Export Tightening, Competition and Firm Innovation: Evidence from the RMB Appreciation[1]

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Abstract

This paper investigates how firm innovation reacts to changes in competitive pressure in the export market. We use the exchange rate appreciation of the RMB during 2005-2007 as a natural experiment and exploit its differential impact on Chinese manufacturing firms with different export exposure. The appreciation reduced exports and imposed greater competitive pressure on exporters relative to non-exporters. In response, exporters increased innovation activities more than non-exporters. Using a difference-in-difference approach, we find the R&D expenses of exporters increased by 11% more than non-exporters during the appreciation period, and the new product development of exporters increased by nearly 1.5 times more than non-exporters. Innovation increased for productive, continuing exporters but decreased for less productive firms that quit exporting. These results contradict the prediction of models that link export and innovation solely via market size effects, and suggest the important role of competition in determining firm innovation.

Keywords: Export, Innovation, Firm Evidence

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1. Introduction

One of the key ideas in international economics is that trade can bring dynamic gains by fostering innovation. Why is trade associated with more innovation? The recent trade literature focused on two channels, one on the export side and one on the import side. On the export side, a number of papers found that export increases the incentive of innovation by expanding firms' market size.[4] On the import side, most of the studies focused on the impact of increased import competition on the innovation behavior of domestic firms.[5]

In the present paper, we investigate a new channel linking trade and innovation: changes in competitive pressure in a firm's export markets. Compared with the market access effects and import competition effects, this channel is much less studied in the trade and innovation literature, possibly because it is rare to observe natural experiments that change firms' competitive pressure in export markets at a systematic level. To this end, we use the real exchange rate appreciation in China during 2005-2007 as a natural experiment and investigate how the increased competitive pressure imposed by the appreciation affects the innovation behavior of Chinese manufacturing firms. We exploit firm heterogeneity in their export status to identify the impact of the appreciation. Specifically, an appreciation of the RMB tightens exports and increases the competitive pressure of firms that already engaged in exporting. For non-exporters, however, the appreciation will not have a direct impact. Therefore, if the competitive pressure does affect innovation, the ex-ante exporters and non-exporters are expected to have different response in their innovation behavior. We adopt a difference-in-difference approach to investigate whether such an effect exists.

One empirical challenge is that the appreciation may affect firm innovation through channels

[4] See Bustos(2011), Lileeva and Trefler(2010), Aw, Roberts and Winston(2007), Aw, Roberts and Xu(2011), Costantini and Melitz (2008), Verhoogen(2008).
[5] See Bloom et al.(2011), Teshima(2008), Iacovane et al.(2011)

other than changing the competitive pressure in the export market. Actually, the appreciation may also affect innovation through the two channels emphasized in the literature (i.e. markets size effects and import competition effects). First, the appreciation implies a tightened export market and contracts the total market size of exporters, thus reducing the incentive for innovation (market size effects). Second, the appreciation makes foreign exporters more competitive in the domestic markets and increases the import competition faced by indigenous firms (import competition effect). We distinguish the effect of each channel separately. First, we include import penetration ratio at the industry-level to isolate the impact of import competition. Second, we isolate the market size effects by investigating the innovation response of exporters quitting the export market (market size contracts severely) and those staying in the export market (market size contracts less severely). Our results show that both market size and import competition have a significant effect on innovation. However, what distinguishes our study from other previous works is that we find the change of competitive pressure in firms' export markets has a significant impact on innovation. This new channel is able to explain our major empirical finding that the innovation behavior of the *ex-ante* exporters rose much faster than *ex ante* non-exporters during the appreciation period. Both market size effects and import competition effects cannot explain the higher innovation growth of exporters. First, since the foreign market contracts more for exporters under the appreciation, market size effects will predict that the innovation of exporters will fall, rather than rise, relative to non-exporters. Second, as long as exporters also have sales in the domestic market as in Melitz (2003), pressures from import competition should be identical for exporters and non-exporters, failing to explain why innovation of exporters rose faster.

To ensure that our results are capturing the effect of exchange rate appreciation rather than something else, we have included a set of firm and industry characteristics in the regression. We also test the robustness of our results by excluding other possible confounding policies, such as MFA expiration and rise of labor costs. Finally, placebo tests show that the innovation growth of exporters is not significantly different from non-exporters before the appreciation.

To preview the results, we find the RMB appreciation caused the R&D expenses of exporters to increase by 11 percent, and new product development to increase by nearly 1.5 times more than non-exporters. In addition, we find heterogeneous innovation responses among the *ex-ante* exporters. Innovation increased for productive, continuing exporters but decreased for less productive firms that quit exporting.

