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THE RISE OF THE PEOPLE'S REPUBLIC OF CHINA AND ITS COMPETITION EFFECTS ON INNOVATION IN JAPAN

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Abstract

This paper empirically examines the “defensive innovation” hypothesis that firms with higher exposure to low-wage economy import competition intensively undertake more innovative activity by using a high quality Japanese firm-level panel dataset over the period 1994–2005. The novel feature of the analysis is the relation of firm-level variations of patent usage to import competition. The results suggest that intensified import competition from the People’s Republic of China has resulted in greater innovative activity by Japanese firms, consistent with the findings of European firms in Bloom et al. (2016). Moreover, such competition has also led to an increase in non-used patents.

JEL Classification: O00, F10

Contents

1. INTRODUCTION

This paper examines the "'defensive innovation" hypothesis first discussed in Wood (1994) and subsequently formalized in Thoenig and Verdier (2003). As a reaction to import competition from low-wage economies, firms in developed economies would respond by upgrading their innovative activities, leading to "defensive skill-biased innovation." In a broader context, the effect of competition on the rate of innovation has been one of the most studied areas in the literature (e.g, Aghion et al. 2005). In the study most relevant to our paper, Bloom et al. (2016) found that a large sample of European firms increased a wide range of their innovative activities (patenting, research and development (R&D) expenditures, computer use, and the TFP growth), driven by intensified competition from the People's Republic of China (PRC). This innovation was conducted within-firm.[1]

Building on the foundation set by the previously mentioned studies, this paper examines the causal effect of intensified Chinese import competition on the innovative activities of a panel of Japanese firms for the period 1994–2005. We focus on patent usage data as an indicator of innovative outputs. Unlike other studies using patent statistics, this study adds to the literature by exploring strategic patent usage as responses to import competition from a low-wage economy (the PRC). It is generally acknowledged that patent statistics are meaningful proxies for firm-level innovation, but it is well known that firm-level patenting serves as much more than just an indicator of knowledge capital output (Nagaoka et al. 2010). Well-known inventor surveys (e.g., the RIETI-Georgia Tech US-Japan survey) have revealed that many of the patents are not used to introduce new products into the market; instead, they are used as effective strategic instruments to "block" other competitors from innovating or imitating. Boldrin and Levine (2013) present a nice case involving Microsoft — a market incumbent with a stockpile of patents blocking Google in the smartphone market).

Studying innovative firms' responses to Chinese import competition provides an interesting and excellent testing ground for the following reasons: First, over the past decades, the PRC has emerged as a pivotal assembly-export economy of high-tech products (mainly, electronics), importing parts and components from other advanced economies and exporting final products (including the famous iPhone). Accordingly, the PRC's export bundle has dramatically changed from labor-intensive goods to high-tech products, exerting considerable competitive pressures on firms in developed economies. Second, many Chinese exports compete at lower cost margins than most high-tech products. For instance, a study by Schott (2008 found that the PRC's export similarity index has become closer to that of Organization for Economic Cooperation and Development (OECD) economies, but the unit prices of Chinese exports have been consistently lower than OECD economies.

The finding suggests that Chinese import competition leads Japanese firms to expand their innovative activities, as found by Bloom et al. (2016. The expansion is partly driven by an increase in firms' numbers of unused patents, which reflect the strategic use of intellectual property (IP) protection.

The organization of this paper is as follows. The next section presents an overview of the PRC in world trade. Section 3 discusses the dataset, followed in Section 4 by the

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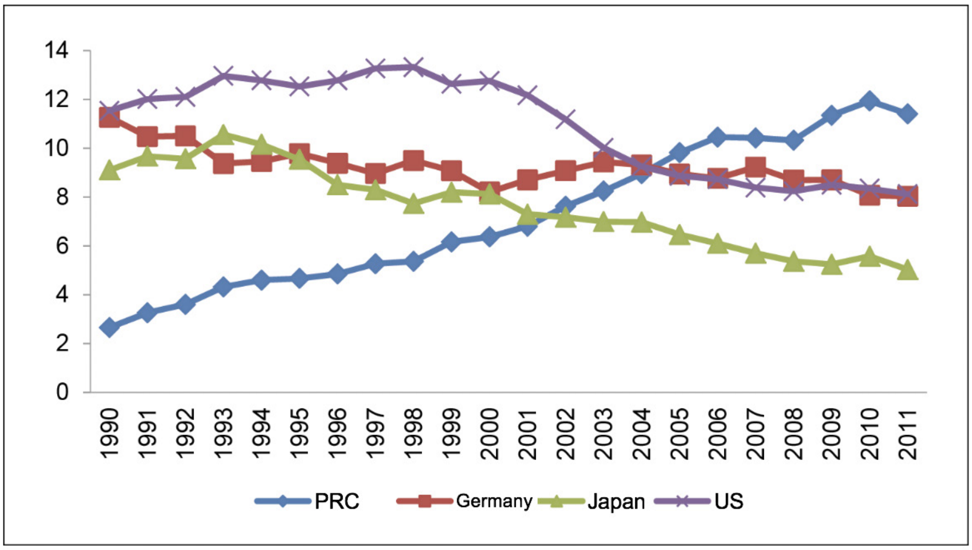
[1] Amiti and Khandelwal (2013) find that increased import competition (measured by a decline in tariffs) spurs a economy's export quality (measured by the market share) in the US market.

empirical approach and a discussion of the preliminary findings. Section 5 concludes the paper.

