5.7%). Chinese subsidiaries are also profitable with the average (median) subsidiary having a return on assets of 5% (3%) and a gross profit margin of 18% (15%), respectively. Average (median) employment is 433 (169) employees and the average (median) wage per employee is yuan 16.7 thous. or $2 thous. (yuan 12 thous. or $1.45 thous.). The average (median) subsidiary has 44% (41%) of their assets as fixed operating assets and sales revenue equal to yuan 122 million ($15 million) (yuan 31 million or $4 million). We report these statistics in Internet Appendix Table IA-B1.

We next validate that the U.S.-China bilateral agreement was beneficial for U.S. firms operating in China prior to the agreement and that, as a result, U.S. firms scaled up their operations in China. To this end, we estimate the following regression specification:

$$y_{i,t} = \alpha_i + \alpha_{jt} + \alpha_{ct} + \delta_{1998} \cdot US_i \cdot d_{1998} + \sum_{t=2000}^{2004} \delta_t \cdot US_i \cdot d_t + \gamma \cdot X_{i,t} + \epsilon_{i,t}, \qquad (1)$$

where i and t index subsidiaries and years, respectively; $y_{i,t}$ stands for subsidiary-level outcome variables; US_i is an indicator variable that takes a value of one for Chinese subsidiaries that can be matched to publicly listed U.S. firms and 0 for all other subsidiaries. We require that all subsidiaries in our sample entered China prior to 1999, the year of the agreement. d_t is an indicator variable that takes a value if 1 for years, 1998-2004, respectively, and 0 otherwise. Year 1999 (the year of the agreement) is omitted in this analysis; $X_{i,t}$ includes the logarithm of sales; α_i denotes subsidiary fixed effects, α_{jt} denotes industry-year fixed effects (based on 791 4-digit industries) and α_{ct} denotes city-year fixed effects (based on 399 cities in our sample); and $\epsilon_{i,t}$ is the error term. Coefficient δ captures the change in the dependent variable at U.S.-Compustat matched subsidiaries in China born prior to 1999 following the 1999 U.S.-China bilateral agreement as compared to the year before the agreement, relative to all other subsidiaries in China.[8] We use a timeline between 1998-2004 to match our baseline analysis.[9]

We report the results in Table 2. Consistent with the fact that the agreement made U.S. subsidiaries in China more profitable, we show that U.S. subsidiary profitability (measured as return on assets (ROA)) in column 1 and gross profit margin in column 2 increase post-1999 relative to the control group, while there is no difference between the two groups prior to the agreement. Following the lifting of restrictions, we find that the subsidiaries of the U.S. matched firms increase their sales relative to the control group (column 3) and increase their production in China as indicated by the fact that the share of fixed assets for production and operation normalized by total assets (column 4) and employment (column 5) increase post-1999. In column 6, we show that scaling up of the U.S. matched subsidiaries does not come with increases in wages per employee. If anything, those weakly decrease post-1999 relative to the control group, consistent with the fact that the agreement has reduced hold-ups for U.S firms from their suppliers of input, allowing them to extract a higher surplus from their operations.

In our analysis, we show that U.S. matched subsidiaries who entered China prior to the agreement scaled up their operations and became more profitable post 1999. Although all U.S. firms could in principle benefit from the bilateral agreement, those already in China had a first-mover advantage and benefited more. Moreover, high fixed costs to offshoring may prevent some firms from entering China (Antràs and Helpman, 2004) offsetting some of the benefits of the agreement. Indeed, within the sample of U.S. publicly listed firms matched to a subsidiary in China, 79% entered China before 1999, while out of those

[8]Variables $d_{(t)}$ and US_i are absorbed by the fixed effects and their coefficients are thus not estimated.

[9]The results are similar if we instead include years 1998-2007 in our analysis.

who had presence in China prior to 1999, 47% expanded their operations by opening new subsidiaries in China post 1999. In contrast, 21% of U.S. publicly listed firms matched to a subsidiary in China only entered China following the bilateral agreement (Panel A, Internet Appendix Table IA-B2).

Moreover, U.S. firms which entered China prior to the agreement operate more subsidiaries, an average (median) of 4.3 (3) versus 1.6 (1) subsidiaries for those firms which entered China only after the agreement (Panel B, Internet Appendix IA-B2). Overall, only 7% of those subsidiaries matched to U.S. parent companies were born in 1999 or later. In addition, those subsidiaries born prior to 1999 are bigger and more profitable. Internet Appendix Table IA-B3 shows that those U.S. subsidiaries which entered China pre-1999 have higher sales and employment and higher return on assets as compared to subsidiaries that entered China post-1999, in a specification with industry-year and city-year fixed effects over the 1998-2007 period.[10]

In sum, our findings that Chinese subsidiaries of U.S. publicly listed firms who had entered China prior to the agreement become more profitable and scale up, increasing their employment, suggests that these firms are now able to reap the benefits of access to 'cheap' Chinese labor by substituting more of their domestic U.S. workers with offshore cheaper workers. As a result, the relative return on investment in process innovation should be lower for these firms. In the sections that follow, we will be testing our hypothesis that U.S. firms will be shifting their production away from process innovation following the 1999 U.S.-China bilateral agreement.

4 Sample construction and summary statistics

The sample is based on the publicly traded firms in the Compustat dataset. As in Bloom et al. (2013), we exclude firms headquartered in the U.S. that never filed at least one patent with the United States Patent and Trademark Office (USPTO). We drop firm-years

[10] We allow all years in the data to enter our sample for the purpose of this analysis, although results are similar if we end our sample in 2004.

for which assets and sales are missing. We also drop firms which employ, on average, less than 200 employees in the pre-treatment (1998-1998) period as the agreement mostly benefits firms for which labor is an important input of production.[11] Our sample period starts in 1995 and ends in 2004, using 10 years of data around the event.

Using the CIS data, we identify U.S. publicly listed firms that have at least one subsidiary in China prior to 1999, as explained in Section 3.1. This group of firms forms the treated group in our analysis. From 10-K filings between 1993 and 1998, we collect information on Compustat firms with subsidiaries outside the U.S. and China. We further identify firms who have subsidiaries in low-wage countries, excluding China. We define low-wage countries to be those that have less than 5% of the U.S. GDP/capita as of 1998, following Bernard et al. (2006). We thus consider two control groups of U.S. multinationals which, prior to 1999, have presence: i) in low-wage countries (except China), or ii) in all countries outside the U.S. (except China). We consider 1999, the year when the U.S.-China bilateral agreement is signed, as the year of the event.

Our dependent variable is *Share of Process Innovations*$_{it}$, which can be defined for firm-years with at least one patent, and it provides a meaningful measure of the changes in the innovation mix over time. The majority of our sample of Compustat firms are manufacturing firms (87% when we define the control group as multinationals in low-wage countries and 82% when we define the control group as all multinationals) followed by services (11% versus 9%, respectively), while the remainder of firms are evenly distributed across the remaining industries.

We use two samples throughout our analysis. The sample that compares treated firms with control firms that have subsidiaries in low-wage countries includes 213,162 patents and 2,539 firm-year observations. The sample that uses all multinationals as the control group instead includes 347,815 patents and 6,210 firm-year observations. Table 1 provides summary statistics of firm characteristics for the two samples. On average, our sample

[11] On average, Compustat firms in the sample employ 7,400 employees in the pre-treatment period and a median of 600 employees.

firms, where the control group is multinationals in low-wage countries, have 622 process claims and 1,017 non-process claims per year. On average, our sample firms, where the control group is all multinationals, have 440 process claims and 681 non-process claims per year. As such, the average share of process to total innovations is about 33% in both samples. In the two samples, a firm has, on average, sales of $7.9 billion and $ 5.1 billion, a market-to-book equity ratio of 3.8 and 6.1, a count of 84 and 56 patents, and approximately 7% and 9.7% in R&D over Sales, respectively.

In Internet Appendix Table IA-B4, we compare the firm characteristics presented in Table 1 between treated and control groups for the two samples used in the analysis as of 1999, the year the U.S.- China bilateral agreement was signed. A t-test in differences in means between treated and control firms shows that there are significant differences across several variables pre-treatment. However, most of these differences become statistically insignificant once we adjust for industry time-varying effects and firm size (when appropriate), which correct for compositional differences between the two groups. To this end, we always control for industry-year fixed effects throughout our analysis, while we show that all our results are robust to controlling for firm size.

5 Results

5.1 The 1999 U.S.-China bilateral agreement and U.S. firms' innovation

We start by plotting the aggregate share of process innovation for all publicly listed firms and for those in the manufacturing sector over our sample period in Figure 1, panel (a). We observe that the ratio follows a distinct pattern, as also discussed in Section 2. It steeply increases starting in mid-80s and subsequently flattens post-1999. This pattern is particularly pronounced in the manufacturing sector. Given 64% of U.S. multinationals are manufacturing firms and U.S. multinationals account for 67% of patents awarded to U.S. public firms on average over the 25 years starting in mid-1980s, we conjecture that the change in the direction of innovation we observe on aggregate may partially be due to a change in innovation strategy of U.S. multinationals following the 1999 U.S.-China bilateral agreement.

To examine the plausibility of this hypothesis, we plot the share of process innovation for multinational firms with presence in China (treated), for firms with subsidiaries in low-wage countries except China (control sample 1) and for those with subsidiaries in all countries except the U.S. and China (control sample 2). Although, the share of process innovation steeply increases for all three groups of firms until 1999, the ratio sharply declines for firms with subsidiaries in China (treated) and it mostly follows an increasing trend for multinational firms in the control groups.

To more formally identify the effect of an improved access to Chinese labor on firms' share of process innovations, we next estimate the following difference-in-differences regression:

$$y_{i,t} = \alpha_i + \alpha_{jt} + \delta \cdot Agreement_{(t>1999)} \cdot China_i + \gamma \cdot X_{i,t-1} + \epsilon_{i,t}, \tag{2}$$

where i and t index firms and years, respectively; $y_{i,t}$ stands for the *Share Process Innovations*$_{it}$; $Agreement_{(t>1999)}$ is an indicator variable that takes a value of one in the post-1999 period; $China_i$ is an indicator variable that takes a value of one for firms in the treated group, and 0 for firms in the control group; $X_{i,t-1}$ are time-varying firm-level control variables (logarithm of firm sales, market-to-book ratio, logarithm of R&D stock) lagged by one year; α_i denote firm fixed effects; α_{jt} denote (3-digit NAICS) industry-year fixed effects to account for any time-varying industry-level omitted variables and $\epsilon_{i,t}$ is the error term. Coefficient δ captures the change in the share of process innovation at firms with a subsidiary in China prior to 1999 following the 1999 U.S.-China bilateral agreement as compared to years before the agreement, relative to firms in the control group.[12]

In Columns 1-4 of Table 3, we present estimates of regression (1) with *Share of Process Innovations*$_{it}$ as the dependent variable, where we define the control group to include multinational firms with presence in low-wage countries (except China) pre-treatment. The specification in Column 1, which does not include any firm-level control variables, shows

[12] Variables $Agreement_{(t>1999)}$ and $China_i$ are absorbed by the fixed effects and their coefficients are thus not estimated.

that the treated firms decrease the share of process innovations relative to control firms post-1999 by 3.6 percentage points, which is a 12% reduction relative to the median ratio in the sample. The estimate of coefficient δ is significant at the 5% level. In Column 2, we additionally control for the logarithm of patents as treated firms seem to patent more pre-treatment (Internet Appendix Table IA-B4). The coefficient on the patent control variable is not statistically significant and the diff-in-diff coefficient of interest remains unchanged. In Column 3, we additionally control for lagged firm size and market-to-book equity ratio.[13] As in Bloom et al. (2013), in Column 4 we control for differences in a firm's stock of knowledge using lagged R&D stock. None of these controls are statistically significant, while our coefficient δ remains significant at the 5% level. These results suggest that our findings are not driven by differences in size, investment opportunities, R&D intensity or industry trends between the two groups of firms.

In Columns 5-8 of Table 3, we repeat the same analysis except we consider all multinationals (except those in China) pre-treatment as our control group. The sample of firms included in this analysis almost triples, potentially at the expense of including less comparable control firms. Nevertheless, as can be observed in Internet Appendix Table IA-B4, treated and control firms are similar in terms of observables after controlling for industry-year changes. One important exception is firm size with treated firms being significantly larger as compared to controls even after controling for industry effects. Column 5 shows that the treated firms decrease the share of process innovations relative to control firms post-1999 by 3 percentage points, which is a 10% reduction relative to the median ratio in this sample. The coefficient estimate remains relatively unchanged after including firm size and the rest of the firm-level controls in Columns 6-8.

U.S. firms may choose to which country to move their production in a non-random way. This raises an identification concern as ex-ante differences in observable and unobservable firm characteristics between the "treatment" and "control" groups may lead to differential intention-to-treat. In light of this concern, we estimate an augmented version of equation (1)

[13] Cohen and Klepper (1996) show that firm size may impact the allocation of R&D between process and product innovation.

with firm, interacted industry and year fixed effects and firm-level controls where we interact $China_i$ with an indicator variable for each year t.[14] In Panel (a), Figure 2, we report the year-by-year coefficients for the sample that uses low-wage country multinationals as the control group. We find that no interaction term is significant pre-treatment. The estimate becomes negative following the agreement and significant at the 5% level in 2002 and 2003. In Panel (b), Figure 2, we report the year-by-year coefficients for the sample that uses all multinationals as the control group. Similarly, we find that no interaction term is significant pre-treatment, while the share of process innovations drops significantly following the agreement. These results show that differential pre-treatment trends are inconsistent with our findings.

The findings from Table 3 are consistent with the intuition that U.S. firms' improved ability to utilize cheap Chinese labor became a more advantageous cost reduction strategy compared to investing in process innovation—innovation that is aimed at reducing production cost by introducing new production methods. More broadly, our findings suggest that an improvement in contracting institutions that lead to a better ability to source labor on cheap labor markets affects firms' innovation decisions. In other words, the agreement increased the return on U.S. firms' Chinese operations relative to investing in process innovation.

To examine whether the effect we are identifying is indeed driven by U.S. firms utilizing low-cost labor in China, we exploit variation within treated firms. This channel suggests that the effect of the agreement should be bigger for the treated firms whose Chinese subsidiaries' labor costs constitute a large share of their overall production costs. To this end, we create a time-invariant measure $China\ Wages/COGS_i$ defined as the wagebill of the Chinese subsidiaries (available in CIS data) divided by the parent firms' cost of goods sold (available in Compustat) as of year 1998. As such, this measure varies across treated firms and is zero for control firms. In Columns 1-2, Panel A, of Table 4, we augment Columns 3-4 of Table 3 with the interaction term of our treatment variable with $Wages/COGS_i$

[14] We omit the 1999 interaction term, that corresponds to the year of the agreement, and thus set 1999 as the baseline year.

for the sample using multinationals in low-wage countries as controls. We find that the differential effect on process innovations is negative and economically significant in both columns. A one standard deviation increase in $\textit{Wages/COGS}_i$ is associated with a 1.1pp further reduction in the share of process innovation. In Columns 3-4, we instead consider the sample using all multinationals as controls and repeat the same analysis. Similarly, we show that a one standard deviation increase in $\textit{Wages/COGS}_i$ is associated with a 1.7pp further reduction in the share of process innovation.

We also argue that the effect we are identifying operates through the ability of U.S. firms to capture a higher portion of the profits from their Chinese operations vis-à-vis the Chinese partners due to the agreement alleviating hold-up problems, increasing effectively U.S. firms' benefit from a lower labor cost in China. This argument suggests that the effect of the agreement should be less pronounced for treated firms that have a higher equity stake in their Chinese subsidiaries relative to the Chinese partners pre-treatment. Intuitively, those firms with a larger stake pre-treatment should benefit less from the agreement as those firms with large enough ownership could alleviate hold-up problems relatively more even before the agreement.

In Panel B, Table 4, we consider the subset of treated firms whose Chinese subsidiaries are joint ventures (typically with local partners). We define $\textit{Share of Foreign Capital}_i$ to be foreign capital at the subsidiary normalized by total capital in 1998. This measure varies across treated firms and is zero for control firms. On average, foreign capital in U.S. subsidiaries is equal to three quarters of the total paid-in capital in the subsidiary pre-treatment. In Columns 1-2 (Columns 3-4), we augment Columns 3-4 of Table 3 with the interaction term of our treatment variable with $\textit{Share of Foreign Capital}_i$ for the two samples using the control groups of low-wage country multinationals and all multinationals, respectively. We find that the differential effect on process innovations is positive and economically significant across columns. A one standard deviation increase in $\textit{Share of Foreign Capital}_i$ is associated with a 3.3pp lower reduction in the share of process innovation in Column 1 (or a 2.5pp lower reduction in Column 3).

Anecdotal and survey evidence supports the argument that U.S. firms invest in China to take advantage of low labor cost. The hourly average factory-worker wage in China was $0.5 in 2000 versus $16.6 in the U.S. (a ratio of 0.03), while the same ratio is 0.04 in 2005, the final year in our sample.[15] Multinational Monitor comments on the agreement: *"U.S. businesses want the right to exploit its [China's] cheap labor, or at least to import goods made in China with cheap labor."* Porter and Rivkin (2012) asked 10,000 Harvard alumni running businesses what are the main reasons for moving production out of the U.S. 70% of the respondents mention lower wages as the main reason for moving existing activities out of the U.S. When the same respondents were asked which are the countries they consider transferring their production to, China was the most common response (42% of the answers).