This paper is related to a broad literature that studies the nexus between trade and innovation. Papers like Bustos (2011), Lileeva and Trefler (2010), Verhoogen (2008) and Aw et al. (2010) link exports to innovation through increased market size. These studies usually set in an export expansion scenario, such as tariff reductions or exchange rate devaluation, and investigate the impact of increased export opportunities on firms' innovation (or upgrading) behaviors, such as R&D, product innovation, ISO certification and technology adoption from advanced countries. The present paper, however, is set in a scenario of export tightening (caused by the exchange rate appreciation) and therefore investigates the flip side of the coin. Interestingly, we find that firm innovation also rise under the appreciation, which contradicts the prediction of the models that link export and innovation solely via market access. Therefore there must be some other forces at work. Another line of literature links trade and innovation through import competition. Papers like Bloom et al. (2011) and Iacovane et al. (2011) investigate the impact of increased import competition from China on the innovation behavior(patent, IT adoption, just-in-time system etc.) of the European and Mexican firms, while the paper by Teshima (2008) investigates the impact of increased import competition resulting from the

Mexican unilateral tariff reductions on firm innovation. Our study joins such a set of literature in that we also investigate the impact of competition on firm innovation. However, we focus on the competitive pressure in firms' export markets instead of import competition in the domestic market. To our best knowledge, our paper is the first to study the impact of competitive pressure in foreign markets on innovation using firm-level micro data.

This paper is also related to the literature that investigates the impact of exchange rate shocks on firm performance. Although this literature has a long history, there are still not many papers using firm-level data. Nucci and Pozzolo (2001, 2010) studies how exchange rate affect investment and employment decisions of Italian manufacturing firms. Ekholm et al. (2011) studies the impact of the real exchange rate appreciation on the employment, productivity and capital intensity of manufacturing firms in Norway. Micro level studies on the RMB appreciation has also begun to emerge recently, but mostly focused on its impact on trade flows (Li et al., 2011; Tang and Zhang, 2012). To our best knowledge, our paper is the first to study how exchange rate shocks affect the innovation behavior of firms.

The rest of the paper is organized as follows. Section 2 describes the data. Section 3 conducts preliminary analysis on the impact of exchange rate appreciation on export, firm performance and innovation. Section 4 estimates the impact of the appreciation on firm innovation using difference-in-difference. Section 5 conducts a series of robustness checks. Section 6 discusses industry and firm heterogeneity. The last section concludes.

2. Data

The firm-level data in this paper comes from Annual Surveys of Manufacturing Firms conducted by the National Bureau of Statistics of China from 2001 to 2007. The survey includes all State Owned Enterprises (SOE) and those Non-State Owned Enterprises with annual sales of RMB five million (or equivalently, about $ 650,000) or more. The dataset includes information from balance sheet, profit and loss and cash flow statements of firms. It includes about 80 variables, and provides detailed information on firm's identification, ownership, export status, employment, capital stock, revenue. Importantly for this study, the survey reports information about annual R&D expenses as well as revenue from new products for each firm. We will use these two variables to construct the main measures of firm innovation. Because of the China Industry Census, R&D and new product data is missing in 2004. We restrict our sample to manufacturing industries.

Based on this dataset, we construct a balanced panel of firms that exist throughout the entire sample period. We conduct the subsequent analysis on the balanced panel for two reasons. First, our paper aims to study the with-in firm performance change instead of cross-firm resource reallocation. Therefore firm entry and exit is not the focus of our study.[6] Second, most micro level studies on export and innovation rely on balanced panel data (e.g. Verhoogen, 2008; Lileeva and Trefler, 2010; Bustos,2011). To clean the data, following Feenstra et al. (2013), we drop the observations that report missing or negative values for any of the following variables: total sales, total revenue, total employment, fixed capital, export value, intermediate inputs. We drop any observations if its export value exceeds total sales or if share of foreign asset exceeds one. We include firms with at least eight employees. The final sample for subsequent analysis consists of 58,182 firms and 407,274 observations.

[6] In order to ensure our results are not purely driven by firm entry and exit, we also repeat the benchmark regression using the unbalanced sample which includes all firms in section 5.