2. THE RISE OF THE PRC IN WORLD TRADE

Figure 1-A depicts the rise of the PRC in world exports for the period 1990–2011. In 1990, the PRC's exports accounted for a tiny share (around 3%) of world exports. Since then, the PRC's share has gradually increased. In particular, the PRC's export growth has risen since the early 2000s. In the second half of 2000, the PRC has achieved formidable export expansion by overtaking Germany for the position of the world's largest exporter, accounting for more than 10% of world exports. The PRC's export share has been growing without any disruptions, while the world shares of Japan, the United States and Germany have not grown during the same period. At the same time, the PRC has become an important economy in the world important market (Figure 1-B). While the United States still accounts for the bulk of world imports (around 15–20% in world imports), its share has gradually been declining since 2000. By contrast, the PRC's share has steadily increased to close to 10% in 2011.

Figure 1: The Rise of the People's Republic of China in World Trade, 1990–2011
(% in total exports)

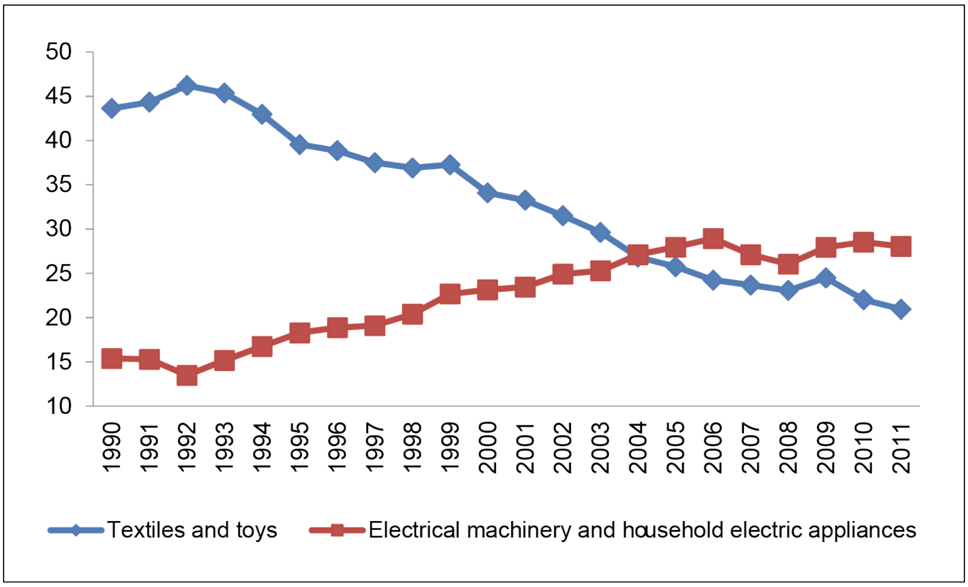


Source: UN Comtrade.

With the rise of the PRC in world trade, its specialization has dramatically changed, as well. Figure 2 depicts the share of relatively more capital- and technology-intensive products like electrical machinery and household electric appliances as compared to more labor-intensive products like textiles and toys. There has been a notable shift of comparative advantages from more labor-intensive products toward more capital- and technology-intensive products. In 1992, textiles and toys accounted for approximately 45% of the PRC's total exports. However, this share continuously declined and dropped to close to 20% in 2011. On the other hand, the export share of electrical machinery and household appliances doubled its share, from less than 15% in 1992 to 30% in 2011. In this product category, the export composition is highly concentrated in Information Communication Technology (ICT) products. Other important product categories include office machines, and telecommunications sound equipment (including mobile phones).

Based on the income-weighted export bundle of Chinese goods, some commentators argue that this is a sign that the technological capability of the PRC is rapidly converging toward the technological frontier of advanced OECD economies, and is now directly competing with them in the export market. However, this should be interpreted cautiously. Allowing for intra-product specialization, it is known that the PRC's export specialization still rests largely on the labor-intensive assembly stage rather than specialization in technological content (Athukorala and Yamashita, 2006). In other words, the PRC's comparative advantages still rests on a labor-intensive segment in high-tech products, even though these products are exported from the PRC (a final assembly economy). This explains why Schott (2008) observes that the unit price of Chinese export bundles are at the lower end of the price range, as compared to those of OECD economies (the price competitiveness coming from the PRC's lower labor costs). In sum, the bulk of Chinese exports are mass-market commodities assembled with relatively low unit costs and imported high-tech parts and components from other industrial economies (notebook computers, mobile phones).