5.2 The 1999 U.S.-China bilateral agreement and U.S. firms' efficiency

We conjecture that the ability of U.S. firms to more efficiently allocate their production inputs following the agreement should increase their efficiency. To test this conjecture, in Table 5, we examine whether lifting the restrictions on U.S. firms' operations in China is positively associated with treated firms' total factor productivity (TFP).

In Columns 1-3, Table 5, we first consider the sample based on the low-wage country multinationals as controls, while in Columns 4-6 we consider the sample based on all multinationals. We include firm and year fixed effects throughout our analysis. The TFP measure, available from İmrohoroğlu and Tüzel (2014), is free of industry effects in any given year and so we do not include industry-year fixed effects in this analysis. Columns 1 and 3 do not include firm-level controls and Columns 2 and 5 control for firm size. We find a positive and economically meaningful effect of the agreement on TFP for treated firms of about 6%, which is statistically significant across specifications. In Columns 3 and 6, we estimate a year-by-year dynamic analysis around the agreement. While we find no

[15]See Exhibit 1 in a Boston Consulting Group report: *"Why manufacturing will return to the U.S."*.

significant pre-trends prior to the agreement (one exception is a negative and significant coefficient in year 1997, Column 3), we find positive and significant effects on TFP following the agreement. The evidence in Table 5 suggests that the agreement lifted constraints on U.S. firms' operations in China and led to increases in U.S. firms' efficiency.

5.3 Identification concerns

In this section, we discuss possible sources of bias of our inferences and perform auxiliary analysis to mitigate these concerns.

Alternative measures for the share of process innovation: In Internet Appendix Table IA-B5, we show that our results hold using alternative measures for the share of process innovations. Although our claim-based measures of process and non-process innovation capture all process and non-process inventions patented by a firm in each year, they ignore differences in the quality of inventions protected by each specific claim. This limitation cannot be addressed using measures based on claims, because there are no indicators of quality (e.g., the number of citations received) of individual claims. To this end, in Internet Appendix Table IA-B5, Panel A, we use the number of citations received by each patent to account for the heterogeneity in quality of innovations and construct citation-weighted measures of the share of process innovations for both samples used in our analysis. In Internet Appendix Table IA-B5, Panel B, we construct the share of process innovations measures using independent claims only, arguably the most important claims in a patent. We find that our results are robust irrespective of the definition used to define our dependent variable.[16]

Process vs. non-process innovations: The reduction in the share of process innovations we document may be due to less process innovations, more non-process innovations, or process and non-process innovations changing at different rates. The agreement alleviated hold-up problems of U.S. firms operating in China, allowing them to benefit more from

[16] In Internet Appendix Table IA-B7, we show that our baseline analysis is robust to using fractional outcome regression models that explicitly account for the fact that our dependent variable is a ratio between zero and one.

the abundant and cheap Chinese labor and thereby reducing U.S. firms' effective labor costs. To the extent that firms have fewer incentives to invest in R&D to reduce production cost, we should find that a lower share of process innovations is due to less process innovations. To this end, Internet Appendix Table IA-B6 examines the effect of the agreement on the quantities of process (Panel A) and non-process (Panel B) innovations separately.

In Panel A, we present estimates of Regression (1) with *Process Innovations*$_{it}$ as the dependent variable. We present the same specifications as in our baseline analysis in Table 3. To reduce the influence of outliers in a right-skewed distribution of innovation across firms, we transform *Process Innovations*$_{it}$ using the inverse hyperbolic sine (IHS) function. The specification in Column 1, which does not include any control variables, shows that the treated firms decrease process innovations relative to control firms post-1999 by almost 18%, albeit the coefficient is not statistically significant. The estimate of coefficient δ is significant at the 1% level in Column 2, after controlling for the logarithm of firm patents. Controlling for patents essentially converts the specification into a share-type specification that resembles our baseline analysis. Including additional firm-level controls in Columns 3-4 has little impact on the magnitude and significance of our δ estimate. These results suggest that our findings are not driven by differences in size, investment opportunities, or stock of R&D knowledge between the two groups of firms. Instead of considering firms with subsidiaries in low-wage countries, Columns 5-8 expand the analysis to include all multinationals in the control group. We find statistically and economically significant negative effects on process innovation across all specifications in this sample. In Panel B, we repeat the analysis examining the effect of the agreement on the quantities of non-process innovations—the dependent variable is IHS-transformed *Non-process Innovations*$_{it}$. We find that the quantity of non-process innovations does not change as δ estimates are not statistically significant in any of the specifications we consider.

Matching analysis: In Internet Appendix Table IA-B12, we show that our results hold when we repeat our analyses on treatment-control matched samples. In Panel A, we refine the sample based on the low-wage country multinationals as controls by finding the nearest neighbor match for each treated firm using a propensity score matching procedure. In Panel B, we refine the sample based on all multinationals by finding up to five nearest neighbor matches for each treated firm using a propensity score matching procedure. The propensity score is estimated based on 1995-1999 period using the following characteristics: year fixed effects, industry (2-digit NAICS) fixed effects, *Log(Employment)*, *Log(Sales)*, *Log(R&D Stock)*, *Log(Patents)*, all lagged by one year, and squared terms of these continuous covariates. For both samples, we present the statistics to evaluate covariate balance before and after matching. A well-balanced sample would have standardized differences of means close to zero and variance ratios close to one. The statistics for the raw samples suggest that there is little balance, especially in firm size and R&D intensity. After matching, the balance substantially improves. Using different specifications and both matched samples, we find statistically and economically significant negative effect of the agreement on the share of process innovations. The magnitudes of the coefficients are in line with our baseline estimates in Table 3.

Placebo test: We conduct a placebo test by randomly assigning firms from our sample into the 'placebo treatment' groups in 1999, while matching exactly the number of treated and control firms in the two sub-samples, and repeating our baseline analysis in Table 3. We repeat this procedure 1000 times, each time estimating the placebo treatment effect. We report the empirical distribution of the obtained estimates in Internet Appendix Figure IA-B2. Panel (a) is based on specification in Column 4 of Table 3. Panel (b) is based on specification in Column 8 of Table 3. In both panels, the vertical line indicates the corresponding "true" coefficient estimates from Table 3. The results show that the distribution of placebo coefficient estimates is centered at zero and that the 'true treatment' coefficient estimates reported in Table 3 are low probability events in the data. Internet Appendix Table IA-B9 reports results of the placebo test using specifications in Columns 3, 4, 5 and 8 of Table 3. The standard errors in this table are computed as standard deviations of the estimated 1000 regression coefficients obtained using the placebo treated groups. We confirm that the estimated true treatment coefficients are always in the very left tail of the generated distributions. This finding suggests that a non-random location of subsidiaries across countries is unlikely to explain our findings.

Mean-reversion in firms' innovation activities: A related concern might be that treated firms' share of process innovations may mean-revert to some firm-specific equilibrium level post-1999, which is captured by our interaction term. We address this concern in Table IA-B10 in the Internet Appendix. We interact the values of the dependent variables in 1997 with the full set of year indicator variables, and add these interaction terms to the specifications in Columns 3-4 and Columns 7-8 of Table 3, respectively. The estimates of δ are similar to our baseline results. We conclude that mean reversion in firms' pre-treatment innovation activities is not consistent with our findings.

Allowing for entry into China: Since entry into China is possibly endogenous to the agreement, we define $China_i$ pre-treatment throughout our main analyses. To the extent that all U.S. firms with a presence in China, including those that enter China after 1999, benefit from the agreement, we repeat the analyses from Table 3 using a time-varying measure of having presence in China. Specifically, we construct an indicator variable $China_{it}$ that takes a value of one if a firm has a subsidiary in China in year t, according to the CIS data, and use it in the interaction with $Agreement_{(t>1999)}$. The negative and significant estimates of δ for the share of process innovations, reported in Table IA-B8 in the Internet Appendix, are analogous to those in Table 3.

5.4 Alternative explanations

In this section, we discuss alternative explanations for our findings. First, we show that our results do not seem to be driven by the response of U.S. firms to increasing Chinese import competition or due to U.S. exports. Second, we show that changes in U.S. firms' patenting practices is inconsistent with our findings. Third, we show that our results do not seem to be explained by U.S. firms refocusing R&D on different technology fields or functional areas following the agreement. Fourth, we show that our results are not affected when we control for improvements in production processes that occur due to innovations embodied in capital goods that are purchased from suppliers.

5.4.1 U.S. trade with China

Increases in import competition from low-wage countries may impact firms' innovation. Specifically, a reduction in the profitability of making low-tech products due to cheaper imports may give U.S. firms stronger incentives to invent new goods and climb the quality ladder in order to escape import competition. Bernard et al. (2011) show that a reduction of trade costs with a low-wage country leads to a change in the product mix offered by Northern firms toward more high-tech products. Bloom et al. (2016) examine the effect of import competition on innovation and find a positive effect for firms affected by Chinese imports. Hombert and Matray (2018) show that R&D intensive firms are able to differentiate their products to escape from Chinese competition and are more resilient to Chinese imports. Therefore, a possible concern is that our results capture U.S. firms' differential responses to accelerating Chinese imports triggered by the agreement. Inconsistent with this alternative explanation, we show in Table IA-B6 that there is no differential effect of the agreement on the quantity of non-process innovations, that are typically new products, of treated firms.

Alternatively, Autor et al. (2020) shows that import competition from China reduces U.S. firms' level of patents as increased competition puts pressure on U.S. firms. To address the concern that the reduction in process innovation is capturing the overall reduction in innovation due to increased Chinese competition, in Column 1, Table 6, we add in our baseline specification variable $Import_{jt}$ and interact this variable with $Agreement_{(t>1999)}$. Following Bernard et al. (2006), $Import_{jt}$ is measured, for each manufacturing 6-digit NAICS industry, as the logarithmic growth rate of Chinese import penetration in the U.S. We show that the estimated coefficient on the new interaction term is not statistically significant in all columns, while the estimates of δ remain negative and statistically significant for the share of process innovations. The magnitude of the effect of the agreement on the process innovation is, if anything, larger compared to the baseline estimates reported in Table 3. This evidence casts doubt on increasing Chinese import competition driving our results.

A related argument is that the removal of trade barriers increases market size and allows firms to sell to new consumers, and thereby induces firms to change their innovation activities (Krugman, 1980; Grossman and Helpman, 1991; Lileeva and Trefler, 2010). Firms may pursue more innovation in order to adapt to local product markets (Utterback and Abernathy, 1975; Klepper, 1996; Mitchell and Skrzypacz, 2015), but they may possibly pursue less innovation because new consumers demand less complex products. Therefore, a possible concern is that our results capture U.S. firms' differential responses to an improved access to the Chinese large and rapidly developing market due to the agreement.

Again, we note that our results in Table IA-B6 on non-process innovations are inconsistent with this alternative explanation. To further rule out this possibility, in Table 6 Column 2 we add in our baseline specification variable $Export_{jt}$ and interact this variable with $Agreement_{(t>1999)}$. Following Bernard et al. (2006), $Export_{jt}$ is measured, for each manufacturing 6-digit NAICS industry, as the logarithmic growth rate of U.S. exports. The estimated coefficient on this interaction term is not statistically significant, while the estimates of δ remain negative and statistically significant for the share of process innovations. We continue to find similar effects when we consider the interacted effect of both $Import_{jt}$ and $Export_{jt}$ together in Column 3.

Finally, we show that our results are robust to considering changes in barriers to trade between China and the U.S. following from the U.S. granting China permanent normal trade relations (PNTR) in 2000.[17] Pierce and Schott (2016) argue that PNTR removes uncertainty about the trade relations between the two countries by eliminating potential tariff increases on Chinese goods. Following Pierce and Schott (2016), we quantify the impact of PNTR across industries by calculating the difference between the "non-Normal" Trade Relations tariff (non-NTR) rate to which tariffs would have risen if annual renewal had failed and the NTR tariff rate that is the permanent tariff rate locked in by PNTR. In Column 4, Table 6, we add in our baseline specification variable $NTR\ Gap_j$ and interact

[17] Since 1979, U.S. and China had the most favored nation (MFN) trading status, which was subject to an annual review by the U.S. The U.S. House of Representatives voted on May 24, 2000, to make MFN status permanent, giving up annual reviews of China's trade status.

this variable with $Agreement_{(t>1999)}$. We show that the estimates of δ remain negative and statistically significant for the share of process innovations.

In Columns 1-4, we considered the sample using low-wage country multinationals as controls. We repeat the same analysis in Columns 5-8 in the sample of all multinationals and find similar results. We conclude that our findings do not seem to be explained by the response of U.S. firms to increasing Chinese import competition or due to lifting of trade restrictions following the agreement.

We further address the concern that the changes in the innovation mix we observe are due to increasing competition from China, as in Autor et al. (2020), by providing evidence from the aggregate data. We split the sample of Compustat manufacturing firms by the median growth rate of Chinese import penetration over 1999-2004. Our measure is at the 6-digit NAICS industry based on Bernard et al. (2006). Figure 3, panel (a) shows that the rapid increase in the share of process innovation and the subsequent decline post-1999, observed in Figure 1, is present for both low and high import growth industries; if anything, this pattern is more pronounced for low import growth industries which is the opposite of what this alternative explanation would predict. Similarly, panel (b), Figure 3 presents the share of process innovation for firms in industries with below and above median $NTR\ Gap_j$. We observe that the sharp increase and decline in the share of process innovation is evident for industries less impacted by the removal of uncertainty about the trade relations between U.S. and China, and not for those that are the most impacted. Again, these patterns do not support an alternative interpretation of our findings, where increased competitive pressure due to China entering WTO is driving the decline in process innovations.

5.4.2 Patenting practices

We examine three possible alternative explanations of our results that are related to changes in U.S. firms' patenting practices. First, U.S. firms may transfer their R&D centers to China following the agreement. This transfer may be more likely for firms with subsidiaries in China, for example, due to positive knowledge spillovers between the production facilities in China and nearby R&D centers. Under this scenario, we may observe an increase in (process) patenting activity by treated firms' Chinese subsidiaries following the agreement, which compensates for a decrease in (process) patenting activity by the treated firms.

To address this possibility, we hand-collect information on the number of patents applied for by the treated firms' Chinese subsidiaries over the 1999-2012 period. When we look for such patents applied for at the USPTO, we are unable to find any. Next, we look for patents applied for at the Chinese State Intellectual Property Office (CSIPO). We find that 55% of the subsidiaries in our sample do not have any CSIPO patents. For the remainder 45% of the subsidiaries, we compute the ratio of the total count of patents filed by the subsidiary over the total count of patents filed by its U.S. parent firm. The median ratio is 0.003. The small magnitude of the ratio shows that this alternative explanation cannot be driving our results.

Second, it may be that trade secrets substitute for process patents. This is possible, for example, if treated firms transfer more of their production to China following the agreement, which may elevate concerns regarding China's weak intellectual property rights protection. Such concerns may be particularly relevant for process patents because they may be easier to steal or less enforceable (Levin et al., 1987).

To address this possibility, we examine the effect of the agreement on U.S. firms' R&D expenditures in Table 7. Substitution from process patents to trade secrets would suggest that R&D expenditures remain unchanged. Columns 1-3 use the sample of firms with subsidiaries in low-wage countries as controls, while Columns 4-6 use the sample of all multinationals as controls. We control for industry-year and firm fixed effects throughout our analysis. In Columns 1 and 4, we additionally control for firm size and find that R&D over sales is lower by 9% or 12% relative to the sample mean, respectively, for treated firms relative to controls, and this reduction is statistically significant at the 5% level. In Columns 2 and 5, the estimates continue to hold after controlling for market-to-book ratio, while Columns 3 and 6 show that there is no evidence of pre-trends in this analysis. Although we do not observe R&D expenditures that are specific to process innovations, these results are consistent with our baseline findings of a reduction in process innovation.

In summary, these results cast doubt on the substitution between process patents and trade secrets as an alternative explanation.

Third, it may be that the change in the mix of patented innovations we document reflects changes in patent quality. For example, due to aggravated secrecy considerations, treated firms may patent only unimportant process innovations, resulting in a lower number of process patents with lower average quality. To address this possibility, in Panel B of Table 7, we estimate the effect of the agreement on the number of citations per process patent. We define a process patent using two alternative definitions. In Columns 1-4, we define a patent to be process if the first claim of the patent is a process claim. In Columns 5-8, we define a patent to be process if all claims in the patent are process claims. We find no differential effect of the agreement on these measures of process patent quality, irrespective of the measure we use. Overall, we conclude that our findings seem inconsistent with changes in U.S. firms' patenting practices following the agreement.[18]

5.4.3 Technology focus

It is possible that U.S. firms refocus their R&D more broadly on different technology fields or functional areas, which may affect patenting of process innovations of treated firms for reasons unrelated to the agreement. To address this possibility, we test the effect of the agreement on a normalized version of process and non-process innovation where we scale process/non-process claim counts by the average number of process/non-process claims taken across all firms that applied for at least one patent in the same technology class in the same year (Bena and Li, 2014).