3. Preliminary analysis

3.1 Background: China's exchange rate regime reform and the RMB appreciation

On July 21, 2005, after 11 years of strictly pegging the RMB to the U.S. dollar at an exchange rate of 8.28, the People's Bank of China (PBOC) announced a revaluation of the currency and a reform of the exchange rate regime. The revaluation puts the RMB at 8.11 against the dollar, which amounts to an appreciation of 2.1%. Under the reform, the PBOC incorporates a (undisclosed)"reference basket" of currencies when choosing its target for the RMB instead of merely focusing on dollars. However, except for the sudden jump of 2.1% on July 21, 2005, the appreciation has proceeded in a so called "gradual" manner. Each day the PBOC will announce its target for the following working day based on that day's RMB closing price in terms of a "central parity." The following day, the RMB exchange rate will be allowed to fluctuate against the dollar and other currencies within a band of plus or minus 0.3% around the announced central parity[7] Despite the small movement allowed in each day, the RMB has actually appreciated 18% against the U.S. as of the end of November, 2008. The effective nominal exchange rate has also appreciated by 14% (see Figure 1).

It is important to emphasize that the gradual manner of the appreciation might be quite important for our study. First, a gradual appreciation allows the firm to adjust to the competitive pressure without being wiped out of the market immediately. Actually, giving the domestic firms enough time to adjust to the competitive pressure is also a major reason why the Chinese government adopts a managed floating exchange regime rather than an independently floating exchange rate regime.[8] Second, a gradual and managed appreciation is helpful for the firms to form correct expectations

[7] In 2007 the fluctuating band against dollar is enlarged to 0.5%, with the band against other currencies unchanged.
[8] http://usa.chinadaily.com.cn/china/2011-03/14/content_12167195.htm

about future exchange rate movements. Expecting further appreciations in the future, firms may take moves to adjust even if the current appreciation is not drastic. Therefore, the innovation response captured in our study may reflect not only the effect of the current appreciation, but also the effect of expectations of further appreciations.

[Insert Figure 1 Here]

3.2 Export tightening

We start by examining whether the appreciation led to export tightening and increased competitive pressure for exporters. In Panel (A) of Table 1 we calculate the average export growth, share of exporters (in terms of number of firms) and average export intensity (defined as export over total sales) in each year. The share of exporters and average export intensity indicates exports at the extensive margin and intensive margin, respectively. The data shows that all three indicators kept rising before 2005, but began to fall after then. Total export growth fell from 24.6% in 2004 to 13.6% in 2007, share of exporters fell from 41.1% to 38.1%, and average export intensity from 24.2% to 22.5%. Thus it is clear that the appreciation has led to sizable export tightening. Panel (B) of Table 1 shows the fraction of firms that enter and exit the export market during the pre-appreciation period (2001-2004) and the appreciation period (2005-2007).[9] Compared to the pre-appreciation period, the fraction of firms entering export market decreased from 9.38% to 3.97%, while that of firms exiting the export market increased from 4.14% to 5.56%. This once again suggests that export shrank at the extensive margin during the appreciation period.

[9] Starting to export means the firm has zero export in the beginning year of the period, but has positive export in the ending year of the period. Continue to export means the firm has positive export in the beginning year of the period, and positive export in the ending year of the period. Quit exporting means positive export in the beginning year of the period but zero export in the ending year of the period. Never export means zero export in both the beginning and ending year of the period.

[Insert Table 1 Here]

The critical assumption we rely on for identification in the econometric analysis is that the appreciation imposed larger competitive pressure for exporters relative to non-exporters. We would like to know whether such differential effects exist in the data. Following, Galdon-Sanchez and Schmitz (2002) and Ekholm (2012), we argue that greater potential negative impact of the appreciation translates to greater competitive pressure. Therefore, we examine whether the appreciation imposed a greater negative impact for exporters relative to non-exporters. Table 2 reports the growth rate of employment, profits and total sales for exporters and non-exporters during the appreciation period and pre-appreciation period, respectively. Growth rate difference between the two periods is also reported. It is evident from Table 2 that exporters experienced a much more severe slow-down in the growth of employment, profits and sales under the appreciation. For example, compared to the pre-appreciation period, employment growth rate reduced by 10.6 percentage points during the appreciation period for exporters but only 4.5 percentage points for non-exporters. Profits and sales show a similar pattern. Thus the data suggest that the appreciation imposed a greater negative shock on exporters and this translates into increased competitive pressure.[10]

[Insert Table 2 Here]

3.3 Firm innovation

Then how do firms' innovation activities respond to the competitive pressure imposed by the

[10] In Appendix Table C1 we show that among exporters, the negative shock of the appreciation is stronger for firms with higher export intensity. However, firms with export intensity equal to one (i.e. pure exporters) are less affected. As mentioned in Dai et al. (2012), a large proportion of pure exporters in China are processing exporters, which import foreign intermediate inputs for assembly and re-export. As processing firms import a large share of inputs, the appreciation may reduce their total cost by making the imported inputs less expensive. This cost-saving effect on the import side may offset the revenue-reducing effect on the export side.