Figure 2: Structural Changes in the People's Republic of China's Export Product Compositions, 1990–2011
(% in total exports)



Source: UN Comtrade.

Table 1 displays the top eight and bottom eight industries by degree of Chinese import competition 1994 (the beginning of the estimation period).[2] In the textile industry, where Chinese firms are considered to have comparative advantages, the degree of import competition was already strong in 1994 — of Japan's import of textile products, 49% came from the PRC. That share continued to increase, reaching 77% in 2005. More strikingly, the largest increase in the PRC's share of Japanese imports is in office and service industry machines; this share rose from 19% in 1994 to 76% in 2005.

[2] Year 1990 data is used in an experimental stage, but the order-import completion-exposed industries are roughly the same in year 1994).

Correspondingly, in the industries whereby the PRC's share increased, there was a decline in the shares of Asian newly industrializing economies (NIEs) — Taipei,China; Hong Kong, China; Republic of Korea; and Singapore) and the US. In the bottom eight industries, an increase in the PRC's share is palpable, with strong growth in electronic equipment and semiconductor devices. Production networks between Japan and the PRC may explain an expansion in Chinese import in those high-tech industries.

Table 1: Change of Import Competition by Source Economies/Groups in Japanese Manufacturing Industry, 1994 and 2005

	1994			
	PRC	**Asian NIEs**	**SE Asia**	**US**
Manufacturing, total	11.4	15.9	10.2	25.7
Top 8 sectors in 1994				
Coal products	68.9	13.2	0.0	2.7
Textile products	**48.7**	**15.1**	**8.0**	**5.6**
Miscellaneous ceramic, stone and clay products	34.4	19.1	3.0	13.6
Rubber products	33.4	18.3	10.1	15.7
Leather and leather products	26.5	19.9	5.8	5.2
Electrical generating, transmission, distribution and industrial apparatus	24.4	24.1	19.5	19.6
Pig iron and crude steel	23.7	4.0	3.0	7.0
Office and service industry machines	**19.4**	**16.5**	**21.6**	**22.1**
Bottom 8 sectors in 1994				
Chemical fibers	1.2	48.9	2.7	26.4
Petroleum products	1.0	22.4	12.0	6.2
Electronic equipment and electric measuring instruments	**0.6**	**3.1**	**0.6**	**63.9**
Pulp, paper, and coated and glazed paper	0.5	1.7	0.9	40.7
Semiconductor devices and integrated circuits	**0.4**	**41.7**	**8.2**	**49.1**
Printing, plate making for printing and bookbinding	0.4	26.0	1.0	64.7
Tobacco	0.1	0.0	0.0	95.3
Motor vehicles	0.0	0.3	0.0	27.7
	2005			
	PRC	**Asian NIEs**	**SE Asia**	**US**
Manufacturing, total	28.6	12.8	10.9	15.2
Top 8 sectors in 1994				
Coal products	92.2	1.5	0.0	0.5
Textile products	**76.5**	**3.5**	**4.0**	**2.0**
Miscellaneous ceramic, stone and clay products	60.4	5.0	3.8	9.6
Rubber products	58.4	6.9	17.2	5.5
Leather and leather products	46.5	1.8	2.7	2.0
Electrical generating, transmission, distribution and industrial apparatus	47.2	8.5	17.2	10.2

Pig iron and crude steel	29.7	6.7	1.5	1.7
Office and service industry machines	**76.2**	**8.2**	**7.7**	**2.7**

continued on next page

Table 1 *continued*

	2005			
	PRC	**Asian NIEs**	**SE Asia**	**US**
Bottom 8 sectors in 1994				
Chemical fibers	13.9	34.2	15.5	13.3
Petroleum products	2.8	21.1	12.8	2.5
Electronic equipment and electric measuring instruments	**10.5**	**3.5**	**4.0**	**38.8**
Pulp, paper, and coated and glazed paper	7.3	6.5	13.4	33.5
Semiconductor devices and integrated circuits	**7.9**	**48.2**	**19.1**	**18.9**
Printing, plate making for printing and bookbinding	13.5	11.2	4.5	23.3
Tobacco	0.6	0.1	0.1	89.6
Motor vehicles	1.4	1.9	0.9	8.8
	Change 94–05			
	PRC	**Asian NIEs**	**SE Asia**	**US**
Manufacturing, total	17.2	–3.1	0.7	–10.5
Top 8 sectors in 1994				
Coal products	23.3	–11.7	0.0	–2.2
Textile products	**27.8**	**–11.6**	**–4.0**	**–3.6**
Miscellaneous ceramic, stone and clay products	26.0	–14.1	0.9	–4.1
Rubber products	25.0	–11.5	7.2	–10.2
Leather and leather products	20.0	–18.0	–3.1	–3.3
Electrical generating, transmission, distribution and industrial apparatus	22.8	–15.6	–2.3	–9.4
Pig iron and crude steel	6.0	2.7	–1.5	–5.3
Office and service industry machines	**56.7**	**–8.4**	**–13.9**	**–19.4**
Bottom 8 sectors in 1994				
Chemical fibers	12.7	–14.7	12.8	–13.1
Petroleum products	1.8	–1.4	0.8	–3.7
Electronic equipment and electric measuring instruments	**9.9**	**0.4**	**3.4**	**–25.1**
Pulp, paper, and coated and glazed paper	6.8	4.8	12.6	–7.1
Semiconductor devices and integrated circuits	**7.5**	**6.5**	**10.9**	**–30.3**
Printing, plate making for printing and bookbinding	13.1	–14.8	3.5	–41.4
Tobacco	0.6	0.1	0.0	–5.8
Motor vehicles	1.4	1.7	0.9	–18.9

Source: JIP 2013 database.