Table 8 presents the results for the samples using low-wage country multinationals as controls (Columns 1-4) and all multinationals as controls (Columns 5-8). While we find a reduction for the technology-adjusted process innovations following the agreement across the two samples, we find no effect on technology-adjusted non-process innovations. We conclude that our findings do not seem to be explained by changes in U.S. firms' focus on

[18] Internet Appendix Table IA-B13 shows no significant differences in the number of citations received between process and non-process patents for the average patent included in our sample.

different technology fields or functional areas following the agreement.

5.4.4 Externally sourced innovations and capital investment

Our main focus is U.S. firms' investments in process innovation following the 1999 U.S.-China bilateral agreement, that is, investments in invention of new production methods driven by a better availability of cheap labor input. As an alternative to own innovation efforts, firms can also purchase innovations embodied in capital goods. According to this view, our measure of internally produced process innovations does not capture firms' overall investments in production cost saving as it does not include improvements in production processes that occur due to innovations embodied in capital goods that firms purchase from suppliers. To explore the importance of such externally sourced innovations, we first examine whether our baseline results capture the substitution between internally produced process innovations and purchases of innovations embedded in intermediate capital goods from suppliers, and, second, we ask how the agreement affects firms' total investment in purchases of capital goods.

We define an industry-level variable $\textit{Supply of Innovations}_{jt}$ to capture the flow of innovations from originating industries to using industries. We use the 2002 U.S. Benchmark Input-Output Accounts to construct weights based on the share of outputs of using industries that are due to the supply of inputs from originating industries (Acemoglu et al., 2012). Assuming that the same weights apply to the supply of innovations embedded in intermediate goods (Delgado and Mills, 2017), we multiply the weights with the count of patents (lagged by one year) of firms in the originating industries and compute the weighted sum of innovations for each using industry in each year. We then repeat the same exercise and compute $\textit{Supply of Process Innovations}_{jt}$ based on the count of process claims (lagged by one year) of firms in the originating industries.

In Table 9, we estimate our baseline regressions additionally controlling for the industry-level supply of innovations, based on overall innovation (Columns 1-2 and 5-6) and process innovation (Columns 3-4 and 7-8), to our sample firms. In all specifications, the estimates of δ are very similar to those reported in Table 3, both in terms of economic magnitude and statistical significance. This evidence shows that changes in the technological content of the intermediate capital goods is not affecting our results, which suggests that our results cannot be explained by the substitution between internally produced and externally sourced innovations.

6 Removal of ownership restrictions on foreign investment and U.S. firms' innovation

The 1999 U.S.-China bilateral agreement was a pre-requisite for China to enter WTO and to further open its economy to foreign direct investment. The Chinese government has been gradually removing ownership restrictions on foreign direct investment imposed by the Chinese government across industries. The biggest removal of these restrictions happened between 1997 and 2002, thereby alleviating contracting frictions U.S. firms face in China. These restrictions on foreign investment, namely caps on the share of equity held by foreign investors in Chinese joint-ventures, affect how the profits of U.S. firms' Chinese subsidiaries are split between the U.S. vis-à-vis the Chinese partners.

Removing ownership restrictions has two implications for U.S. firms. First, for those firms that increase equity shares in their Chinese subsidiaries, there is a direct increase in the share of profits from the subsidiaries. Second, there is an increase in the bargaining power of U.S. firms vis-à-vis their Chinese partners, which indirectly allows them to extract a higher share of the profits. Consider a (typical) example of a sector where the Chinese partner holds a controlling stake in a subsidiary. Similarly to the effects of the 1999 U.S.-China bilateral agreement, lifting the majority ownership restriction allows the U.S. firm to gain more control over the subsidiary and thereby eliminate the potential for hold-up problems and/or resolve contract incompleteness to its benefit. The removal of the ownership restrictions on foreign investment therefore implies a reduction in effective labor costs.

The restrictions are published in the Catalogue of Industries Guiding Foreign Investment issued jointly by the National Development and Reform Commission (NDRC) and the

Ministry of Commerce (MOFCOM), China's governing bodies on economic development and trade and investment policy, respectively, and are an integral part of Chinese longstanding industrial policy. The 1999 U.S.-China bilateral agreement improved upon doing business in China, and the biggest change in ownership restrictions takes place between 1997 and 2002.

The Catalogue was first published in 1995. Since then, it was revised five times: in 1997, 2002, 2004, 2007, and 2011. For each industry, the Catalogue indicates whether there are restrictions on foreign shareholdings by requiring specific types of foreign investments or by capping the percentage of equity held by foreign investors. Industry sectors not included in the Catalogue are "permitted", as outlined in the Regulation on Guiding Foreign Investment Direction (State Council Order 346), and no ownership restrictions apply. Sectors included in the Catalogue are "encouraged", "restricted", or "prohibited". "Restricted" sectors are subject to ownership restrictions. "Encouraged" sectors can be either "permitted", and thus no ownership restrictions apply, or "restricted", which are subject to restrictions, but enjoy easier approval procedures. No investment is allowed in "prohibited" sectors. Across all revisions, the structure of the Catalogue remains the same.

We map industry descriptions used in the Catalogue into the 4-digit NAICS industry classification.[19] We then group 4-digit NAICS industries into two categories: "permitted" industries that are not subject to ownership restrictions (permitted and encouraged-permitted sectors according to the Catalogue) and "restricted" industries that are subject to such restrictions (restricted, encouraged-restricted, and prohibited sectors according to the Catalogue). We create a dummy variable which takes a value of one if an industry is not subject to ownership restrictions for each year between the year of issue of the Catalogue and the year of issue of the next Catalogue, and zero if such restrictions are in effect. We end up with time-series information on ownership restrictions for 58 industries between 1995, the year of the first Catalogue, and 2012. Figure 2 presents the share of industries in our sample that are not subject to restrictions in each year the Catalogue was

[19] The descriptions that do not match with 4-digit NAICS industries are dropped from the analysis.

issued. Consistent with the opening of China to foreign investors, the share of industries not subject to restrictions is increasing over time with the biggest change observed between 1997 and 2002.

We estimate a difference-in-differences regression similar to the one introduced in Section V.1. The regression specification is as follows:

$$\begin{aligned} y_{i,t} =& \alpha_i + \beta_t + \delta_1 \cdot \textit{No Ownership Restrictions}_{j,t} \cdot \textit{China}_{it} + \delta_2 \cdot \textit{China}_{it} \\ &+ \delta_3 \cdot \textit{No Ownership Restrictions}_{j,t} + \gamma \cdot X_{i,t-1} + \epsilon_{i,t}, \end{aligned} \tag{3}$$

where i, j, and t index firms, industries, and years, respectively; $y_{i,t}$ stands for *Share of Process Innovations*$_{it}$; *No Ownership Restrictions*$_{jt}$ is an indicator variable that takes a value of one if an industry is not subject to ownership restrictions at year t, and is zero otherwise; *China*$_{it}$, an indicator variable which takes a value of one for firms we identify as having a subsidiary in China at year t using the CIS data, 0 otherwise. $X_{i,t-1}$ are time-varying firm-level control variables lagged by one year; α_i and β_t denote firm and year fixed effects, respectively; and $\epsilon_{i,t}$ is the error term. Coefficient δ_1 captures the change in the dependent variable at U.S. firms with a subsidiary in China (treated) operating in industries where the restrictions on foreign investment are lifted as compared to years when these restrictions are in effect, relative to U.S. firms with subsidiaries in low-wage countries other than China (control) or firms with subsidiaries in all other countries other than China (alternative control group).

Table 10 presents the estimates of regression (2). Columns 1-2 present results using multinationals in low-wage countries as the control group. Columns 3-4 present results using multinationals in all countries as the control group. All columns include firm fixed effects and year fixed effects. We find that the share of process innovations decrease at treated firms following the ownership restrictions removal, as compared to control firms, across specifications. Treated firms, in Column 1, reduce their share of process innovations by 5.8% (3.5% in Column 3) more in industries where ownership restrictions are removed as compared to the control group. Overall, the results in Table 10 support our main finding that a better ability of U.S. firms to utilize cheap and abundant Chinese labor due to removal of contracting frictions leads to a shift in firms innovation mix towards less process innovations.

7 Conclusion

China's integration into the global economy has been one the most important economic developments of recent decades. Among other things, this integration is manifested by a large flow of investment by foreign companies into China that want to tap local labor market (China received $1.9 trillion FDI over the 1995-2012 period according to the World Bank). In this paper, we examine how the availability of abundant, cheap Chinese labor to U.S. multinational firms affects their mix of corporate innovation.

To answer this question, we construct a novel firm-level data set on process and non-process innovations using text-based analysis of patent claims. We show that the 1999 U.S.-China bilateral agreement benefited subsidiaries of U.S. firms already in China prior to the agreement, increasing their profitability. U.S. firms scale up their operations in China following the agreement, increasing their subsidiaries' employment. U.S. firms' better ability to tap cheap offshore labor due to an improvement in contracting institutions brought by the 1999 U.S.-China bilateral agreement leads them to shift their innovation activities away from process innovation. We obtain the same result using the inter-temporal variation in ownership restrictions on foreign investment in China across industries. Our findings suggest that changes in the prices of production inputs affects the types of technologies that are being developed—less process innovation aimed at reducing production cost. Currently, there is a heated debate on the effects of globalization, with one argument being that it leads to U.S. jobs being relocated to low wage countries. Our results suggest that stopping the "globalization of work" may not lead to more jobs in the U.S. as the firms respond by investing more in process innovation and thus rely less on labor overall.

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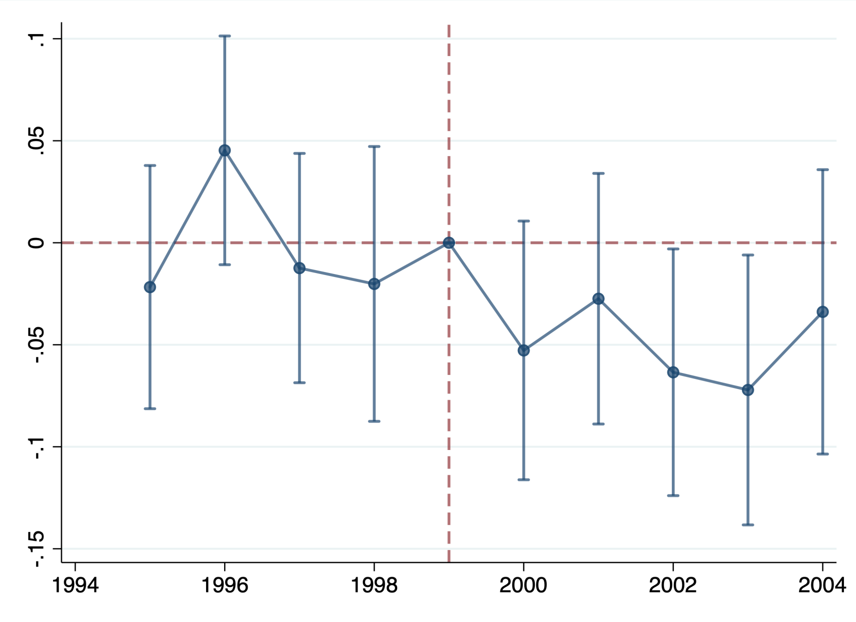
Panel (a): Aggregate and manufacturing sector

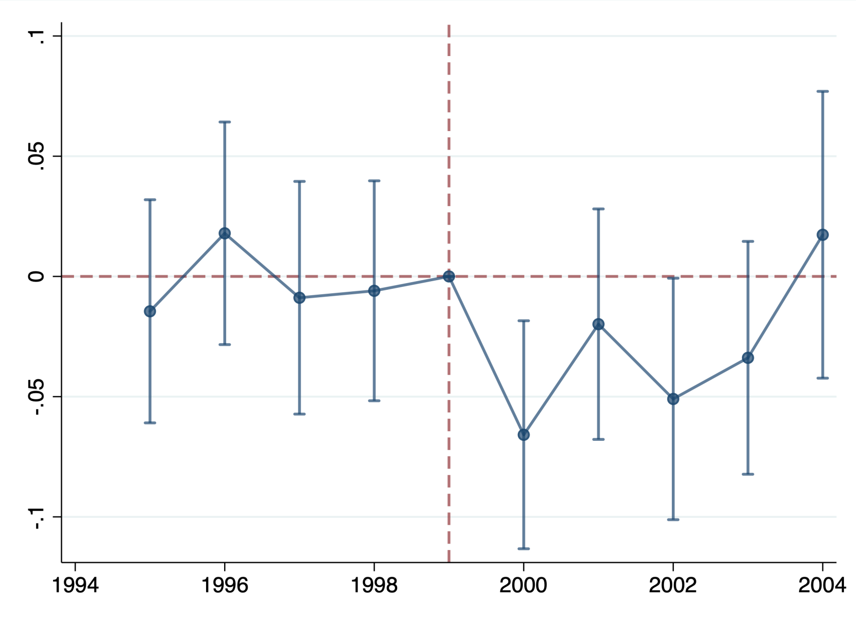
Panel (b): U.S. multinationals

Figure 1: Share of process innovations in U.S. listed firms

This figure plots the share of process innovations computed for U.S. listed firms. In Panel (a), the share is computed for all firms and for firms in the manufacturing sector (NAICS 31-33). In Panel (b), the share is computed for firms with a subsidiary in China prior to 1999, for firms with subsidiaries in low-wage countries (except China), and for firms with subsidiaries in all countries (except the U.S. and China). The dashed vertical line indicates 1999, the year when the U.S.-China bilateral agreement was signed.



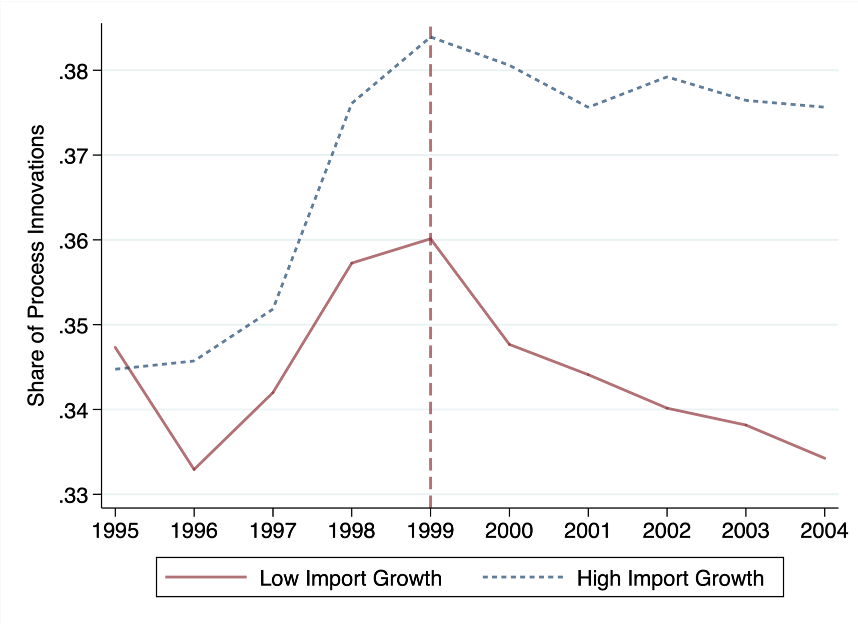
Panel (a): U.S. multinationals in low-wage countries



Panel (b): U.S. multinationals

Figure 2: Share of process innovations around the 1999 U.S.-China bilateral agreement event

This figure plots the year-by-year coefficient estimates for the share of process innovation around the 1999 U.S.-China bilateral agreement. In Panel (a), the control group includes firms with subsidiaries in low-wage countries (except China). In Panel (b), the control group includes firms with subsidiaries in all countries (except the U.S. and China). Vertical lines in each year represent 95% confidence intervals. The dashed vertical line indicates 1999, the year of the agreement.



Panel (a): By industries with low vs. high import growth from China in 1999-2004

Panel (b): By industries with low vs. high NTR Gap

Figure 3: Share of process innovations and U.S. trade with China

This figure plots the share of process innovations computed for U.S. listed firms in the manufacturing sector (NAICS 31-33). In Panel (a), the share is computed separately for firms experiencing below vs. above median growth rate of Chinese import penetration over 1999-2004 where imports are measured at 6-digit NAICS industry. In Panel (b), the share is computed separately for firms in industries with below vs. above median $NTR\ Gap_j$. The dashed vertical line indicates 1999, the year when the U.S.-China bilateral agreement was signed.

Figure 4: Breakdown of "Permitted" and "Restricted" industries for each Foreign Investment Catalogue

This figure shows the fraction of industries where foreign investment is subject to ownership restrictions (light grey) and those where investment is permitted without ownership restrictions (dark grey). The information is collected from the Catalogue of Industries Guiding Foreign Investment issued jointly by the National Development and Reform Commission ("NDRC") and the Ministry of Commerce ("MOFCOM") of China. The Catalogue was initially published in 1995 and was revised five times in 1997, 2002, 2004, 2007, and 2011.