appreciation? Do exporters increase innovation faster than non-exporters because the incremental competitive pressure is larger? We measure innovation with two variables. The first is the annual R&D expenses of the firm, and the second is new product development, defined as the revenue from sales of the new products over total sales revenue. R&D expenses measures the input side of innovation, while new product revenue share measures the output side. In Figure 2 we draw the log R&D expenses (Figure 2a) and the new product revenue share (Figure 2b) for exporters and non-exporters over the sample years. Two patterns emerge immediately from Figure 2, the most important figure in the present paper. First, consistently with the literature, exporters on average have a better performance in innovation (Bustos,2011; Lileeva and Trefler, 2010; Aw et al., 2012). They invest more in R&D and recoup a larger share of revenue from new products. Second, before 2005, R&D expenses and new product revenue share have a similar *trend* for both exporters and non-exporters, while after 2005, both R&D and new product revenue share obviously rose faster for exporters. Such a data pattern is consistent with our previous conjecture that the export tightening under the appreciation imposed larger competitive pressure for exporters relative to non-exporters and induced more innovation from exporters. Notice that the innovation of non-exporters also rose slightly after 2005, possibly due to increased import competition resulting from the appreciation. We share control for import competition in our subsequent econometric analysis.

[Insert Figure 2 Here]

In order to show the innovation difference for exporters and non-exporters more clearly, we run the following regression in a flexible specification:

$$INV_{ft} = \alpha + \sum_{t=2002}^{2007} \beta_t EXP_{ft} \times Year_t + \sum_{t=2002}^{2007} Year_t + v_f + \varepsilon_{ft} \qquad (1)$$

where INV_{ft} is the innovation measure for firm f in year t. We include a full set of year dummy $Year_t$ as well as the exporter dummy interacted with the year dummy $EXP_{ft} \times Year_t$. v_f is firm fixed effects and ε_{ft} is the error term with conventional properties. A simple derivation shows that:

$$\beta_t = E(INV_{ft} \mid EXP_{ft} = 1, Year = t) - E(INV_{ft} \mid EXP_{ft} = 0, Year = t) \qquad (2)$$

Thus β_t measures the average innovation difference between exporters and non-exporter in year t. By tracking the evolution of β_t over the years we can see how the innovation difference has changed over time. This flexible specification has the advantage of not imposing arbitrary structure on the data. We plot the β_t for year 2002-2007, together with their 95% confidence intervals, in Figure 3. It is clear that β_t are low and steady before 2005, but rose dramatically afterwards. The β_t in 2007 is almost 4 times its value in 2003, indicating that the RMB appreciation might have a large impact on innovation behavior of exporters. However, the previous results might be caused by other firm and industry characteristics instead of the exchange rate movements, so we turn to control for these factors in the following econometric analysis.

[Insert Figure 3 Here]

4. Estimating the impact of the appreciation on firm innovation

4.1 Empirical Strategy

Realizing that the appreciation has differential impact on exporters and non-exporters, we use a difference-in-difference (DID) approach for estimations. In a seminal paper, Bertrand et al.(2008) point out that a multiple period DID specification (like the one in equation (1)) with persistent dependent variable (such as R&D) may run into serious serial correlation problem and lead to over-rejection of the null hypothesis. To fix this problem, we adopt one of their suggested remedies and collapse the data into a pre-appreciation period (2001-2004) and a post-appreciation period

(2005-2007). We take the following specification:

$$INV_{ft} = \alpha + \beta_1 Post05_t + \beta_2 EXP04_f \times Post05_t + v_f + \varepsilon_{ft} \qquad t = 0,1, \qquad (3)$$

where $t=0$ and $t=1$ refers to the pre-appreciation period and the appreciation period, respectively. INV_{ft} is the *year average* of innovation measure for firm f in period t. In the benchmark results, we used four indicators of innovation: (1) log R&D expenses (2) a R&D dummy that equals 1 if a firm conducts positive R&D and equals 0 otherwise. (3) new product revenue share, and (4) a new product development dummy that equals 1 if a firm has positive revenue share from new products. $Post05_t$ is a dummy variable that equals 1 for the years after(and including) 2005, and equals 0 otherwise.[11] $EXP04_f$ is a dummy variable that equals 1 for exporters in year 2004, and equals 0 for non-exporters.[12] v_f and ε_{ft} are again firm fixed effects and error term. Taking a difference for equation (3) yields our final estimation equation:

$$\Delta INV_f = \beta_1 + \beta_2 EXP04_f + X_{f04} + X_{i04} + \varepsilon_f^* \qquad (4)$$