3. DATA AND VARIABLES

3.1 Firm-level Patent Data

Patent statistics as an indicator for innovative outputs have recently become widely available to researchers because of significant progress made in data accessibility (e.g., US NBER patent, Japan Patent Office, PATSTAT). Patent statistics carry important invention-related information such as bibliographic data, backward and forward citations, the technology fields, name of inventor, and usefulness. However, it has been well-documented from survey-based studies that not all patents are in use (but rather, are "sleeping"). In Japan, it has been reported that approximately 60% of pharmaceutical patents are not currently in use (Nagaoka et al. 2010.[3] Rather, firms obtain patents as a defensive blocking mechanism in response to technology competition.[4] "Blocking" patents might protect a firm's once-exclusive market as it becomes commercialized. This project, for the first time in the literature, empirically relates this unexploited nature of patent holdings to import competition from a low-wage economy.

For this purpose, we extracted the relevant data from a Japanese firm-level survey — the Basic Survey of Business Structure and Activity, conducted by the Ministry of Economy, Trade and Industry (METI data)[5] — covering the period 1994–2005.

The firm-level patent-usage data is then merged with industry-level exposures to Chinese import competition, resulting in a unique dataset for the following aspects: First, it provides a panel dataset of patent usage as it relates to competitive pressures. The available surveys tend to report single-year responses, only depicting the static nature of patent usage.[6] Using a panel of firm-level data offers the perspective of within-firm variations of patent usage in response to import competition. Second, the data period is long enough to cover the PRC's changing comparative advantage from more labor-intensive to more skill- and technology-intensive goods. Third, using panel data allows firm-specific effects to be included, because (unobserved) managerial skills (assuming time variant intra-firm elements) can be controlled, along with industry and year fixed effects. Clearly, in a cross-sectional setup, this cannot be controlled.

Based on firm-level information, we created the patent-usage variables as shown in Figure 3. In short, for each firm we count the patents owned (PAT), the patents in use (USE) and patents that are not in use (NON-USE). Within PAT-USE, we have

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3 More generally, it is more common in the *discrete* technology industries. In the pharmaceutical industry, R&D can take as long as 10–15 years before new drugs can be introduced into the market. Hence, there is a substantial number of patents for drugs that are still in the process of R&D and not yet in the market.

4 It is important to note that those unused patents may simply reflect firms that lack the internal assets to commercialize, or are searching for licensees.

5 This survey is governed by the Japanese Statistics Act, and failure to reply results in a fine. The survey sample is restricted to firms that have more than 50 employees and capital of more than 30 million yen. It collects firms' accounting information (sales, employment, employment compensation, the number of establishments, R&D spending, exports, and imports). The industry classification is available at a 3-digit level. But, for our purpose of analyzing the impact of import competition, we restricted the sample to only manufacturing firms. All individual firms are assigned unique identifiers, making it possible to track the operations of the same firms over time (the panel data).

6 Motohashi (2008) uses the data from the Survey of Intellectual Property Activities by the Japan Patent Office (JPO) conducted in 2001 in order to classify patent usage. It was found that some of the patents are withheld by firms wishing to use them (or license them out) in the future. Others are kept because a firm needs them for future licensing negotiations. This practice is common in the electronics industry where cross-licensing is occurs more frequently.

information for the number of patents based on internal inventions (DEV), and the number of patents that are licensed out (LICENSE). These variables form the dependent variables in the regression analysis that follows.

Figure 3: Patent Usage and Variable Definitions

	Variable Symbol	Brief Explanations and Definitions
Patent Owned	**PAT**	The count of patents owned (including those purchased and cross-licensed) reported by a firm in a given fiscal year. This includes the cumulative count of patents owned by firms, not just patents for which application has been made in a given year.
Use (including licensed out)	**USE**	Those patents currently in use.
In-house inventions	**DEV**	Patents based on internal inventions that are in use.
-use	**NON-USE**	Defined as PAT minus USE, including blocking and future commercial use/negotiation.
Licensed out	**LICENSE**	Total count of patents which are licensed out. Domestic and international segregation is available, as well as the amount of money received.

It is important to note several limitations. First, the patent statistics in our data is a patent pool — all patents in which the firms have ownership. Empirical work that uses patent statistics collected from the patent office normally covers those patents for which application has been made, as well those patents that have been granted to the firm. In our data, all patents are presumably those granted (because the survey question asks how many patents a firm owns, rather than patents that have been applied for or are being granted). Since patent applications can indicate firms' innovative efforts, our measure may underestimate them.