Table 1: Summary statistics

	N	Mean	Std.	p25	p50	p75
Panel A: U.S. Multinationals in Low-wage Countries						
Share of Process Innovations	2539	0.33	0.22	0.16	0.31	0.46
Process Innovations	2539	622	1883	23	100	404
Non-Process Innovations	2539	1017	2725	65	248	803
Patents	2539	84	219	5	19	64
Adjusted Process Innovations	2539	3.37	7.08	0.00	0.69	2.64
Adjusted Non-Process Innovations	2539	3.17	5.93	0.27	0.89	2.86
Citations per Process Patent	1859	2.76	3.60	0.55	1.84	3.92
Citations per Pure Process Patent	1820	2.78	4.15	0.50	1.80	3.88
Sales (mil. $)	2539	7896	20009	830	2047	6639
Market to Book	2453	3.85	10.89	1.78	2.75	4.41
R&D Stock	2515	1565	4453	67	257	913
R&D/Sales (mil. $)	2539	0.07	0.34	0.01	0.03	0.08
TFP	2251	-0.13	0.44	-0.34	-0.17	0.08
Panel B: U.S. Multinationals						
Share of Process Innovations	6210	0.32	0.26	0.11	0.30	0.47
Process Innovations	6210	440	2065	7	36	166
Non-Process Innovations	6210	681	2625	25	89	371
Patents	6210	56	226	2	6	27
Adjusted Process Innovations	6210	2.18	7.89	0.00	0.24	1.14
Adjusted Non-Process Innovations	6210	1.92	4.92	0.11	0.36	1.38
Citations per Process Patent	3549	2.88	4.49	0.22	1.67	3.90
Citations per Pure Process Patent	3437	2.88	4.97	0.12	1.60	3.86
Sales (mil. $)	6210	5112	16249	255	930	3171
Market to Book	5981	6.09	118	1.54	2.46	4.03
R&D Stock (mil. $)	6164	841	3190	17	90	361
R&D/Sales	6210	0.10	0.50	0.01	0.03	0.10
TFP	5182	-0.19	0.47	-0.40	-0.21	0.02

This table reports summary statistics for U.S. multinationals in China and low-wage countries in Panel A, and U.S. multinationals in China and all other countries in Panel B. The sample period is 1995-2004. We define all variables in the Appendix.

Table 2: 1999 U.S.-China bilateral agreement and U.S. firms' Chinese subsidiary outcomes

	ROA	Gross Profit Margin	Log(Sales)	Fixed Operating Assets Ratio	Log(Employ -ment)	Log(Wages /Employment)
	(1)	(2)	(3)	(4)	(5)	(6)
$d_{1998} \cdot US_i$	-0.013	-0.005	-0.100*	-0.001	0.063	-0.008
	(0.009)	(0.011)	(0.057)	(0.015)	(0.048)	(0.060)
$d_{2000} \cdot US_i$	0.021**	0.011	0.083**	0.038**	0.103*	-0.113*
	(0.008)	(0.009)	(0.038)	(0.015)	(0.054)	(0.065)
$d_{2001} \cdot US_i$	0.022**	0.013	0.139***	0.050***	0.097**	-0.092
	(0.010)	(0.011)	(0.050)	(0.017)	(0.049)	(0.059)
$d_{2002} \cdot US_i$	0.037***	0.021*	0.075	0.056***	0.034	-0.029
	(0.010)	(0.011)	(0.060)	(0.018)	(0.050)	(0.054)
$d_{2003} \cdot US_i$	0.044***	0.022*	0.120**	0.020	0.058	-0.109*
	(0.011)	(0.012)	(0.061)	(0.020)	(0.053)	(0.062)
$d_{2004} \cdot US_i$	0.051***	0.027**	0.138**	0.029	0.001	-0.045
	(0.012)	(0.012)	(0.070)	(0.020)	(0.059)	(0.058)
Log(Sales)	0.059***	0.019***		-0.042***		0.103***
	(0.001)	(0.001)		(0.002)		(0.007)
Establishment FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
City × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Establishments	17666	17666	17666	17666	17578	17202
Observations	75267	75275	75275	75267	74481	72216
Adjusted R^2	0.589	0.691	0.892	0.679	0.879	0.597

This table reports results of OLS regressions of Chinese subsidiaries' outcomes around the 1999 U.S.-China bilateral agreement. We examine return on assets (ROA, operating profits/total assets in Column 1, gross profit margin (sales minus cost of sales as a fraction of sales) in Column 2, sales (log-transformed) in Column 3, fixed operating assets ratio (total fixed assets for production and operation as a fraction of total assets) in Column 4, employment (log-transformed) in Column 5, wages per employee (log-transformed) in Column 6. d_t is an indicator variable for year t. US_i is an indicator variable equal to one for Chinese subsidiaries that are matched to Compustat publicly-listed U.S. firms, and 0 for all other Chinese subsidiaries with foreign ownership. All regressions include establishment fixed effects, industry-by-year fixed effects (based on 791 4-digit industries), city-by-year fixed effects (based on 399 cities). The data for Chinese subsidiaries are from 'Chinese Industrial Survey' (CIS) database described in Section 3.1. The sample includes all subsidiaries in China with some foreign ownership over the period 1998-2004. All dependent variables not in logs are winsorized at the 1% level. Standard errors are clustered at the subsidiary-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 3: 1999 U.S.-China bilateral agreement and share of process innovations

	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.036**	-0.036**	-0.049**	-0.048**	-0.030**	-0.030**	-0.032**	-0.030**
	(0.018)	(0.018)	(0.020)	(0.019)	(0.013)	(0.013)	(0.014)	(0.014)
Log(Patents)		-0.002	-0.005	-0.005		-0.010*	-0.011**	-0.012**
		(0.007)	(0.008)	(0.008)		(0.005)	(0.006)	(0.006)
Log(Sales)			0.001	-0.003			0.000	-0.006
			(0.012)	(0.015)			(0.010)	(0.011)
Log(Market to Book)			0.001	0.001			0.000	0.000
			(0.001)	(0.001)			(0.001)	(0.001)
Log(R&D Stock)				0.008				0.013
				(0.014)				(0.009)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	339	339	324	324	991	991	936	936
Observations	2539	2539	2336	2336	6210	6210	5662	5662
Adjusted R^2	0.526	0.526	0.537	0.537	0.466	0.466	0.476	0.476

This table reports results of OLS regressions of U.S. firms' share of process innovation around the 1999 U.S.-China bilateral agreement. The sample in Columns 1-4 includes U.S. multinationals in China and other low-wage countries. The sample in Columns 5-8 includes U.S. multinationals in China and elsewhere. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-4) or in any other country except China (Columns 5-8). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 4: Cross-sectional heterogeneity: Share of Chinese subsidiary's wage bill in production costs and share of foreign capital of U.S. firms' Chinese subsidiaries

Panel A: Share of Chinese wage bill in the cost of goods sold (COGS)

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
$\text{Agreement}_{t>1999} \cdot \text{China}_i \cdot \text{Wage/COGS}_i$	-7.967**	-7.899**	-7.723*	-7.632*
	(3.477)	(3.366)	(4.266)	(4.104)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.054**	-0.053**	-0.031*	-0.030*
	(0.022)	(0.022)	(0.016)	(0.016)
Log(Sales)	-0.004	-0.009	-0.002	-0.008
	(0.012)	(0.016)	(0.010)	(0.011)
Log(Market to Book)	0.001	0.001	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.001	-0.001	-0.010*	-0.011*
	(0.009)	(0.009)	(0.006)	(0.006)
Log(R&D Stock)		0.010		0.013
		(0.017)		(0.010)
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
Number of Firms	280	280	892	892
Observations	1978	1978	5277	5277
Adjusted R^2	0.540	0.540	0.474	0.474

Panel B: Share of foreign capital

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
Agreement$_{t>1999}\cdot$ China$_i\cdot$ %Foreign Capital$_i$	0.140**	0.143**	0.117**	0.121**
	(0.070)	(0.070)	(0.060)	(0.059)
Agreement$_{t>1999}\cdot$ China$_i$	-0.160***	-0.161***	-0.123***	-0.125***
	(0.049)	(0.049)	(0.038)	(0.038)
Log(Sales)	-0.003	-0.020	-0.001	-0.011
	(0.015)	(0.019)	(0.011)	(0.012)
Log(Market to Book)	0.001	0.001	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.008	-0.008	-0.013**	-0.014**
	(0.010)	(0.010)	(0.006)	(0.006)
Log(R&D Stock)		0.034		0.020*
		(0.022)		(0.011)
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
Number of Firms	255	255	870	870
Observations	1597	1597	4904	4904
Adjusted R^2	0.529	0.531	0.465	0.466

This table reports results of OLS regressions of U.S. firms' share of process innovation around the 1999 U.S.-China bilateral agreement. The sample and regression specifications correspond to those in Table 3, Columns 3-4 and Columns 7-8, except that we include the interaction of $Agreement(t > 1999) \times China_i$ with variable $Wage/COGS_i$ in Panel A and with $\%ForeignCapital_i$ in Panel B. $Wage/COGS_i$ is the ratio of the wagebill of the Chinese subsidiary over the cost of goods sold (COGS) of the U.S. Compustat matched parent company in 1998. $\%ForeignCapital_i$ is the share of foreign capital divided by the total capital of the subsidiary in 1998. This ratio is meaningful for joint ventures, and thus, the sample in Panel B includes treated firms with Chinese subsidiaries that are joint ventures. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-2) or in any other country except China (Columns 3-4). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 5: U.S. Firms' Total Factor Productivity

	TFP					
	U.S. Multinationals in Low-wage Countries			U.S. Multinationals		
	(1)	(2)	(3)	(4)	(5)	(6)
Agreement$_{t>1999}\cdot$ China$_i$	0.063**	0.064**		0.059***	0.063***	
	(0.032)	(0.032)		(0.018)	(0.019)	
d$_{1995}\cdot$ China$_i$			0.003			-0.028
			(0.036)			(0.028)
d$_{1996}\cdot$ China$_i$			0.002			-0.036
			(0.037)			(0.028)
d$_{1997}\cdot$ China$_i$			-0.035			-0.045*
			(0.034)			(0.026)
d$_{1998}\cdot$ China$_i$			-0.010			-0.028
			(0.032)			(0.024)
d$_{2000}\cdot$ China$_i$			0.003			0.003
			(0.029)			(0.020)
d$_{2001}\cdot$ China$_i$			0.121**			0.069**
			(0.052)			(0.028)
d$_{2002}\cdot$ China$_i$			0.090**			0.058**
			(0.043)			(0.027)
d$_{2003}\cdot$ China$_i$			0.040			0.023
			(0.042)			(0.031)
d$_{2004}\cdot$ China$_i$			0.023			0.006
			(0.041)			(0.032)
Log(Sales)		0.019			0.023	
		(0.036)			(0.021)	
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	363	363	363	1153	1153	1153
Observations	2889	2889	2889	8694	8694	8694
Adjusted R^2	0.613	0.613	0.613	0.518	0.518	0.518

This table reports results of OLS regressions on U.S. firms' total factor productivity (TFP) around the 1999 U.S.-China bilateral agreement. The sample in Columns 1-3 includes U.S. multinationals in China and other low-wage countries. The sample in Columns 3-6 includes U.S. multinationals in China and elsewhere. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-3) or in any other country except China (Columns 4-6). d_t is an indicator variable for year t. TFP is constructed using the methodology of Olley and Pakes (1996) applied on Compustat data using the procedure in İmrohoroğlu and Tüzel (2014). *Log(Sales)* are lagged by one year. All regressions include firm and year fixed effects. TFP, by construction, controls for industry effects in each year. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 6: U.S. trade with China

	Share of Process Innovations							
	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Agreement}_{t>1999} \cdot China_i$	-0.052**	-0.049**	-0.053**	-0.048**	-0.035**	-0.030*	-0.035**	-0.025*
	(0.021)	(0.021)	(0.021)	(0.022)	(0.015)	(0.015)	(0.015)	(0.015)
$\text{Agreement}_{t>1999} \cdot Import_{jt}$	-0.001		-0.001		0.002		0.001	
	(0.007)		(0.007)		(0.006)		(0.005)	
Agreement(t>1999) $\cdot Export_{jt}$		-0.025	-0.033			0.002	-0.010	
		(0.025)	(0.027)			(0.015)	(0.017)	
$\text{Agreement}_{t>1999} \cdot NTRGap_j$				-0.222**				-0.214**
				(0.112)				(0.088)
Import_{jt}	-0.001		-0.002		-0.014		-0.013	
	(0.012)		(0.012)		(0.010)		(0.010)	
Export_{jt}		0.001	0.010			-0.003	0.012	
		(0.017)	(0.020)			(0.011)	(0.011)	
NTR Gap_j				-0.196				0.015
				(0.169)				(0.130)
Log(Sales)	0.001	-0.003	0.000	-0.007	-0.001	-0.003	-0.001	0.002
	(0.015)	(0.016)	(0.016)	(0.016)	(0.013)	(0.013)	(0.013)	(0.012)
Log(Market to Book)	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.004	-0.004	-0.004	-0.005	-0.010	-0.011	-0.010	-0.013**
	(0.009)	(0.009)	(0.009)	(0.009)	(0.007)	(0.007)	(0.007)	(0.006)
Log(R&D Stock)	0.014	0.014	0.014	0.012	0.010	0.010	0.010	0.012
	(0.015)	(0.015)	(0.015)	(0.015)	(0.011)	(0.011)	(0.011)	(0.011)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	250	252	250	274	658	670	658	746
Observations	1803	1822	1803	1949	4102	4188	4102	4615
Adjusted R^2	0.520	0.519	0.520	0.556	0.450	0.441	0.450	0.485

This table reports results of OLS regressions on the share of process innovation around the 1999 U.S.-China bilateral agreement. The sample in Columns 1-4 includes U.S. multinationals in China and other low-wage countries. The sample in Columns 5-8 includes U.S. multinationals in China and elsewhere. The regression specifications correspond to those in Table 2 Column 4, except we focus on manufacturing firms and include additional variables $Import_{jt}$, $Export_{jt}$ and $NTRGap_j$ and interact those variables with Agreement(t>1999). Following Bernard et al. (2006), for each manufacturing 6-digit NAICS industry, $Import_{jt}$ is the logarithmic growth rate of Chinese import penetration in the U.S, while $Export_{jt}$ is the logarithmic growth rate of U.S. exports. Following Pierce and Schott (2016), we define $NTRGap_j$ as the difference between the non-NTR rate to which tariffs would have risen if annual renewal had failed and the NTR tariff rate that is locked in by PNTR for (a 6-digit NAICS) industry j. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated), and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-4) or in another country except China (Columns 5-8). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 7: Trade secrets substituting for process innovations

Panel A: R&D expenditure

	Log(R&D/Sales)					
	U.S. Multinationals in Low-wage Countries			U.S. Multinationals		
	(1)	(2)	(3)	(4)	(5)	(6)
Agreement$_{t>1999}$· China$_i$	-0.007**	-0.008**		-0.012*	-0.013*	
	(0.003)	(0.004)		(0.007)	(0.007)	
d$_{1995}$· China$_i$			-0.004			-0.002
			(0.007)			(0.010)
d$_{1996}$· China$_i$			-0.005			-0.006
			(0.008)			(0.010)
d$_{1997}$· China$_i$			-0.002			-0.002
			(0.007)			(0.009)
d$_{1998}$· China$_i$			-0.004			-0.006
			(0.007)			(0.008)
d$_{2000}$· China$_i$			-0.003			-0.008
			(0.005)			(0.007)
d$_{2001}$· China$_i$			-0.008			-0.014
			(0.009)			(0.011)
d$_{2002}$· China$_i$			-0.011			-0.015
			(0.008)			(0.010)
d$_{2003}$· China$_i$			-0.016*			-0.019*
			(0.009)			(0.011)
d$_{2004}$· China$_i$			-0.015*			-0.022*
			(0.009)			(0.013)
Log(Sales)	-0.015*	-0.010*	-0.015*	-0.027***	-0.028*	-0.027***
	(0.008)	(0.006)	(0.008)	(0.010)	(0.014)	(0.010)
Log(Market to Book)		-0.000			-0.000	
		(0.000)			(0.000)	
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	389	380	389	1318	1279	1318
Observations	3346	3101	3346	11008	10084	11008
Adjusted R^2	0.826	0.873	0.826	0.742	0.757	0.742

Panel B: Citation intensity

	Citations of Process Innovations				Citations of Pure Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals		U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.054	-0.049	-0.101	-0.092	-0.063	-0.164	-0.198	-0.196
	(0.110)	(0.108)	(0.085)	(0.084)	(0.348)	(0.343)	(0.276)	(0.270)
Log(Sales)	0.093	0.074	0.101	0.060	0.345	0.777	0.297	0.290
	(0.090)	(0.106)	(0.071)	(0.076)	(0.403)	(0.584)	(0.442)	(0.488)
Log(Market to Book)	-0.003	-0.003	-0.002	-0.002	-0.011	-0.014	0.001	0.001
	(0.005)	(0.005)	(0.004)	(0.004)	(0.017)	(0.017)	(0.015)	(0.015)
Log(Patents)	0.117^{***}	0.116^{**}	0.132^{***}	0.130^{***}	0.053	0.079	0.176	0.175
	(0.045)	(0.045)	(0.038)	(0.038)	(0.179)	(0.186)	(0.183)	(0.184)
Log(R&D Stock)		0.030		0.075		-0.700		0.012
		(0.088)		(0.067)		(0.512)		(0.426)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	257	257	551	551	253	253	532	532
Observations	1684	1684	3077	3077	1644	1644	2966	2966
Adjusted R^2	0.389	0.389	0.372	0.372	0.274	0.275	0.261	0.260