Following Trefler (2004), we include a series of firm and industry control variables to control for the firm and industry characteristics that may both be correlated with the exchange rate movements and also affect firm innovation. Firm-level controls include firm-level TFP[13], firm size, proxied by log employment, and firm fixed capital stock. Industry-level controls include 2-digit industry-level import penetration ratio to control for the impact of import competition.[14], as well as 4-digit industry-level total export and total domestic sales (both in logs) to control for foreign and domestic demand shocks

[11] Although the appreciation began only in July, 2005, and the actual appreciation during 2005 is modest, we still choose 2005 as the first year of the appreciation period. As mentioned, the innovation response may not only result from the actual appreciation, but also the expectations for future appreciations. In this sense, although the actual appreciation in 2005 is not drastic, the exchange rate regime reform has already changed firm behavior by altering their expectations for the future exchange rate movement. For robustness, we have also used year 2006 as the first year of the appreciation period. The results are quite similar.

[12] We use the exporting status one year before the exchange rate shock to avoid potential endogeneity. Results using exporting status in 2005 show similar results (results available upon request)

[13] TFP is estimated using the Olley-Pakes (1996) approach. Detailed estimation procedures are described in Appendix A.

[14] Industry import penetration ratio is defined as value of import over total absorption (detailed calculation procedure in Appendix B).

that might affect firm innovation through market size effects. All control variables take the value of the year prior to the appreciation shock (i.e. 2004) to avoid possible reverse causality.[15] We estimate equation (4) using OLS. Standard errors are clustered at the four-digit industry level.[16] Table 3 reports the summary statistics of the major variables used in estimations.

[Insert Table 3 Here]

4.2 Results

Table 4 reports the benchmark estimation results. No matter which indicator is used to measure innovation, the coefficient of the export dummy ($EXP04_f$) is always positive and significant. This suggests that the innovation of exporters increase more than non-exporters during the appreciation period. Since we take logs for the R&D expenses, the coefficient in Column 1 suggests that the R&D investment by exporters increased by 11 percent more than non-exporters. For new product revenue share (Column 3), the new product revenue share by exporters increase 0.1 percentage points more than non-exporters. This number may seem small at first glance. However, the new product revenue share for non-exporters increased by only 0.066 percentage points during the same period. Thus the coefficient suggests that the increase in new product revenue share for exporters is actually nearly 1.5 times more than that of non-exporters. In addition, the coefficient of import penetration ratio is also positively significant in some cases, though the significance is not robust to the measure of innovation.[17]

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[15] All control variables taking the value of the initial year, i.e. 2001, yields similar results.

[16] Considering that firm R&D and new product share has lots of zeros, it is tempting to run a Tobit regression instead of simple OLS. However, since the estimation equation has been taken first-difference, the dependent variable is no longer left or right censored. Therefore the usual Tobit approach will not apply. But we indeed tried a Tobit model in levels, as in equation (3). The results are qualitatively similar to the benchmark results. The results are available upon request.

[17] In Appendix Table C2 we also investigate whether the innovation response is larger for firms with higher export intensity. We replace the export dummy in equation (4) with export intensity and then rerun the regression. The results show that when pure exporters are excluded, firms with higher export intensity have larger increase in innovation. However, the coefficients become not significant when pure exporters are included. We discuss the role of pure exporters in Section 6.3.

[Insert Table 4 Here]

5. Robustness

5.1 Using one year before and after the shock

In section 4 we use the year average of innovation in the pre-appreciation and appreciation period as the dependent variable. Taking year average has the advantage that it takes advantage of innovation information in all years and helps to capture the full impact of the appreciation if any lagged effects exist. However, a potential problem with this approach is that our estimation result might also capture the effect of other policies that took effect during the appreciation period and influence the innovations of exporters and non-exporters differently. As suggested by Bertrand et al. (2004), an alternative way to estimate is to use just one year before and after the appreciation shock. To this end, we repeat the DID regression in equation (4), using the observations in year 2003 and 2006 only. The result reported in Table 5 show that the coefficient of the variable $EXP04_f$ is slightly smaller than the benchmark results in Table 5, but is nonetheless positive and highly significant.