Second, our patent data is simply the count. However, other studies employing patent statistics usually weight the patent count to its (backward and forward) citations, thus controlling for patent quality. The higher quality (or sometimes more basic) inventions attract more forward citations than lower quality inventions (sometimes, referred to as "patent thickness"). Without the ability to link our data on firm-owned patents with the citation information, we are unable to account for this quality dimension.

Third, our data does not adjust for the depreciation rate of outdated patents. It is appropriate to adjust for the depreciation rate of patents, because some firm-held patents can become obsolete. However, with no identification of the grant (or application) date of each patent, the deprecation rate cannot be applied in our data. We therefore look at the growth rate of each patent usage (rather than a simple count), hoping to minimize the bias coming from the non-depreciation of the patents.

3.2 Japan Industry Productivity Data

Industry level variables used in the regression analysis are mainly sourced from Japan Industrial Productivity (JIP) data (JIP 2013) stored in the online database in the Research Institute of Economy, Trade and Industry (RIETI) in Japan.[7] The JIP dataset is organized at the 3-digit industry level (52 manufacturing industries).

[7] http://www.rieti.go.jp/en/database/JIP2013/ See the Appendix for further details on JIP database.

3.2.1 Chinese Import Competition

We use the value of imports originating from the PRC ($IM^{\text{the PRC}}$) as a share of total world imports (IM^{World}) as a measure of the exposure to Chinese import competition in given JIP industries (a subscript *j*) .

$$\mathrm{CHM}_j = \frac{\text{Chinese imports}_j}{\text{Imports}_j}. \tag{1}$$

We also employ the conventional method of constructing Chinese import penetration by normalizing Chinese import on domestic absorption (i.e., domestic absorption = value added + imports – exports).[8]

$$\mathrm{CHM}_j = \frac{\text{Chinese imports}_j}{(\text{Value Added}_j + \text{Imports}_j - \text{Exports}_j)} \tag{2}$$

3.2.2 Instrumental Variable

While our motivation for the empirical analysis is to estimate the causal effects of Chinese import competition on patent outputs, we encounter the possible endogeneity problem: Firm-level innovative activity for reasons other than Chinese import competition may also shape trade flows, altering the degree of import competition in the industry (for example, more innovative firms might opt to do more offshoring to the PRC in order to facilitate their innovative home operations). For the same reason, the reverse causality is also a possibility: Imports from the PRC may be correlated with industry-wide technology shocks (to some degree, industry-specific fixed effects may take care of this concern, but it might not be sufficient). This makes ordinary least square (OLS) estimators biased and inconsistent.

We used a measure of Chinese (labor) productivity as an instrument for the endogenous Chinese import variables in the technology equation. This implied volatility (IV) strategy extracts any exogenous variations affecting Chinese export supply capacity, while indirectly affecting the level of innovative activity only through the intensified import competition in Japan. This instrument is inspired by the use of an instrument in other studies: Autor et al. (2015) used the exposure to Chinese import competition of eight advanced economies [9] as instruments to measure US exposure to Chinese imports. The motivation for their IV strategy was to extract supply-side productivity elements in Chinese export performance. However, as pointed out by Autor et al. (2015), their instrument faces a validity challenge, whereby industry technological changes among those advanced economies must be separate incidents. In other words, the technological diffusions must be limited across those high income economies. In our implementation of the IV strategy, we directly used the productivity measure (labor productivity) of Chinese industries, which undoubtedly has been behind the surge in Chinese export growth, yet is indirectly related to firm-level innovative activity. These data are extracted from the PRC Industrial Productivity (CIP) database.[10] There is no strict industry correlation between CIP

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[8] "Value-added" is defined as the difference between gross output and intermediate inputs. Gross output is measured as the sum of industry shipment, revenues from repairing and fixing services and revenues from performing subcontracting works. Intermediate inputs are defined as the sum of raw materials, fuels, electricity and subcontracting expenditure.

[9] Australia, Denmark, Finland, Germany, Japan, New Zealand, Spain and Switzerland.

[10] http://www.rieti.go.jp/en/database/CIP2015/index.html.

and JIP industries, so we arbitrarily assigned the corresponding CIP manufacturing industries to 52 JIP industries.

4. EMPIRICAL SPECIFICATION AND RESULTS

We used the following linear specification to relate firm-level patent growth (for different patent usages, separately) to the exposure of Chinese import competition at industries:

$$\Delta \ln(\mathrm{PAT})_{ijt} = \alpha_i + \alpha_{jt} + \beta_1 \mathrm{CHM}_{jt-5} + \varepsilon_{ijt}. \tag{3}$$

where subscripts *i, j* and *t* denote firm, industry and time. For each firm *I*, we have the count of patents owned (PAT), the count of patents in use (USE) and patents that are not in use (NON-USE). Within the group, USE, we also have breakdown information of patents that are based on in-house inventions (DEV). We also have the count of patents that are licensed out (LICENSE). These variables form the dependent variables separately in a regression analysis that follows.