This table reports results of OLS regressions on R&D expenditure over sales (Panel A) and citations per (pure) process patent (Panel B) around the 1999 U.S.-China bilateral agreement. We add one to R&D over sales and log-transform the variable. We count citations received over a five-year window period starting from each patent's award year. We transform the citation variables in Panel B using the inverse hyperbolic sine function. The sample in Columns 1-3 (Panel A) and Columns 1-4 (Panel B) includes U.S. multinationals in China and other low-wage countries. The sample in Columns 4-6 (Panel A) and Columns 5-8 (Panel B) includes U.S. multinationals in China and elsewhere. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated), and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-3 in Panel A and Columns 1-4 in Panel B) or in another country except China (Columns 4-6 in Panel A and Columns 5-8 in Panel B). d_t is an indicator variable for year t. *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 8: Technology focus

	Adjusted Process Innovations		Adjusted Non -process Innovations		Adjusted Process Innovations		Adjusted Non -process Innovations	
	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Agreement_{t>1999} \cdot China_i$	-0.112**	-0.112**	0.013	0.022	-0.100**	-0.101**	-0.019	-0.015
	(0.055)	(0.055)	(0.045)	(0.045)	(0.043)	(0.043)	(0.032)	(0.032)
Log(Sales)	0.045	0.048	0.064*	0.024	0.045**	0.049**	0.021	0.007
	(0.039)	(0.039)	(0.033)	(0.033)	(0.020)	(0.021)	(0.019)	(0.020)
Log(Market to Book)	0.001	0.001	-0.001	-0.001	0.000	0.000	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	0.509***	0.509***	0.540***	0.537***	0.390***	0.390***	0.458***	0.457***
	(0.032)	(0.032)	(0.025)	(0.025)	(0.020)	(0.021)	(0.018)	(0.018)
Log(R&D Stock)		-0.004		0.081***		-0.009		0.029**
		(0.027)		(0.024)		(0.015)		(0.015)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	324	324	324	324	936	936	936	936
Observations	2336	2336	2336	2336	5662	5662	5662	5662
Adjusted R^2	0.892	0.892	0.940	0.940	0.879	0.879	0.930	0.930

This table reports results of OLS regressions of U.S. firms' process and non-process innovations, adjusted using technology-class-and-time-period means computed across all patenting firms, around the 1999 U.S.-China bilateral agreement. The measures of adjusted process (non-process) innovations are based on process (non-process) patents and transformed using the inverse hyperbolic sine function. The sample in Columns 1-4 includes U.S. multinationals in China and other low-wage countries, while the sample in Columns 5-8 includes U.S. multinationals in China and elsewhere. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-4) or in any other country except China (Columns 5-8). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 9: Externally sourced innovations

	Share of Process Innovations							
	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agreement$_{t>1999}$ $\cdot$ China$_i$	-0.049**	-0.048**	-0.049**	-0.047**	-0.034**	-0.032**	-0.033**	-0.032**
	(0.020)	(0.020)	(0.020)	(0.020)	(0.014)	(0.014)	(0.014)	(0.014)
Log(Sales)	0.007	0.001	0.007	0.001	0.007	-0.000	0.007	-0.000
	(0.013)	(0.016)	(0.013)	(0.016)	(0.010)	(0.011)	(0.010)	(0.011)
Log(Market to Book)	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.006	-0.007	-0.007	-0.007	-0.012*	-0.012**	-0.012**	-0.012**
	(0.008)	(0.009)	(0.008)	(0.009)	(0.006)	(0.006)	(0.006)	(0.006)
Log(R&D Stock)		0.012		0.012		0.014		0.014
		(0.015)		(0.015)		(0.009)		(0.009)
Log(Supply of Innovations$_{jt}$)	-0.076***	-0.079***			-0.058***	-0.059***		
	(0.028)	(0.029)			(0.018)	(0.018)		
Log(Supply of Process Innovations$_{jt}$)			-0.068**	-0.071***			-0.050***	-0.051***
			(0.026)	(0.027)			(0.018)	(0.018)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry $\times$ Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	307	307	307	307	904	904	904	904
Observations	2170	2170	2170	2170	5383	5383	5383	5383
Adjusted R^2	0.549	0.549	0.548	0.549	0.476	0.477	0.476	0.476

This table reports results of OLS regressions of U.S. firms' share of process innovation around the 1999 U.S.-China bilateral agreement. The sample in Columns 1-4 includes U.S. multinationals in China and other low-wage countries, while the sample in Columns 5-8 includes U.S. multinationals in China and elsewhere. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-4) or in any other country except China (Columns 5-8). We include additional industry-level control variables *Supply of Innovations*$_{jt}$ (Columns 1-2 and 5-6) and *Supply of Process Innovations*$_{jt}$ (Columns 3-4 and 7-8). *Supply of Innovations*$_{jt}$ is the weighted sum of patented innovations of firms in the originating industries (lagged by one year) computed for each using industry in each year. Originating and using industry linkages are defined using the 2002 U.S. Benchmark Input-Output Accounts with weights being the shares of outputs of using industries that are due to the supply of inputs from originating industries. *Supply of Process Innovations*$_{jt}$ is the analogous measure for process innovation. *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table 10: Removal of ownership restrictions on FDI and the share of process innovation

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
No Ownership Restrictions$_{jt}$ · China$_{it}$	-0.058**	-0.057**	-0.035*	-0.034*
	(0.026)	(0.026)	(0.019)	(0.019)
No Ownership Restrictions$_{jt}$	0.053**	0.052**	0.027*	0.028*
	(0.023)	(0.023)	(0.015)	(0.015)
China$_{it}$	0.027	0.025	0.017	0.014
	(0.025)	(0.025)	(0.025)	(0.025)
Log(Sales)	0.007	0.000	0.010	-0.003
	(0.013)	(0.016)	(0.010)	(0.011)
Log(Market to Book)	-0.000	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.008	-0.009	-0.015**	-0.017***
	(0.009)	(0.009)	(0.006)	(0.006)
Log(R&D Stock)		0.012		0.024***
		(0.012)		(0.009)
Firm FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Number of Firms	374	374	864	864
Observations	2446	2446	4862	4862
Adjusted R^2	0.558	0.558	0.480	0.482

This table reports results of OLS regressions of U.S. firms' share of process innovation on firms that operate in industries with no restrictions on foreign ownership of Chinese subsidiaries imposed by the Chinese government (*No Ownership Restrictions*$_{jt}$) as compared to control firms. The sample in Columns 1-2 includes U.S. multinationals in China and other low-wage countries. The sample in Columns 3-4 includes U.S. multinationals in China and elsewhere. The sample period is 1995-2012. *No Ownership Restrictions*$_{jt}$ is an indicator variable equal to one if the U.S. firm's industry, defined at the 4-digit NAICS level, is not subject to foreign ownership restrictions at a given year, and equal to zero otherwise. *China*$_{it}$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China in a given year (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-2) or in any other country except China (Columns 3-4). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Appendix: Variable definitions

Variable	Definition
Share of Process Innovations$_{it}$	Ratio of the number of process claims to the number of all claims included in patents applied for by firm i in year t. Source: The United States Patent and Trademark Office (USPTO).
Share of Citation-weighted (Pure) Process Innovations$_{it}$	Ratio of the citation-weighted number of process patents to the citation-weighted number of all patents applied for by firm i in year t, where the weight is the number of citations received by a patent within a five-year window period starting from each patent's award year. We classify a patent as a process patent if the first patent's claim is a process claim. Alternatively, we classify a patent as a pure process patent if all patent's claims are process claims. Source: USPTO.
Share of Process Innovations_Independent$_{it}$	Ratio of the number of independent process claims to the number of all independent claims included in patents applied for by firm i in year t. Source: USPTO.
Process (Non-process) Innovations$_{it}$	Number of process (non-process) claims included in patents applied for by firm i in year t. We transform the variables using the inverse hyperbolic sine function. Source: (USPTO).
(Pure) Process (Non-process) Innovations_Adjusted$_{it}$	Adjusted number of (pure) process (non-process) patents applied for by firm i in year t. The adjustment is done in three steps. First, for each technology class k and patent application year t, we compute the mean value of the number of process (non-process) patents in technology class k with application year t across all firms that were awarded at least one patent in technology class k with application year t. Second, we scale the number of process (non-process) patents of firm i in technology class k with application year t by the corresponding (technology class- and application year-specific) mean value from the first step. Third, for firm i, we sum the scaled number of patents from the second step across all technology classes in year t. We assign a patent proportionally to all technology classes listed on the patent. Technology classes are defined using the Cooperative Patent Classification (CPC) classification. We classify a patent as a process patent if the first patent's claim is a process claim, and as a non-process patent if the first patent's claim is a non-process claim. Alternatively, we classify a patent as a pure process patent if all patent's claims are process claims, and as a pure non-process patent if all patent's claims are non-process claims. We transform the variables using the inverse hyperbolic sine function. Source: USPTO.
Citations of (Pure) Process Innovations$_{it}$	Number of citations received by (pure) process patents applied for by firm i in year t divided by the number of (pure) process patents applied for by firm i in year t. We count citations received over a five-year window period starting from each patent's award year. We transform the variables using the inverse hyperbolic sine function. Source: USPTO.
Log(Patents$_{it}$)	Natural logarithm of one plus the number of patents applied for by firm i in year t. Source: USPTO.
TFP	TFP is constructed using the methodology of Olley and Pakes (1996) applied on Compustat data using the procedure in İmrohoroğlu and Tüzel (2014). Source: İmrohoroğlu and Tüzel (2014).
Log(R&D/Sales)	Natural logarithm of one plus R&D expenditures over sales R&D/Sales is winsorized at 1% level. Source: Compustat.
Log(Sales$_{it}$)	Natural logarithm of sales of firm i in year t. The variable is winsorized at 1% level. Source: Compustat.
Log(Market to Book$_{it}$)	Natural logarithm of the market to book ratio of firm i in year t. The variable is winsorized at 1% level. Source: Compustat.
Log(R&D Stock$_{it}$)	Natural logarithm of a firm's R&D stock computed by adding its R&D spending year-by-year since 1950 and assuming an annual depreciation rate of 15%. Firm-years with missing R&D spending are set to zero. Source: Compustat.

Appendix: Variable definitions (cont.)

Variable	Definition
Wage/COGS$_i$	Ratio of the wage bill of the U.S. firms' Chinese subsidiaries over the cost of goods sold (COGS) of the U.S. Compustat matched parent company in 1998. This variable varies across treated firms and is zero for control firms. Source: 'Chinese Industrial Survey' (CIS) data described in Section 3.1 and Compustat.
Foreign Capital$_i$	Ratio of foreign capital divided by the total capital of the U.S. firms' Chinese subsidiaries in 1998. We define this measure for Foreign-Chinese joint ventures based on their registration status. This variable varies across treated firms and is zero for control firms. Source: Source: 'Chinese Industrial Survey' (CIS) data described in Section 3.1 and Compustat.
Import$_{jt}$	For each manufacturing 6-digit NAICS industry j, we define $Import_{jt}$ as the logarithmic growth rate of Chinese import penetration in the U.S. Source: Bernard et al. (2006).
Export$_{jt}$	For each manufacturing 6-digit NAICS industry j, we define $Export_{jt}$ as the logarithmic growth rate of exports from the U.S. Source: Bernard et al. (2006).
NTR Gap$_j$	For each manufacturing 6-digit NAICS industry j, we define $NTR\ Gap_j$ as the difference between the non-NTR rate to which tariffs would have risen if annual renewal had failed and the NTR tariff rate that is locked in by the Permanent Normal Trade Relations (PNTR). Source: Pierce and Schott (2016).
Supply of (Process) Innovations$_{jt}$	Weighted sum of firms' (process claims) patents in the originating industries (lagged by one year) computed for each using industry j and each year t. Originating and using industry linkages are defined using the 2002 U.S. Benchmark Input-Output Accounts with weights being the shares of outputs of using industries that are due to the supply of inputs from originating industries. To construct these weights, we follow Acemoglu et al. (2012). We translate the I-O industry codes into NAICS industry codes available in Compustat. Source: USPTO and BEA Benchmark Input-Output Data.
No Ownership Restrictions$_{jt}$	Indicator variable that takes a value of one if industry j is not subject to ownership restrictions on foreign investment imposed by the Chinese government at year t, and is zero otherwise. We map industry descriptions used in the Catalogue into the 4-digit NAICS industry classification. Source: Catalogue of Industries Guiding Foreign Investment issued jointly by the National Development and Reform Commission (NDRC) and the Ministry of Commerce (MOFCOM).

Internet Appendix to

Machines could not compete with Chinese labor: Evidence from U.S. firms' innovation

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Elena Simintzi
University of North Carolina and CEPR

December, 2022

A Patented process innovation - Methodology

A.1 Textual analysis to identify inventions of new processes

Data from patent grant publication documents issued by the United States Patent and Trademark Office (USPTO) are available in machine readable data format using the 'PatentsView by USPTO' project available at `https://patentsview.org/`. This data include full texts of patent claims. Claims define–in technical terms–the subject matter the patent protects. Claims are critical defining elements of a patent and are the primary subject of examination in patent prosecution. Claims are also crucial in patent litigation cases.

Within a patent grant publication document, claims are numbered sequentially, with the first claim typically being the broadest and the most important one. Claims are of two basic types: process and non-process. Claims are written in a very legalistic and stilted way, which allows us to apply text analysis techniques to clearly determine the claim type. Claims that refer to process innovations begin with "A method for" or "A process for" (or minor variations of these two strings) followed by a verb (typically in gerund form), which directs to actions that are to take place as part of the process. We machine-read the text of all claims in USPTO patents and use regular expression language to denote claims that begin in this way as process claims, while we denote the residual as non-process claims.

A.2 Summary statistics

Table IA-A1 reports summary statistics on claim types per patent. Panel A is based on the universe of 4,233,476 utility patents issued by USPTO with application dates between January 1976 and December 2012. On average, a patent has 15.2 claims, of which 4.6 are process, 10.7 are non-process, 2.7 are independent, and 12.5 are dependent. In this sample, process claims are 30% of total claims. When we look at the patent decomposition, there are 14.7% patents that contain only process claims and 25.4% patents with a process claim as the first claim. Panel B is based on 1,855,328 utility patents applied for at USPTO by firms matched to Compustat with application dates between January 1976 and December

2012. The innovation mix of Compustat firms is very similar to that of the patent universe. Specifically, on average, a patent has 16.0 claims, of which 5.3 are process, 10.7 are non-process, 2.9 are independent, and 13.1 are dependent. In this sample, process claims are 33% of total claims. When we look at the patent decomposition, there are 15.7% patents that contain only process claims and 29.7% patents with a process claim as the first claim.

A.3 Validation

We validate our measures by providing comparisons with external sources. The 'Business Research and Development and Innovation Survey' in the U.S., conducted by the National Science Foundation (NSF), reports the number of R&D performing firms that introduced new processes every year since 2006. On average, 42% of firms performing R&D over the 2006-2011 period, and 44% of firms with R&D activity over $100 million, report that they perform process innovation. Comparably, using our data, we find that 46% of Compustat firms patented process innovations over the same period. We also find that over the same period, on average, 39% of patented innovations are process innovations, albeit there is no question in the NSF survey that would allow us to make a direct comparison.[20] Analogous statistics to those available in the NSF survey are also provided by the 'European Firms in Global Economy: internal policies for external competitiveness' (EFIGE) survey performed in 2010 in 8 European countries. Table IA-A2 shows that the percentage of firms active in process innovation ranges from 40 to 51 in these countries. Overall, both surveys confirm our finding that about 45% of R&D-active firms engage in process innovation.

Process innovation reduces firms' overall production costs (Cohen and Klepper, 1996; Eswaran and Gallini, 1996; Link, 1982; Scherer, 1982, 1984). We present further evidence that, in our sample on average, process innovation shares the features of a labor-saving technology. According to the labor economics literature, labor-saving technology is one key driver for the displacement of low- and middle-skilled jobs that we observe in the aggregate data (Acemoglu and Autor, 2011; Autor et al., 2003). At the same time, this same tech-

[20]Estimates from earlier studies of the average process share in the manufacturing sector in the 1980s ranges between 25% to 30%. See Cohen and Klepper (1996) for a more detailed discussion.

nology should increase demand for high-skill workers as new technology disproportionally increases productivity of high-skill employees. In other words, technology is complementary to human capital (Autor et al., 1998; Krueger, 1993). Consistent with broader patterns of technology adoption in the economy, we show that the share of process innovation sharply increases starting in late 80s/early 90s in manufacturing and services (Figure IA-A3), while the largest increase characterizes industries that have high labor-to-capital ratios which are presumably investing in automation to reduce their dependence on labor (Figure IA-A4). We futher show that the share of process innovation is i) positively correlated with capital intensity, ii) negatively correlated with the share of low- and middle-skilled employees, and iii) positively correlated with average productivity and with average wages.