[Insert Table 5 Here]

5.2 Control for other confounding polices

Although using one year before and after the shock may alleviate the effect of the confounding policies long before and after the shock, it will not be able to exclude the effect of policies that took effect contemporaneously with the exchange rate shock. Here we consider two highly relevant policies. The first is the expiration of multi-fiber arrangement (MFA) since January, 2005, as documented in Brambilla et al. (2010). The quota elimination on textile and apparel products led to a surge in exports to the United States and the European countries. This may promote the innovation of textile exporters through the market size effects. To rule out the effect of MFA, we repeat the DID regression but excluding textile related industries. Results are reported in Panel (A), Table 6. The second possible confounding factor is the rise of labor costs in China after 2005 (Zhang et al., 2011), which might induce firms to adopt more skill intensive techniques. We control for this factor by including change of log average wage as the additional control variable. Results are reported in Panel (B), Table 6. In both cases, the main result in the previous section holds very well.

[Insert Table 6 Here]

5.3 Placebo tests

One of the critical assumption in applying DID is that the outcome variable for the treatment group should be identical with the control group in the absence of the treatment. In our case, this assumption means the innovation of exporters and non-exporters should have a statistically identical trend before the exchange rate appreciation. If not so, the impact we find in the previous section may just be spurious. We test this hypothesis by picking some year *before* the appreciation to conduct a DID regression. The result using 2002 and 2004 as the dividing years are reported in Panel (A) and Panel (B) of Table 7, respectively.[18] In both cases, none of the coefficients before the export dummy is positively significant. Thus, it is not likely that our previous result is driven by the innate different innovation trend between exporters and non-exporters.

[Insert Table 7 Here]

5.4 Firm entry and exit

All the previous results are based on a balanced panel and therefore do not take into account firm

[18] We can not do the test using 2003 as the dividing year because the innovation for 2004 is missing.

entry and exit. However, it is well documented in the literature that entry and exit of firms is not random. Less productive firms are more likely to exit the sample (Pavnick, 2002) and thus excluded in the previous analysis. These firms might have different innovation response compared with firms that stay throughout the sample period. To ensure that our previous result is not driven by sample selection, we repeat the DID exercise using the full unbalanced sample and report the results in Table 8. It is clear that the benchmark results still hold qualitatively.

[Insert Table 8 Here]

6. Industry and firm heterogeneity

6.1 Industry heterogeneity

In section 4 we see that the increased competitive pressure imposed by the appreciation induced more innovations from exporters relative to non-exporters. In this section we examine whether such effects vary across industries and firms. Intuitively, R&D is more critical for competitiveness in industries that are more R&D intensive. Therefore, firms in R&D intensive industries should be more likely to respond to the competitive pressure by increasing innovation. To test whether this is true in the data, we include in equation (4) an interaction term of the export dummy and the R&D intensity (defined as R&D expenses over total sales) of each 4-digit industry. In Table 9, all the coefficients before the interaction term are positively significant. Therefore, while in general exporters respond to increased competitive pressure with more innovation, such response is larger in industries with higher reliance on research and development.

[Insert Table 9 Here]

6.2 Firm heterogeneity

Firm heterogeneity has been the focus of the new generation of trade literature. We may expect that exporters with different initial productivity might respond to the appreciation differently. As discussed in the introduction, the appreciation can affect innovation through two offsetting channels: the market size effect and the competition effect. The magnitude for these two effects may vary with firm productivity. Specifically, highly productive firms might be able to continue exporting in the face of the appreciation thus the market contraction for these firms is less severe. Therefore, the positive competition effect is more likely to dominate the negative market size effect, leading to a net increase of innovation. Less productive firms, however, are more likely to be forced out of the export market. The entire exit from the export market implies a substantial market size contraction (as in the model of Melitz, 2003), so the negative market size effect is more likely to dominate the positive competition effect, leading to a net decrease of innovation.

To investigate this issue, we divide exporters into two sub-groups: continuing exporters and export quitters. We define continuing exporters to be firms that export in 2004 and continue exporting during 2005-2007. Export quitters are firms that export in 2004 but quit the export market in some year during 2005-2007 and never export afterwards. Table D1 in Appendix D compares the productivity (measured by TFP), firm size (log employment) and log sales of continuing exporters and export quitters. Consistent with the literature (e.g. Pavcnik, 2002), continuing exporters are larger and more productive. We re-run the DID regression in equation (4), but now restrict the treatment group to continuing exporters or export quitters.[19] The results are reported in Table 10. The results show that the coefficient before the exporter dummy in the continuing exporter sample is still positively significant, and the magnitude is larger than what we find in section 4 using exporters in general as

[19] The comparison group is firms that do not export in 2004 and afterwards. Results are similar using firms that never export during the whole sample period as the comparison group.