The dependent variable is the 5-year (log) change in the patent usage categories as an indicator of firms' innovative activity. An explanatory variable, $CHM_{it-5,}$ is in level for the period, *t-5*. This linear specification slightly differs from that used by Bloom et al. (2016, wherein the 5-year log changes in both dependent (technology) and explanatory (an exposure to Chinese import competition) variables were used. The formulation of Equation (3) is preferred in our data and is intuitively more appealing because creating technology (and filing for patents) requires more time.[11] This specification literally tests the subsequent firms' innovative reaction to Chinese import competition experienced in the period *t-5.*[12] Aghion et al. (2005 and Amiti and Khandelwal (2013) also use a specification similar to Equation (3).

The baseline specification also includes both firm fixed effects (α_{it}) and industry-year fixed effects (α_j), to purge invariant shocks common in the respective dimensions (such as the unobserved managerial techniques within firms), and an industry-specific propensity to patent. It has been concretely reported that some industries are intrinsically prone to produce more patents than other industries because of effective patent enforcement (chemical and pharmaceutical).

We also form the patent production function to include other explanatory variables, which are drawn from the knowledge production function that treats patents as knowledge output and other firm characteristics as knowledge inputs. They are (log) employment, (log) age of firm, and (log) R&D ratio to sales (R&D intensity).

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[11] Growth rate is also preferred for a technical reason. Our data on the patent count includes the cumulative number of patents in which firms claim ownership. Hence, by using growth rate, we only account for newer patents, while discounting older patents.

[12] Even using the same specification as Bloom et al. (2016), it turns out that the estimation results are quite similar. This goes to show the persistent impact of Chinese import competition on the technology variables.

5. RESULTS

Table 2 presents benchmark results. We ran a set of regressions in OLS with firm and industry-year fixed effects. To aid the interpretation of the main results, descriptions of key variables are presented in the Appendix, Tables 1A and 2A. Column (1) indicates that Chinese import competition provides an overall inducement for more innovative activities among Japanese firms, although its estimated effect seems to be relatively smaller than the one found in Bloom et al. (2015): a 10-percentage point increase in Chinese import competition would result in a 0.37% increase in firm-level patents. Across the results, there is a visible position effect of Chinese import competition, with the exception of PAT-DEV and LICENSE.[13]

The most interesting finding is that Chinese import competition also generates more unused patents (NON-USE). It appears that the estimated coefficient is consistently larger than the one estimated for a USE equation (column 2): a 10-percentage point increase in Chinese import competition would result in a 0.26% increase in unused patents (versus a 0.13% increase in patents that are in use). While a reservation about the limitation in this variable exists (i.e., not all unused patents are used for the purpose of "blocking"), it is still suggestive evidence that Japanese firms would undertake more defensive reactions to the increased Chinese import competition.

The regression result indicates that lower Chinese import competition would trigger more patents based on in-house inventions (by judging from a negative sign in a DEV regression, column 3, Table 2) In addition, Chinese import competition has no statistically significant effects on patents designed for licensing out (LICENSE), as shown in column 4.

Table 2: Chinese Import Competition and Patent Usage, 1994 and 2005

	OLS				
	(1)	(2)	(3)	(4)	(5)
	PAT	USE	DEV	NON-USE	LICENSE
CHM_{jt-5}	0.037***	0.013*	–0.019***	0.026***	–0.001
	(0.008)	(0.007)	(0.006)	(0.007)	(0.001)
Constant	–0.552***	–0.353*	0.359**	–0.447**	0.106***
	(0.191)	(0.198)	(0.169)	(0.171)	(0.033)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes
R-sq	0.394	0.346	0.342	0.298	0.289
N	35,200	35,200	35,200	35,200	35,200

Notes: *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance. Estimation is by OLS with standard errors clustered by industry. The dependent variable is in five-year log differences of each patent usage type. Chinese imports as a fraction of total industry imports represent an explanatory variable. All columns include a full set of firm and industry-year fixed effects.

[13] In fact, it is puzzling to see that the intensified Chinese import competition would actually lower the rate of in-house invention patents, while it has no statistically significant impact on patents designed for licensing out.

These results and associated interpretations are reinforced upon taking an instrumental approach (Table 3). In first stage regression (not shown), labor productivity has a statistical significance that is on the level of Chinese import competition.[14] The estimated coefficients in all regressions now show larger effects as compared to the OLS estimates.[15]

Table 3: Chinese Import Competition and Patent Usage (IV Regressions), 1994 and 2005

	Instrumental Variable				
	(1) PAT	**(2) USE**	**(3) DEV**	**(4) NON-USE**	**(5) LICENSE**
CHM_{jt-5}	**0.113*** **	**0.064*** **	**–0.073*** **	**0.077*** **	**–0.009*** **
	(0.004)	**(0.004)**	**(0.004)**	**(0.004)**	**(0.001)**
Constant	–1.017***	–0.524***	0.366***	–0.828***	0.065**
	(0.090)	(0.091)	(0.094)	(0.098)	(0.030)
Firm fixed effects	Yes	Yes	Yes	Yes	Yes
Industry-Year fixed effects	Yes	Yes	Yes	Yes	Yes
N	35,200	35,200	35,200	35,200	35,200

Notes: *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance. Estimation is by OLS with standard errors clustered by industry. The dependent variable is in five-year log differences of each patent usage type. Chinese imports as a fraction of total industry imports represent an explanatory variable. All columns include a full set of firm and industry-year fixed effects.