We use data at the (6-digit NAICS) industry and year level from the NBER-CES Manufacturing Industry Database. Our sample covers the 1975-2010 period, for which our measure of share of process innovation is available. Table IA-A3 presents the results. We control for industry and year fixed effects in all columns and we lag our industry-level measure of the share of process innovation by one year. Column 1 shows that an increase in process innovation is associated with higher capital intensity in the industry. We measure industry capital intensity as the real capital invested in equipment over the total number of employees. In contrast, we capture no significant association when we instead measure capital intensity as the real capital invested in structures (e.g., buildings) over the total number of employees in Column 2. Consistent with labor-saving technology displacing low- and middle-skilled workers, we find in Column 3 that process innovation is negatively associated with the subsequent share of production workers. At the same time, consistent with technology increasing the productivity of high-skill employees, we find that process innovation positively relates to average employee productivity (proxied by sales per employee) in Column 4 and to average wages (proxied by total wages per employee) in Column 5.

Method of manufacturing a vehicle

US 8317964 B2

ABSTRACT

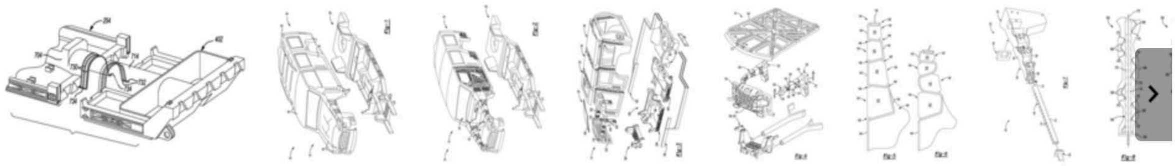
A method of manufacturing a vehicle. A set of vehicle body structure components is assembled with interlocking mating features.

Publication number	US8317964 B2
Publication type	Grant
Application number	US 11/622,164
Publication date	27 Nov 2012
Filing date	11 Jan 2007
Priority date	11 Jan 2007
Also published as	US20080201952
Inventors	Gregory Thomas Hedderly
Original Assignee	Ford Motor Company
Export Citation	BiBTeX, EndNote, RefMan

Patent Citations (99), Non-Patent Citations (28), Referenced by (4), Classifications (25), Legal Events (1)

External Links: USPTO, USPTO Assignment, Espacenet

IMAGES (35)



DESCRIPTION

BACKGROUND OF THE INVENTION Field of the Invention

The present invention relates to a method of manufacturing a vehicle.

SUMMARY OF THE INVENTION

In at least one embodiment of the present invention, a method of manufacturing a vehicle is provided. The method includes providing a set of cast vehicle body

CLAIMS (11)

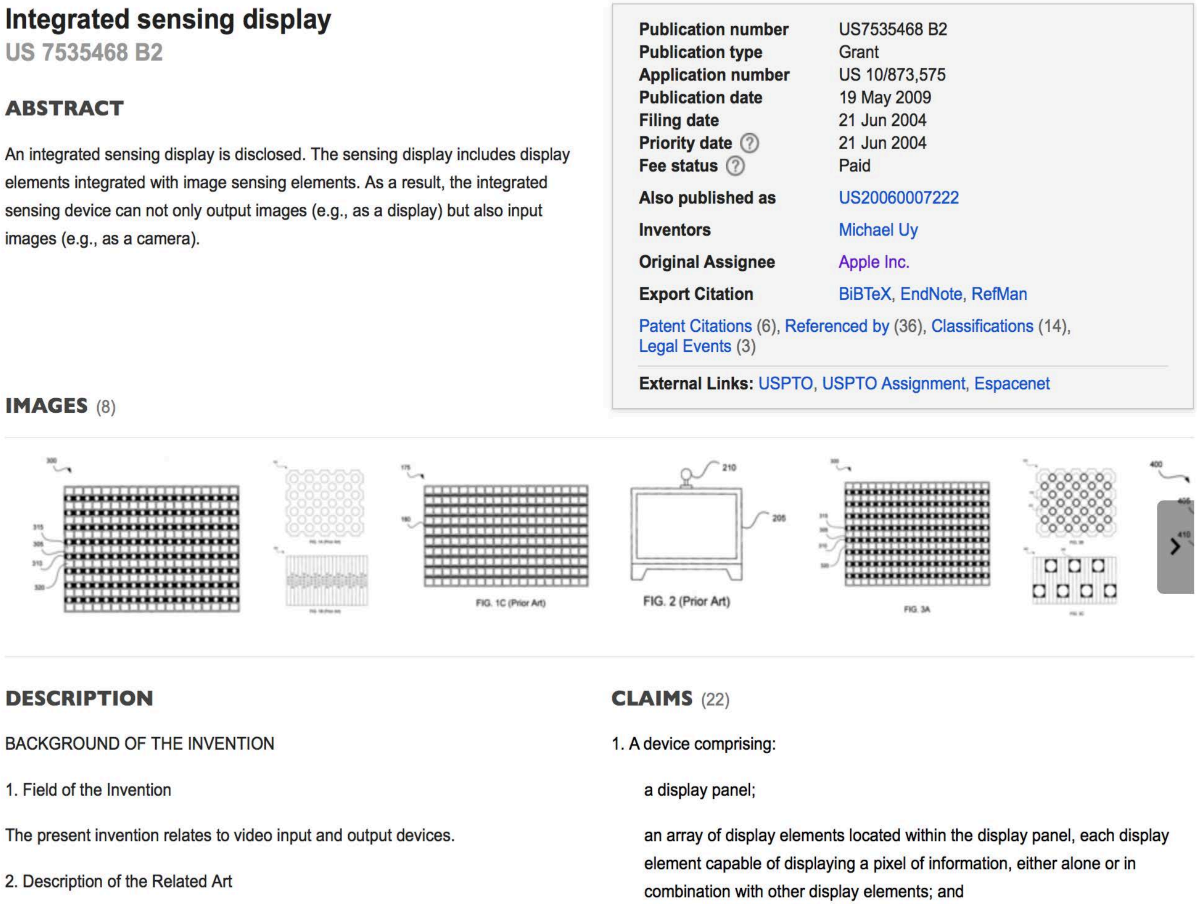
1. A method of manufacturing a vehicle, comprising:

selecting first and second subsets from a set of body structure components;

assembling a floor portion by interlocking members of the first subset, wherein a first member has substantially parallel tunnel ribs that are spaced apart and extend continuously from a first upwardly extending cuff over a tunnel to a second upwardly extending cuff and that are received in

Figure IA-A1: Example of process innovations (US 8317964 B2)

This figure shows an example of a process patent comprised of 11 claims.



Integrated sensing display

US 7535468 B2

ABSTRACT

An integrated sensing display is disclosed. The sensing display includes display elements integrated with image sensing elements. As a result, the integrated sensing device can not only output images (e.g., as a display) but also input images (e.g., as a camera).

Publication number	US7535468 B2
Publication type	Grant
Application number	US 10/873,575
Publication date	19 May 2009
Filing date	21 Jun 2004
Priority date	21 Jun 2004
Fee status	Paid
Also published as	US20060007222
Inventors	Michael Uy
Original Assignee	Apple Inc.
Export Citation	BiBTeX, EndNote, RefMan

Patent Citations (6), Referenced by (36), Classifications (14), Legal Events (3)

External Links: USPTO, USPTO Assignment, Espacenet

IMAGES (8)

FIG. 1C (Prior Art)

FIG. 2 (Prior Art)

FIG. 3A

DESCRIPTION

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to video input and output devices.

2. Description of the Related Art

CLAIMS (22)

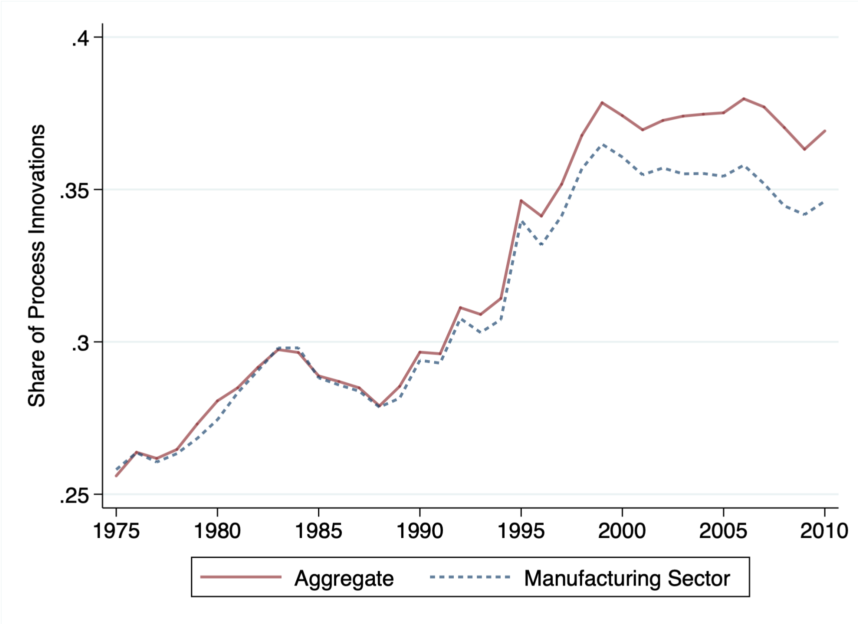
1. A device comprising:

a display panel;

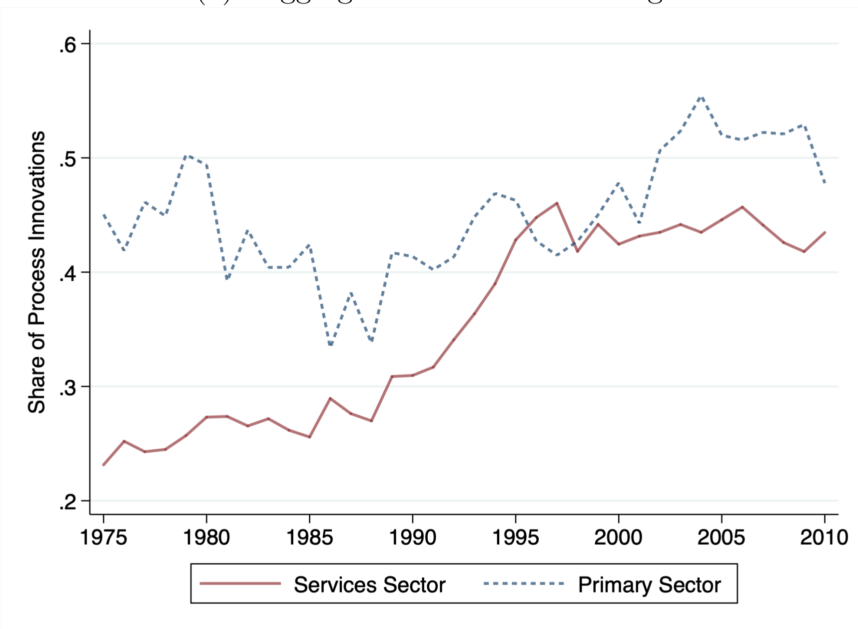
an array of display elements located within the display panel, each display element capable of displaying a pixel of information, either alone or in combination with other display elements; and

Figure IA-A2: Example of non-process innovations (US 7535468 B2)

This figure shows an example of a non-process patent comprised of 22 claims.



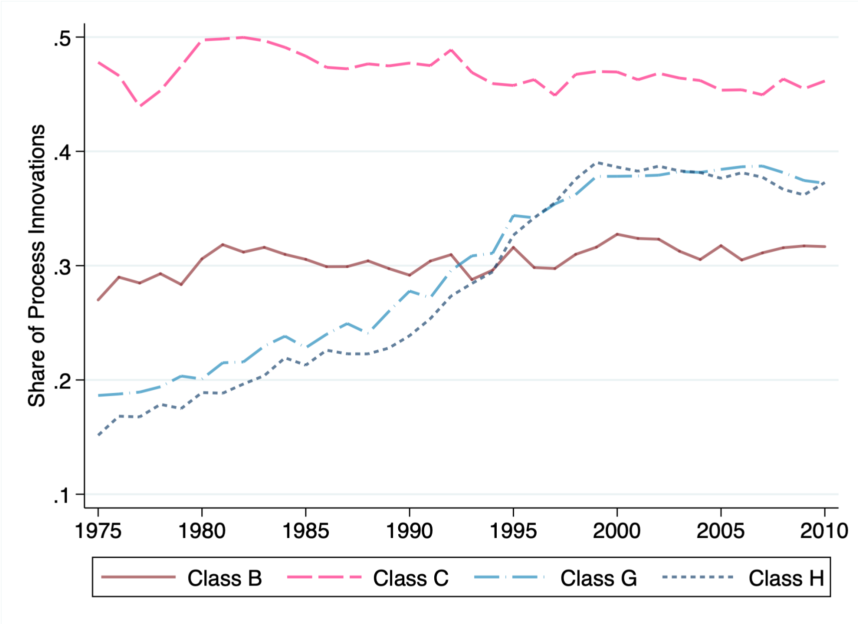
Panel (a): Aggregate and manufacturing sector



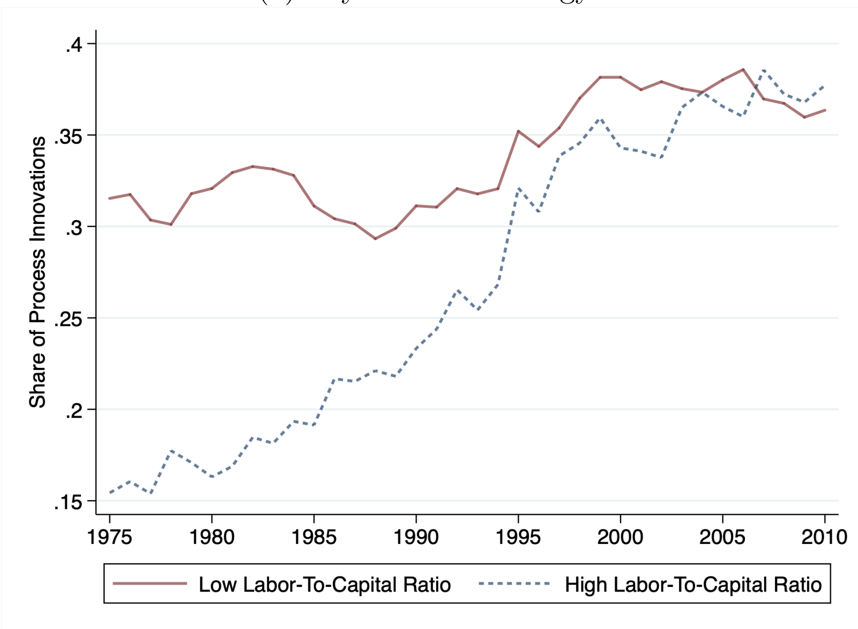
Panel (b): Services and primary sectors

Figure IA-A3: Share of process innovations in U.S. listed firms by sectors

This figure plots the share of process innovations computed for U.S. listed firms. In Panel (a), the share is computed for all firms and for firms in the manufacturing sector (NAICS 31-33). In Panel (b), the share is computed for firms in the services sector (NAICS >33) and in the primary sector (NAICS <31).



Panel (a): By main technology classes



Panel (b): By labor-to-capital ratio

Figure IA-A4: Share of process innovations in U.S. listed firms by fields of technology and labor intensity

This figure plots the share of process innovations computed for U.S. listed firms. In Panel (a), the share is computed separately based on patents that are classified into the Sections of the Cooperative Patent Classification (CPC) of patents. We assign a patent proportionally to all CPC Sections listed on the patent. We only plot CPC Sections with more than 10% of the total number of patents. In Panel (b), the share is computed separately for firms below vs. above median labor-to-capital ratio (defined as Compustat item 'emp' divided by item 'ppent').

Table IA-A1: Process and non-process innovation

	Mean	Std.	p25	p50	p75
Panel A: Universe of Utility Patents Issued by USPTO					
Number of claims per patent	15.20	12.40	7	13	20
Number of process claims	4.56	8.16	0	0	7
Number of non-process claims	10.70	10.50	3	9	15
Number of independent claims	2.70	2.29	1	2	3
Number of dependent claims	12.50	11.40	5	10	17
Panel B: Compustat Firms' Patents					
Number of claims per patent	15.20	12.40	7	13	20
Number of process claims	4.56	8.16	0	0	7
Number of non-process claims	10.70	10.50	3	9	15
Number of independent claims	2.70	2.29	1	2	3
Number of dependent claims	12.50	11.40	5	10	17

This table reports summary statistics on patent claims for the universe of utility patents (Panel A) and the utility patents matched to Compustat firms (Panel B) applied for at the USPTO with application dates from January 1976 till December 2012. Panel A statistics are based on 4,233,476 patents. Panel B statistics are based on 1,855,328 patents. Patent claims define, in technical terms, the scope of protection conferred by a patent and thus define what subject matter the patent protects. A process claim refers to an innovation that typically describes a new way to produce an existing good, while a non-process claim refers to an innovation that typically describes a new good that did not exist before. An independent claim stands on its own. In contrast, a dependent claim only has meaning when combined with a claim of the same patent it refers to.