the treatment group. However, for export quitters, the coefficient are all negative, though most of them insignificant. Therefore, although exporters in general increased innovation in response to the appreciation, such effects are restricted to more productive exporters that manage to survive in the export market. [20]

[Insert Table 10 Here]

6.3 Processing versus non-processing exporters

Processing trade accounts for nearly 50% of China's exports. The recent literature finds that processing firms perform quite differently than non-processing exporters (Dai et al., 2011; Yu, 2011). These firms import foreign intermediate inputs for assembly and re-export, and are associated with low-end labor intensive tasks. We expect less innovation response from these firms for two reasons. First, processing firms usually receive patents and blueprints from the foreign suppliers, and do not have their own brands or products. Therefore, their competitiveness depends little on in-house innovation. Second, processing firms is usually associated with high import intensity because they need to import foreign materials for assembly. As a result, the appreciation may increase the competitiveness of processing firms by making the imported inputs less expensive. Thus, the competitive pressure imposed on processing exporters is expected to be less than that on non-processing exporters.

[20] One might worry that export market may not actually tighten for continuing, so their innovation increase might simply reflect the effect of expanding market size instead of competition. To check this possibility, we calculate the average export growth and export intensity for continuing exporters for each year in the sample period in Appendix Table D2. It is quite obvious that continuing exporters also experienced certain degrees of market contraction. While their export growth is over 60% in the pre-appreciation period, it reduced to around 10% in the appreciation period. Export intensity also fall. Therefore, the increased innovation by continuing exporters cannot be the result of market size effects. It is driven by the competitive pressure from the foreign markets.

Ideally, we need a variable indicating the firm's processing status in order to investigate the response of processing exporters. Unfortunately our firm-level production data does not provide such information. However, Dai et al. (2011) finds that pure exporters in China are highly correlated with processing exporters. Therefore, we use a pure exporter dummy to proxy for a firm's processing status. The regression results in Table 11 show that generally processing exporters do not increase their innovation in the face of the appreciation. Except for the new product share case, the coefficients before the pure exporter dummy are not significant. This is consistent with our previous conjuncture.

[Insert Table 11 Here]

7 Conclusions

This paper aims to investigate a new channel linking trade and innovation: changes of competitive pressure in firms' export markets. We use the RMB exchange rate appreciation during 2005-2007 as a natural experiment and exploit its differential impact on exporters and non-exporters. The appreciation reduced exports and imposed larger competitive pressure for exporters than for non-exporters. Exporters will respond to this competitive pressure with more innovation. Our benchmark results show that the appreciation caused the R&D expenses of ex-ante exporters to increase by 11 percent more than non-exporters, and the new product development to increase by nearly 1.5 times more. This result cannot be explained by either market size effect or import competition, the two channels that are mostly intensively discussed in the trade and innovation literature. We also find heterogeneous innovation response from exporters with different productivity. Productive firms continue exporting and increase innovation, while less productive exporters quit the export market and reduce innovation. This suggests that both market size effect and competition effect are affecting firm innovation, and the net change depends on which effect dominates.

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Table 1 Export Tightening

Panel (A): Export Growth, Share of Exporters and Average Export Intensity (%)

	(1)	(2)	(3)
Year	Total export growth	Proportion of exporters	Average export intensity
2001	-	35.89	22.43
2002	23.81	37.35	22.93
2003	25.79	38.12	23.08
2004	26.35	41.09	24.24
2005	14.73	39.86	23.22
2006	22.85	39.67	23.01
2007	13.64	38.09	22.46

Panel (B): Share of Firms by Entry and Exit Status (%)

	(1)	(2)
Type	Pre-appreciation period	Appreciation period
Start to export	9.38	3.792
Continue to export	31.72	34.31
Quit exporting	4.143	5.563
Never export	54.73	56.33

Note: Panel A reports total export growth, proportion of exporters and average export intensity by year. Panel B reports the proportion of firms that start to export, continue to export, quit exporting and never export during the pre-appreciation and appreciation period. All numbers are in percentage points. In Panel B, pre-appreciation period,2001-2004; appreciation period,2005-2007. Starting to export: export=0 in the beginning year of the period, export=1 in the ending year of the period. Coninue to export:export=1 in the beginning year of the period, export=1 in the ending year of the period. Quit exporting:export=1 in the beginning year of the period, export=0 in the ending year of the period. Never export:export=0 in the beginning year of the period, export=0 in the ending year of the period.