In Table 4, the empirical specification follows a form of the conventional knowledge production function, treating patents as knowledge outputs. Even after we control for relevant firm characteristics, Chinese import competition remains positive and statistically significant. With respect to firm size (measured by the number of employees), it indicates that smaller firms obtain more patents, and older firms (in terms of the age of the firm) engage in more innovative activity (interestingly, the estimated coefficients for firm characteristics withhold much larger than a variable of capturing the level of import competition from the PRC): a 10 percentage point decrease in employment leads to a 4.4% increase in innovative activity. Other than a PAT regression, we found the effect of Chinese competition to be positive and statistically significant in a NON-USE regression (column 4). Conditioned on relevant firm characteristics, Chinese import competition would produce patents of a more defensive (unused patents) among Japanese firms.

Table 5 sequentially introduces the import competition indicators from other economies. We introduced import competition from Asian NIEs (Singapore; Republic of Korea; Hong Kong, China; and Taipei,China) separately for those from high-income OECD economies (including the United States and high-wage European economies).[16] Overall, the main results remain the same: increased Chinese import competition would make Japanese firms pursue more patenting, while import competition from other high-wage economies has no statistical significance. These findings conform to those found in Bloom et al. (2016. The theoretical intuition drawn from the trapped-factor model is that import

[14] A full set of tests needs to be carried out to establish the validity of instruments.

[15] In Bloom et al. (2016), similar results were obtained.

[16] In an experimental stage, import competition from other low-wage economies (such as those in mainland Southeast Asia) was included, but it turns out that it is not important, and does not change the estimated coefficient for CHM.

competition from high-wage economies is not a substitute for old products, which do not create incentives for innovation. There is positive and statistically significant effect on non-use patents (NON-USE), while in other regressions, the sign for CHM has been changed or has lost statistical significance as compared to the benchmark estimation.

Table 4: Chinese Import Competition and Patent Usage (OLS with Firm-Level Characteristic Controls), 1994 and 2005

	(1) PAT	(2) USE	(3) DEV	(4) NON-USE	(5) LICENSE
CHM_{jt-5}	**0.031*** **	**0.010**	**–0.012***	**0.021*** **	**–0.000**
	(0.008)	**(0.007)**	**(0.006)**	**(0.007)**	**(0.001)**
Log $(Emp)_{it-5}$	–0.445***	–0.113	0.023	–0.532***	0.029
	(0.096)	(0.098)	(0.106)	(0.098)	(0.028)
Log$(Age)_{it-5}$	0.517***	0.326***	–0.617***	0.372***	–0.089***
	(0.109)	(0.110)	(0.139)	(0.134)	(0.029)
Log$(R\&D)_{it-5}$	–0.253***	–0.372***	–0.696***	–0.032	–0.069**
	(0.056)	(0.101)	(0.118)	(0.075)	(0.026)
Constant	0.276	–0.714	2.564***	1.307**	0.266
	(0.597)	(0.589)	(0.556)	(0.634)	(0.165)
R-sq	0.398	0.349	0.350	0.301	0.291
N	35,164	35,164	35,164	35,164	35,164

Notes: *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance. Estimation is by OLS with standard errors clustered by industry. The dependent variable is in five-year log differences of each patent usage type. Chinese imports as a fraction of total industry imports represent an explanatory variable. All columns include a full set of firm and industry-year fixed effects.

Table 5: Chinese Import Competition and Patent Usage (OLS with Other Import Competition Variables), 1994 and 2005

	(1) PAT	(2) PAT	(3) USE	(4) USE	(5) NON-USE
CHM_{jt-5}	**0.036*** **	**0.033*** **	**0.015*** **	**0.007**	**0.025*** **
	(0.008)	**(0.009)**	**(0.005)**	**(0.009)**	**(0.008)**
NIE_{jt-5}	–0.003		0.005		–0.004
	(0.008)		(0.008)		(0.005)
$High_{jt-5}$		–0.007		–0.008**	
		(0.006)		(0.004)	
Constant	–0.494**	–0.144	–0.471*	0.126	–0.351*
	(0.238)	(0.366)	(0.233)	(0.336)	(0.200)
R-sq	0.394	0.395	0.346	0.347	0.298
N	35200	35200	35200	35200	35200

continued on next page

Table 5 *continued*

	(6) NON-USE	(7) DEV	(8) DEV	(9) LICENSE	(10) LICENSE
CHM*jt-5*	**0.023*****	**–0.021*****	**–0.019****	**–0.002***	**0.000**
	(0.007)	**(0.005)**	**(0.008)**	**(0.001)**	**(0.001)**
NIE*jt-5*		–0.007		–0.002	
		(0.007)		(0.001)	
High*jt-5*	–0.005		–0.000		0.002*
	(0.008)		(0.005)		(0.001)
Constant	–0.170	0.512**	0.365	0.154***	–0.003
	(0.408)	(0.214)	(0.390)	(0.032)	(0.077)
R-sq	0.298	0.342	0.342	0.290	0.290
N	35,200	35,200	35,200	35,200	35,200