Table IA-A2: Process innovation: Survey comparisons

	Source	% of of R&D firms performing process innovation
U.S.	NSF	42
U.S.	Compustat	46
Austria	EFIGE	48
France	EFIGE	44
Germany	EFIGE	43
Hungary	EFIGE	40
Italy	EFIGE	45
Spain	EFIGE	51
UK	EFIGE	43

This table reports the percentage of R&D performing firms which reported to have introduced process innovations at the National Science Foundation (NSF) survey for the U.S., and the EFIGE (European Firms in a Global Economy: internal policies for external competitiveness) survey for Europe. This number is compared to the universe of Compustat firms with process patents during the same time period. The reported number for the NSF is the average percentage of R&D performing firms doing process innovations over the period 2006-2011. The reported number for Compustat is the average number of firms which have patented process innovations over the 2006-2011 period. The EGIGE survey took place in early 2010 and covers 8 European countries.

Table IA-A3: Share of process innovation and industry outcomes

	Log(Equipment/ Employment)	Log(Structures/ Employment)	Production Workers Ratio	Log(Sales/ Employment)	Log(Wages/ Employment)
	(1)	(2)	(3)	(4)	(5)
Shares of Process Innovations$_{t-1}$	0.078***	0.024	-0.008**	0.037***	0.020***
	(0.027)	(0.025)	(0.003)	(0.014)	(0.007)
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes
Observations	8315	8315	8315	8315	8315
Adjusted R^2	0.926	0.902	0.921	0.968	0.979

This table reports the results of OLS regressions of industry capital intensity, share of production workers, productivity and wages per employee on lagged industry share of process innovation. Capital intensity is measured as the logarithm of the real capital invested in equipment over industry employment in Column 1, and as the logarithm of the real capital invested in structures (e.g., buildings) over industry employment in Column 2. In Column 3, share of production workers is the number of production workers over total industry employment. In Column 4, we proxy productivity with the logarithm of total value of shipment over employment, and in Column 5, we measure average industry wages as the logarithm of total payroll divided by total employment. $Share of Process$ *innovation* is the logarithm of counts of process claims divided by counts of all claims at the industry-year level and is lagged by one year. Industry is defined at the 6-digit NAICS level. Data are available from the NBER-CES Manufacturing Industry Database. All regressions include (6-digit NAICS) industry and year fixed effects. The sample period is 1976-2011. Standard errors are clustered at the 6-digit NAICS industry level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

B Robustness checks

This section of the Internet Appendix provides additional results and robustness analyses referenced in the main text.

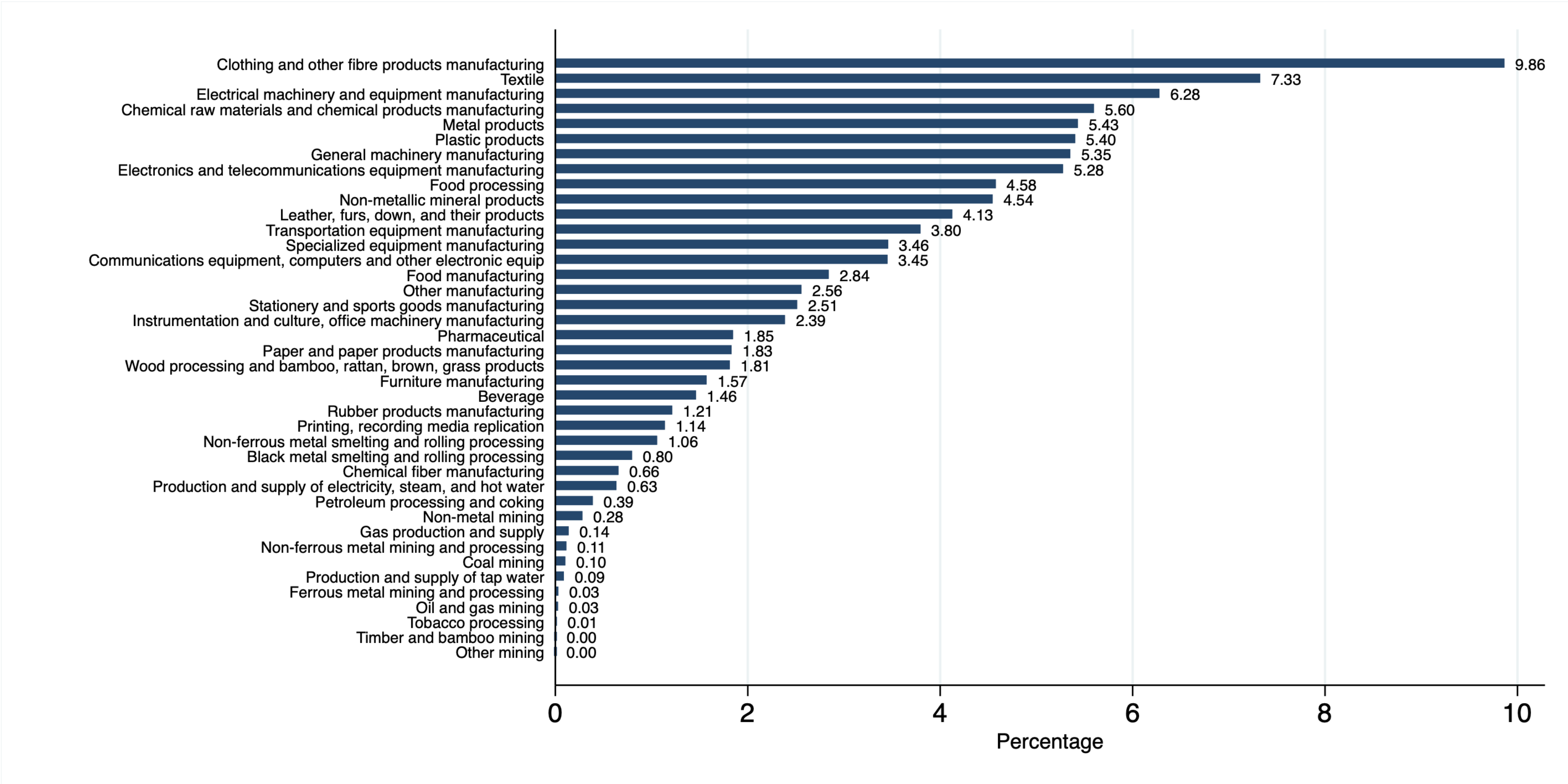
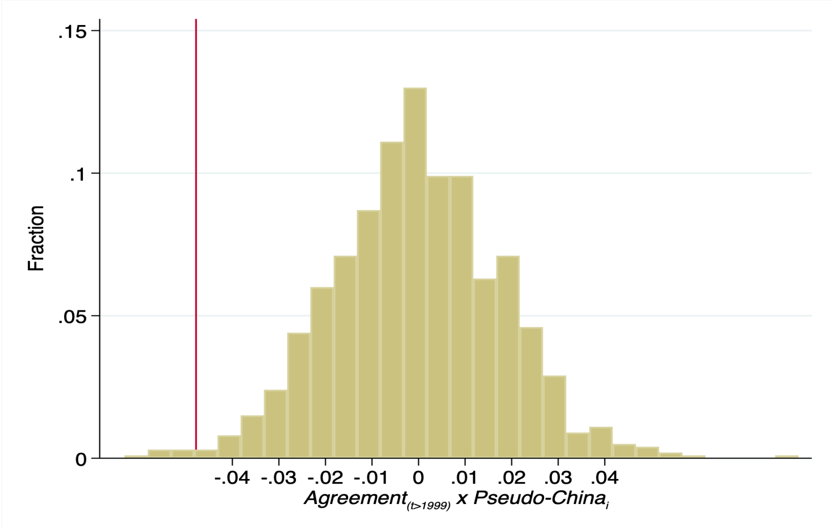
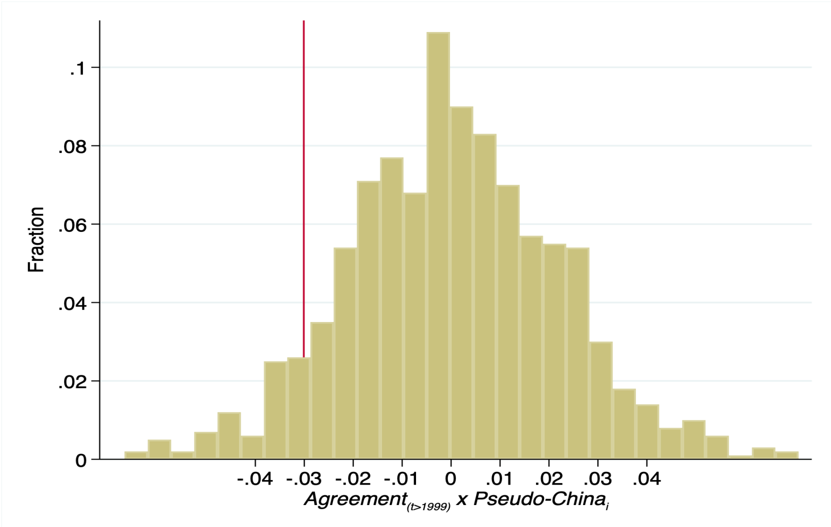


Figure IA-B1: Industry Distribution of Chinese Subsidiaries

This figure plots the industry distribution of the Chinese subsidiaries. The data for Chinese subsidiaries are from 'Chinese Industrial Survey' (CIS) database described in Section 3.1. The sample includes all subsidiaries in China with some foreign ownership.



Panel (a): U.S. Multinationals in Low-wage Countries



Panel (b): U.S. Multinationals

Figure IA-B2: Histogram of coefficients estimated using a placebo test

This figure plots the histogram of estimated coefficients from 1000 trials of the placebo test presented in Table IA-B9. The plot in Panel (a) is based on the sample of U.S. multinationals in China and other low-wage countries, specification in Column 4 of Table 3. The plot in Panel (b) is based on the sample of U.S. multinationals in China and elsewhere, specification in Column 8 of Table 3. In both panels, the vertical line indicates the corresponding coefficients from Table 3.

Table IA-B1: Summary statistics of Chinese subsidiaries

	N	Mean	Std.	p25	p50	p75
ROA	75267	0.05	0.12	-0.00	0.03	0.09
Gross Profit Margin	75275	0.18	0.14	0.09	0.15	0.25
Sales (mil. Yuan)	75275	122.22	311.82	13.18	31.16	87.19
% Fixed Operating Assets	75267	0.44	0.28	0.23	0.41	0.62
Employees	74481	433.23	1714.31	80	169	380
Wage/Employee (thous. Yuan)	72216	16.66	15.05	8.01	12.05	19.33

This table reports summary statistics for Chinese subsidiaries used in Table 2. ROA is defined as operating profits/total assets. Gross profit margin is sales minus cost of sales divided by total sales. Sales is denoted in million Yuan. Fixed operating assets is defined as total fixed assets for production and operation divided by total assets. Employment is number of employees in the subsdiary. Wages per employee is denoted in thousand Yuan. The data for Chinese subsidiaries are from 'Chinese Industrial Survey' (CIS) database described in Section 3.1. The sample period is 1998-2004.

Table IA-B2: U.S. firms and entry in China

Panel A: Fraction of U.S. firms with subsidiaries in China

Compustat firms with subsidiaries in China pre-1999	Compustat firms with subsidiaries in China post-1999		
	Yes	No	Total
No	21.43%	0.00%	21.43%
Yes	47.02%	31.55%	78.57%
Total	68.45%	31.55%	100.00%

Panel B: Number of U.S. firms' subsidiaries in China

	N	Min	25th	50th	75th	Max	Mean	Std.
Firms that entered China before 1999	614	0	1	3	8	13	4.3	4.03
Firms that entered China only after 1999	45	1	1	1	2	4	1.62	1.03

This table includes the sample of U.S. publicly listed firms matched to subsidiary data in China. Panel A reports what fraction of U.S. firms established subsidiaries in China both pre-1999 and post-1999, what fraction of U.S. firms established subsidiaries in China pre-1999 but not post-1999, what fraction of U.S. firms established subsidiaries in China only post-1999. Panel B reports the distribution of subsidiaries in China for U.S. publicly listed (Compustat) firms matched with firms in the 'Chinese Industrial Survey' (CIS) data, depending on whether the firm entered China for the first time pre- or post-1999. The sample timeline is 1998-2007.

Table IA-B3: First-mover advantage for U.S. Compustat Chinese subsidiaries founded prior to 1999

	(1) ROA	(2) Log(Employment)	(3) Log(Sales)
$\text{Founded}_{t<1999}$	0.032^{**}	0.446^{***}	0.508^{***}
	(0.015)	(0.143)	(0.161)
Log(Sales)	0.043^{***}		
	(0.004)		
Industry × Year	Yes	Yes	Yes
City × Year	Yes	Yes	Yes
Sample	1998-2007	1998-2007	1998-2007
Number of Establishments	533	534	533
Observations	2493	2474	2493
Adjusted R^2	0.226	0.209	0.266

This table reports results of OLS regressions of outcomes of Chinese subsidiaries matched to Compustat U.S. publicly listed firms on an indicator capturing whether the Chinese subsidiary was founded prior to the 1999 U.S.-China bilateral agreement. We examine return on assets (ROA, operating profits/total assets in Column 1, employment (log-transformed) in Column 2, sales (log-transformed) in Column 3. $Founded_{t<1999}$ takes a value of 1 for subsidiaries founded prior to 1999, and 0 for subsidiaries founded post 1999. All regressions include industry-by-year fixed effects (based on 791 4-digit industries) and city-by-year fixed effects (based on 399 cities). The data for Chinese subsidiaries are from 'Chinese Industrial Survey' (CIS) database described in Section 3.1. The sample includes subsidiaries in China with some foreign ownership that are matched to Compustat U.S. firms over the period 1998-2007. We use all the available timeline in this analysis, but results are similar if we were to stop in 2004 as in Table 2. All dependent variables not in logs are winsorized at the 1% level. Standard errors are clustered at the subsidiary-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B4: Summary statistics: Comparisons between treated and control firms

	1999			
	Control	Treated	P-val	P-val of Residual
Panel A: U.S. Multinationals in Low-wage Countries				
Share of Process Innovations	0.356	0.301	0.044	0.680
Process Innovations	476.956	734.611	0.181	0.297
Non-Process Innovations	673.212	1284.730	0.026	0.111
Patents	52.942	109.698	0.014	0.087
Adjusted Process Innovations	2.324	4.415	0.009	0.240
Adjusted Non-Process Innovations	1.938	4.612	0.000	0.026
Citations per Process Patent	3.676	2.789	0.086	0.373
Citations per Pure Process Patent	3.638	2.810	0.121	0.377
Sales	6948.208	8655.783	0.470	0.547
Market to Book	4.146	3.970	0.866	0.874
R&D Stock	973.048	1997.398	0.048	0.791
R&D/Sales	0.069	0.093	0.542	0.633
TFP	-0.125	-0.124	0.980	0.401
Panel B: U.S. Multinationals				
Share of Process Innovations	0.326	0.300	0.319	0.714
Process Innovations	368.572	729.134	0.097	0.823
Non-Process Innovations	510.949	1275.984	0.004	0.707
Patents	41.099	108.961	0.003	0.656
Adjusted Process Innovations	1.607	4.391	0.000	0.564
Adjusted Non-Process Innovations	1.318	4.585	0.000	0.004
Citations per Process Patent	3.328	2.810	0.294	0.533
Citations per Pure Process Patent	3.333	2.832	0.332	0.554
Sales	3719.471	8637.289	0.000	0.000
Market to Book	4.459	3.967	0.779	0.825
R&D Stock	481.931	1981.567	0.000	0.177
R&D/Sales	0.089	0.093	0.908	0.727
TFP	-0.201	-0.124	0.161	0.104

We report means of the variables presented in Table 1 for treated and control firms in the sample of U.S. multinationals in low-wage countries (Panel A) and in the sample of U.S. multinationals (Panel B) in 1999, the year of the U.S.-China bilateral agreement. Column 1 reports the mean for the control firms. Column 2 reports the mean for the treated firms. Column 3 reports p-values of a t-test in differences in means. Column 4 reports p-values of a t-test in differences in means of the residual of these variables. The residuals are obtained by regressing these variables on industry-year fixed effects as well as on the logarithm of sales for the variables that are not scaled (Process (non-process) innovation, patents, R&D stock, adjusted process (non-process) innovation).