Notes: *** denotes 1% significance; ** denotes 5% significance; * denotes 10% significance. Estimation is by OLS with standard errors clustered by industry. The dependent variable is in five-year log differences of each patent usage type. Chinese imports as a fraction of total industry imports represent an explanatory variable. All columns include a full set of firm and industry-year fixed effects.

6. CONCLUSION

This paper examined the impact of Chinese import competition on the innovation responses of a panel of Japanese manufacturing firms for the period 1994–2005. Based on the unusually detailed firm-patent dataset, we have uncovered several heterogeneous dimensions of the impact of innovation in the case of import competition from the PRC. First, we found that, while increased imports from the PRC have induced Japanese firms to take out more patents, they are mostly of lower quality (i.e., patents with zero-forward citation). This was inferred as evidence suggesting that Japanese firms have increased the defensive nature of patents in order to protect their core inventions. This is similar to a strategy followed by firms in “continuous” technology-intensive industries in the field of Information and Communication Technology (ICT); to build up the patent fence in order to deter new entrants in the technology field. This finding coincides with a sector that has been subject to intensified import competition from the PRC over the past two decades.

Second, when the sample of firms is split into globally-engaged firms with positive importing (and exporting) activity and domestic-oriented firms, the former group has responded positively to import competition from the PRC by increasing its R&D intensity. Our interpretation of this result is that Japanese firms (and presumably more innovative firms) have built up their innovation capacity while moving away from low-cost manufactured goods, in which the PRC has more comparative advantages. In contrast, such effects are consistently muted for firms with a domestic market focus. These types of firms are completely insulated from Chinese import competition.

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APPENDIX

Appendix Table 1A: Descriptive Statistics

	PAT	NON-USE	USE	DEV	LICENSE	CHM
Year	Mean	Mean	Mean	Mean	Mean	Mean
1994	109.1	77.2	35.0	27.9	0.4	10.3
1995	107.2	75.2	32.2	27.8	0.3	12.5
1996	121.1	86.7	34.6	30.7	0.4	13.7
1997	98.6	64.3	34.4	91.7	0.6	15.1
1998	106.4	68.1	38.3	101.2	0.5	16.0
1999	115.2	73.3	41.9	108.8	0.6	16.8
2000	50.2	36.6	24.1	40.7	0.9	18.2
2001	123.3	75.4	47.9	38.9	0.8	20.5
2002	124.3	78.1	46.3	38.8	0.7	23.0
2003	142.5	91.9	50.5	41.4	0.7	24.1
2004	141.9	88.7	53.2	43.1	2.1	26.5
2005	130.9	81.0	49.9	43.2	2.3	28.9
	PAT	USE	NON-USE	LICENSE	# of Firms	
Year	Sum	Sum	Sum	Sum	Sum	
1994	46,908	16,118	30,790	200	**6,374**	
1995	49,417	16,300	33,117	79	**6,637**	
1996	53,485	17,650	35,835	300	**6,614**	
1997	53,352	17,600	35,752	800	**6,464**	
1998	52,119	17,200	34,919	228	**6,513**	
1999	55,909	18,692	37,217	247	**6,447**	
2000	43,166	9,800	33,366	344	**6,340**	
2001	50,000	39,726	10,274	938	**6,415**	
2002	47,000	24,670	22,330	301	**6,269**	
2003	48,061	20,155	27,906	350	**5,764**	
2004	47,166	43,000	4,166	8,930	**6,088**	
2005	42,662	34,000	8,662	10,000	**5,937**	

Source: Own calculation.

Appendix Table 2A: Descriptive Statistics for Variables Used in Regressions

Variable	Unit	Obs	Mean	Std. Dev.	Min	Max
PAT	Count	75,862	113.8	1,102.1	0	55,909
USE	Count	75,862	40.4	433.2	0	43,000
NON_USE	Count	75,862	74.5	819.2	0	42,662
DEV	Count	75,862	53.1	653.8	0	55,909
LICENSE	Count	75,862	0.8	49.3	0	10,000
Emp. total	Unit	75,862	629.0	2,424.1	50	80,500
R&D expenditures	Value in yen	75,862	888.4	10,266.2	0	527,359
Est. year	Year	75,857	1,951.0	111.0	0	2,006
CHM	Percentage	75,862	18.6	16.2	0.02	98

Source: Own calculation.