Table IA-B5: Alternative definitions for the share of process innovations

Panel A: Based on citation-weighted patents

	Share of Process Innovations							
	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.066**	-0.067***	-0.057**	-0.056**	-0.033*	-0.033*	-0.031*	-0.031*
	(0.026)	(0.026)	(0.025)	(0.025)	(0.018)	(0.018)	(0.018)	(0.018)
Log(Sales)	0.032*	0.037*	0.027	0.026	0.023	0.024	0.023	0.024
	(0.019)	(0.022)	(0.020)	(0.023)	(0.014)	(0.015)	(0.014)	(0.015)
Log(Market to Book)	0.001	0.001	0.001	0.001	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.013	-0.013	-0.013	-0.013	-0.010	-0.010	-0.007	-0.007
	(0.012)	(0.012)	(0.012)	(0.012)	(0.009)	(0.009)	(0.009)	(0.009)
Log(R&D Stock)		-0.009		0.002		-0.003		-0.002
		(0.019)		(0.018)		(0.013)		(0.012)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	307	307	303	303	826	826	807	807
Observations	2212	2212	2175	2175	4977	4977	4845	4845
Adjusted R^2	0.422	0.421	0.453	0.453	0.387	0.387	0.419	0.419

Panel B: Based on independent claims

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.040**	-0.040*	-0.026*	-0.025*
	(0.020)	(0.020)	(0.014)	(0.014)
Log(Sales)	0.001	-0.002	-0.000	-0.005
	(0.012)	(0.014)	(0.010)	(0.011)
Log(Market to Book)	0.001	0.001	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.007	-0.008	-0.011*	-0.012**
	(0.008)	(0.008)	(0.006)	(0.006)
Log(R&D Stock)		0.007		0.010
		(0.012)		(0.009)
Firm FE	Yes	Yes	Yes	Yes
Industry × Year	Yes	Yes	Yes	Yes
Number of Firms	324	324	936	936
Observations	2336	2336	5662	5662
Adjusted R^2	0.518	0.518	0.453	0.453

This table reports results of OLS regressions of U.S. firms' share of process innovations around the 1999 U.S.-China bilateral agreement. Panel A defines the share of process innovations using citation-weighted patents. We count citations received over a five-year window period starting from each patent's award year. In Columns 1-2 and 5-6, we classify a patent as a process patent if the first patent's claim is a process claim. In Columns 3-4 and 7-8, we classify a patent as a pure process patent if all patent's claims are process claims. Panel B defines the share of process innovations using independent claims—the most important claims in a patent that are standalone. The sample in Columns 1-4, Panel A, and Columns 1-2, Panel B, includes U.S. multinationals in China and other low-wage countries. The sample in Columns 5-8, Panel A, and Columns 3-4, Panel B, includes U.S. multinationals in China and elsewhere. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China or in any other country except China. *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B6: 1999 U.S.-China bilateral agreement and process and non-process innovation

Panel A: Process Innovations

	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agreement$_{t>1999}\cdot$ China$_i$	-0.181	-0.240***	-0.277***	-0.278***	-0.223**	-0.182***	-0.206***	-0.201***
	(0.155)	(0.092)	(0.099)	(0.098)	(0.110)	(0.068)	(0.073)	(0.074)
Log(Patents)		1.336***	1.341***	1.341***		1.398***	1.383***	1.381***
		(0.039)	(0.044)	(0.044)		(0.030)	(0.032)	(0.032)
Log(Sales)			-0.117*	-0.110			-0.034	-0.050
			(0.067)	(0.085)			(0.050)	(0.057)
Log(Market to Book)			0.003	0.003			0.001	0.001
			(0.004)	(0.004)			(0.003)	(0.003)
Log(R&D Stock)				-0.013				0.034
				(0.090)				(0.052)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	339	339	324	324	991	991	936	936
Observations	2539	2539	2336	2336	6210	6210	5662	5662
Adjusted R^2	0.788	0.888	0.890	0.890	0.750	0.845	0.849	0.849

Panel B: Non-process Innovations

	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	0.092	0.034	0.056	0.045	0.020	0.062	0.044	0.038
	(0.135)	(0.064)	(0.066)	(0.065)	(0.097)	(0.050)	(0.052)	(0.051)
Log(Patents)		1.306^{***}	1.317^{***}	1.320^{***}		1.409^{***}	1.406^{***}	1.408^{***}
		(0.030)	(0.035)	(0.035)		(0.024)	(0.026)	(0.026)
Log(Sales)			-0.103^{*}	-0.057			-0.041	-0.021
			(0.059)	(0.063)			(0.042)	(0.046)
Log(Market to Book)			-0.001	-0.002			-0.001	-0.001
			(0.003)	(0.003)			(0.002)	(0.002)
Log(R&D Stock)				-0.093^{**}				-0.042
				(0.038)				(0.036)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	339	339	324	324	991	991	936	936
Observations	2539	2539	2336	2336	6210	6210	5662	5662
Adjusted R^2	0.783	0.915	0.918	0.919	0.746	0.880	0.884	0.885

This table reports results of OLS regressions of U.S. firms' process (Panel A) and non-process (Panel B) innovation around the 1999 U.S.-China bilateral agreement. Process and non-process innovation is transformed using the inverse hyperbolic sine function. In both panels, the sample in Columns 1-4 includes U.S. multinationals in China and other low-wage countries, while the sample in Columns 5-8 includes U.S. multinationals in China and elsewhere. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-4) or in any other country except China (Columns 5-8). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include firm and (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B7: Fractional outcome regression models

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.176***	-0.180***	-0.135***	-0.144***
	(0.058)	(0.058)	(0.042)	(0.042)
Log(Sales)	-0.003	-0.013	-0.013	-0.025*
	(0.018)	(0.019)	(0.012)	(0.013)
Log(Market to Book)	0.002	0.002	0.003	0.003
	(0.003)	(0.003)	(0.002)	(0.002)
Log(Patents)	0.033*	0.019	0.037***	0.010
	(0.018)	(0.020)	(0.012)	(0.014)
Log(R&D Stock)		0.024*		0.038***
		(0.013)		(0.010)
Industry × Year	Yes	Yes	Yes	Yes
Number of Firms	371	371	1143	1143
Observations	2516	2516	5999	5999
Pseudo R^2	0.080	0.080	0.072	0.074

This table reports results of regressions of U.S. firms' share of process innovations around the 1999 U.S.-China bilateral agreement. The sample and specifications correspond to those in Table 3 Columns 3-4 and Columns 7-8, except the estimation is implemented using the fractional outcome regression models. $China_i$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-2) or in any other country except China (Columns 3-4). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B8: Allowing for entry into China

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
$\text{Agreement}_{t>1999} \cdot \text{China}_{it}$	-0.049***	-0.048***	-0.033**	-0.031**
	(0.018)	(0.018)	(0.014)	(0.014)
China_{it}	-0.009	-0.010	-0.006	-0.009
	(0.024)	(0.024)	(0.023)	(0.023)
Log(Sales)	-0.007	-0.011	0.002	-0.006
	(0.012)	(0.014)	(0.009)	(0.010)
Log(Market to Book)	-0.000	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.003	-0.003	-0.011**	-0.012**
	(0.007)	(0.007)	(0.005)	(0.005)
Log(R&D Stock)		0.008		0.017**
		(0.010)		(0.008)
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
Number of Firms	479	479	1204	1204
Observations	2969	2969	6344	6344
Adjusted R^2	0.547	0.547	0.484	0.485

This table reports results of OLS regressions of U.S. firms' share of process innovation around the 1999 U.S.-China bilateral agreement. The sample and regression specifications correspond to those in Columns 3-4 and Columns 7-8, Table 3, except that we use a time-varying measure of treatment. $China_{it}$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China in year t (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-2) or in any other country except China (Columns 3-4). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B9: Placebo test

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
$\text{Agreement}_{t>1999} \cdot \text{Pseudo China}_i$	-0.036***	-0.048***	-0.030	-0.030
	(0.016)	(0.018)	(0.021)	(0.022)
Controls	No	Yes	No	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
Repetitions (in times)	1000	1000	1000	1000

This table reports results of a placebo test that randomly assigns firms from our sample into the 'placebo treatment' groups in 1999, while matching exactly the number of treated and control firms in the two sub-samples, and repeating our baseline analysis in Table 3. We repeat this procedure 1000 times, each time estimating the placebo treatment effect. For this test, we use specifications in Columns 3, 4, 5 and 8 of Table 3. The coefficients reported in this table are repeated from Table 3 while the standard errors are computed as standard deviations of the estimated 1000 regression coefficients obtained using the pseudo treated groups. All firm-level variables are winsorized at the 1% level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B10: Mean-reversion in firms' innovation activities

	Share of Process Innovations			
	U.S. Multinationals in Low-wage Countries		U.S. Multinationals	
	(1)	(2)	(3)	(4)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.046**	-0.045**	-0.037***	-0.035***
	(0.018)	(0.018)	(0.012)	(0.012)
Log(Sales)	0.005	0.002	0.010	0.001
	(0.011)	(0.013)	(0.009)	(0.010)
Log(Market to Book)	0.000	0.000	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	-0.004	-0.005	-0.011*	-0.012**
	(0.008)	(0.008)	(0.006)	(0.006)
Log(R&D Stock)		0.007		0.018**
		(0.013)		(0.009)
Year FE × Share of Process Ratio in 97	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Industry × Year FE	Yes	Yes	Yes	Yes
Number of Firms	292	292	718	718
Observations	2219	2219	4888	4888
Adjusted R^2	0.589	0.589	0.537	0.538

This table reports results of OLS regressions of U.S. firms' share of process innovation around the 1999 U.S.-China bilateral agreement. The sample and regression specifications correspond to those in Columns 3-4 and Columns 7-8, Table 3, except that we additionally control for firm-specific innovation trends. Specifically, we control for year fixed effects interacted with the dependent variable defined in 1997. $China_{it}$ is an indicator variable equal to one if a U.S. firm has a subsidiary in China in year t (treated) across columns, and equal to zero if it has a subsidiary in a low-wage country except China (Columns 1-2) or in any other country except China (Columns 3-4). *Log(Sales)*, *Log(Market to Book)*, and *Log(R&D Stock)* are lagged by one year. All regressions include (3-digit NAICS) industry-year fixed effects. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B11: Technology focus - Alternative Definition

	Adjusted Process Innovations		Adjusted Non -Process Innovations		Adjusted Process Innovations		Adjusted Non -Process Innovations	
	U.S. Multinationals in Low-wage Countries				U.S. Multinationals			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.107*	-0.106*	-0.013	-0.003	-0.098**	-0.099**	-0.034	-0.030
	(0.057)	(0.056)	(0.048)	(0.048)	(0.044)	(0.044)	(0.034)	(0.034)
Log(Sales)	0.054	0.052	0.055	0.013	0.050**	0.055**	0.009	-0.005
	(0.041)	(0.040)	(0.035)	(0.035)	(0.021)	(0.022)	(0.020)	(0.020)
Log(Market to Book)	0.000	0.000	-0.002	-0.001	0.000	0.000	-0.000	-0.000
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Log(Patents)	0.499***	0.499***	0.536***	0.533***	0.384***	0.384***	0.452***	0.451***
	(0.032)	(0.032)	(0.027)	(0.027)	(0.021)	(0.021)	(0.019)	(0.019)
Log(R&D Stock)		0.003		0.086***		-0.009		0.030*
		(0.027)		(0.026)		(0.016)		(0.015)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry × Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of Firms	324	324	324	324	936	936	936	936
Observations	2336	2336	2336	2336	5662	5662	5662	5662
Adjusted R^2	0.888	0.888	0.930	0.930	0.874	0.874	0.920	0.920

This table reports results of OLS regressions of U.S. firms' process and non-process innovations, adjusted using technology-class-and-time-period means computed across all patenting firms, around the 1999 U.S.-China bilateral agreement. The table is analogous to Table 8, except the measures of adjusted process (non-process) innovations are based on pure process (pure non-process) patents.

Table IA-B12: Estimates based on a propensity score matched sample

Panel A: U.S. Multinationals in Low-wage Countries

	Share of Process Innovations					
	(1)	(2)	(3)	(4)	(5)	(6)
$\text{Agreement}_{t>1999} \cdot \text{China}_i$	-0.051**	-0.056**	-0.064***	-0.066***	-0.036*	-0.035*
	(0.023)	(0.023)	(0.023)	(0.023)	(0.020)	(0.020)
Log(Patents)		0.018***	0.010	0.001	0.002	0.001
		(0.005)	(0.007)	(0.008)	(0.009)	(0.009)
Log(Sales)			0.015*	0.012	0.007	0.004
			(0.007)	(0.008)	(0.013)	(0.016)
Log(Market to Book)			0.002	0.002	0.001	0.001
			(0.001)	(0.001)	(0.001)	(0.001)
Log(R&D Stock)				0.010		0.006
				(0.007)		(0.016)
Firm FE	No	No	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	No	No
Number of Firms	246	246	244	244	238	238
Industry × Year FE	No	No	No	No	Yes	Yes
Observations	2032	2032	1923	1923	1851	1851
Adjusted R^2	0.004	0.021	0.028	0.033	0.504	0.503

Covariate balance summary

	Standardized Differences		Variance Ratio	
	Raw	Matched	Raw	Matched
Log(Employment)	0.688	-0.085	0.990	1.113
Log(Employment)^2	0.645	-0.047	1.644	0.818
Log(Sales)	0.624	-0.075	0.881	1.128
Log(Sales)^2	0.631	-0.063	1.027	1.028
Log(R&D Stock)	0.408	0.041	0.992	0.839
$\text{Log(R\&D Stock)}^2$	0.431	-0.001	1.541	0.945
Log(Patents)	0.611	-0.026	1.107	1.010
Log(Patents)^2	0.548	-0.021	1.681	1.106

This table reports results of OLS regressions of U.S. firms' share of process innovation around the 1999 U.S.-China bilateral agreement. We refine the sample used in Columns 1-4 of Table 3 by finding the nearest neighbor match for each treated firm using a propensity score matching procedure. The propensity score is estimated based on 1995-1999 period using the following characteristics: year fixed effects, industry (2-digit NAICS) fixed effects, *Log(Employment)*, *Log(Sales)*, *Log(R&D Stock)*, *Log(Patents)*, all lagged by one year, and squared terms of these continuous covariates. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Panel B: U.S. Multinationals

	Share of Process Innovations					
	(1)	(2)	(3)	(4)	(5)	(6)
$Agreement_{t>1999} \cdot China_i$	-0.034*	-0.049***	-0.051***	-0.052***	-0.024*	-0.024*
	(0.017)	(0.017)	(0.017)	(0.017)	(0.015)	(0.015)
Log(Patents)		0.017***	0.018***	0.007	-0.010	-0.010
		(0.004)	(0.005)	(0.006)	(0.007)	(0.007)
Log(Sales)			-0.000	-0.003	-0.005	-0.005
			(0.006)	(0.006)	(0.011)	(0.013)
Log(Market to Book)			0.001	0.001	0.001	0.001
			(0.001)	(0.001)	(0.001)	(0.001)
Log(R&D Stock)				0.013***		-0.000
				(0.005)		(0.011)
Firm FE	No	No	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	No	No
Industry × Year FE	No	No	No	No	Yes	Yes
Number of Firms	567	567	560	560	539	539
Observations	4222	4222	3967	3967	3890	3890
Adjusted R^2	0.002	0.015	0.016	0.023	0.477	0.477

Covariate balance summary

	Standardized Differences		Variance Ratio	
	Raw	Matched	Raw	Matched
Log(Employment)	1.226	-0.035	0.816	1.087
$Log(Employment)^2$	1.001	0.013	2.445	0.926
Log(Sales)	1.180	-0.057	0.790	1.156
$Log(Sales)^2$	1.180	-0.036	1.127	1.069
Log(R&D Stock)	0.821	-0.060	1.101	1.019
$Log(R\&D\ Stock)^2$	0.834	-0.051	2.027	1.024
Log(Patent)	1.023	0.019	1.253	0.903
$Log(Patent)^2$	0.851	-0.009	2.049	1.007

This table reports results of OLS regressions of U.S. firms' share of process innovation around the 1999 U.S.-China bilateral agreement. We refine the sample used in Columns 5-8 of Table 3 by finding up to five nearest neighbor matches for each treated firm using a propensity score matching procedure. The propensity score is estimated based on 1995-1999 period using the following characteristics: year fixed effects, industry (2-digit NAICS) fixed effects, *Log(Employment)*, *Log(Sales)*, *Log(R&D Stock)*, *Log(Patents)*, all lagged by one year, and squared terms of these continuous covariates. The sample period is 1995-2004. Firm-level variables are defined in the Appendix. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

Table IA-B13: Citations of process vs. non-process patents

	Number of citations per patent		
	(1)	(2)	(3)
Process Patent	-0.022	-0.015	-0.024
	(0.025)	(0.022)	(0.019)
Combined Technology Class FE	Yes		
Year FE	Yes		
Combined Technology Class FE × Year Fixed Effects		Yes	Yes
Firm Fixed Effects × Year FE			Yes
Observations	129,980	123,118	123,015
Adjusted R^2	0.098	0.113	0.141

The table reports the results of OLS regressions of the number of citations received by each patent over a 5-year window starting by the patent award year (log transformed) on *Process Patent*, which is an indicator variable equal to one for process patents and zero otherwise. The sample includes process and non-process patents that are applied for by firms in our sample in years covered by our sample period. Standard errors are clustered at the firm-level. *** indicates $p < 0.01$, ** indicates $p < 0.05$, and * indicates $p < 0.1$.

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