Table 2 Growth of Employment, Profit and Total Sales(%) for Exporters and Non-exporters

	Employment	Profit	Total sales
Exporter			
Appreciation period	3.285	87.90	17.23
Pre-appreciation period	13.95	116.4	34.01
Difference	-10.66	-28.54	-16.78
Non-exporter			
Appreciation period	2.603	117.9	23.59
Pre-appreciation period	7.123	104.8	32.92
Difference	-4.52	13.08	-9.326

Note: This table reports average growth rate of employment, profit and total sales during the appreciation period and pre-appreciation period, for exporters and non-exporters in 2004 separately. All numbers are in percentage points.

Table 3 Summary Statistics of Major Variables

Variables	Mean	Std.Deviation
Dependent variable （ΔINV_f）		
Δlog R&D expenses	0.129	1.694
ΔR&D dummy	-0.011	0.295
Δnew product revenue share	0.013	0.129
Δnew product dummy	0.040	0.257
Key independent variable		
Exporter dummy（$EXP04_f$）	0.411	0.492
Firm-level control variable		
TFP_OP	4.284	1.163
Log employment	5.233	1.093
Log capital stock	8.996	1.724
Industry-level control variable		
Import penetration ratio	0.110	0.125
Log industry export	15.095	1.867
Log industry domestic sales	16.582	1.478

Table 4 Benchmark Regression Result of Equation (4)

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
$EXP04_f$	0.112***	0.016***	0.010***	0.014***
	(4.73)	(4.52)	(5.96)	(4.04)
TFP	0.083***	0.010***	0.003***	0.010***
	(8.78)	(6.51)	(4.86)	(6.90)
Log employment	0.073***	0.003*	0.001	0.002
	(6.01)	(1.85)	(0.79)	(1.04)
Log capital	0.065***	0.005***	0.001***	0.002**
	(10.77)	(6.27)	(3.30)	(2.37)
Import penetration	0.084***	0.003	0.002**	0.001
	(4.14)	(1.31)	(2.06)	(0.23)
Industry export	-0.003	0.001	0.002***	0.002*
	(-0.28)	(0.99)	(4.19)	(1.96)
Industry dom. sales	0.009	0.001	-0.001**	-0.003*
	(0.62)	(0.06)	(-2.21)	(-1.86)
Constant	-1.350***	-0.143***	-0.019**	-0.020
	(-6.63)	(-6.55)	(-2.12)	(-0.94)
Observations	57,330	57,330	57,006	57,006
R-squared	0.019	0.005	0.004	0.004

Note: This table reports the estimation results for equation (4). Dependent variable is the difference of average innovation between the appreciation period and pre-appreciation period. $EXP04_f = 1$, exporter in 2004. $EXP04_f = 0$, non-exporter in 2004. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Table 5 Using One Year Before and After The Shock

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
$EXP04_f$	0.108***	0.014***	0.011***	0.010**
	(3.69)	(2.80)	(5.27)	(2.09)
Firm-Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	57,330	57,330	57,006	57,006
R-squared	0.007	0.002	0.004	0.001

Note: This table reports the regression results of equation (4), using only one year before and after the exchange rate regime reform(year 2003 and 2006). Dependent variable is the difference of innovation. $EXP04_f = 1$, exporter in 2004. $EXP04_f = 0$, non-exporter in 2004. Firm level controls include log employment, log fixed capital, TFP; Industry-level controls include industry import penetration ratio, log industry total exports, log industry total domestic sales. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Table 6 Excluding the Influence of Other Confounding Policies

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
(A) Excluding textile sectors				
$EXP04_f$	0.138***	0.019***	0.011***	0.016***
	(5.57)	(4.80)	(5.89)	(4.07)
Firm-Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	48,,406	48,406	48,121	48,121
R-squared	0.020	0.005	0.004	0.005
(B)Including wage growth				
$EXP04_f$	0.113***	0.016***	0.010***	0.014***
	(4.78)	(4.57)	(5.97)	(4.04)
ΔLog Wage	0.053***	0.007***	0.001	-0.002
	(3.69)	(2.92)	(0.77)	(-0.88)
Firm-Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	57,322	57,322	57,001	57,001
R-squared	0.019	0.005	0.004	0.004

Note: This table reports the regression results of equation (4). Panel (A) exclude textile industries. Panel (B) include change of log wage as additional controls. Dependent variable is the difference of average innovation between the appreciation period and pre-appreciation period. $EXP04_f = 1$, exporter in 2004. $EXP04_f = 0$, non-exporter in 2004. Firm level controls include log employment, log fixed capital, TFP; Industry-level controls include industry import penetration ratio, log industry total exports, log industry total domestic sales. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Table 7 Placebo Test

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
(A) Dividing year: 2002				
$EXP01_f$	-0.023	-0.003	-0.001	-0.015***
	(-0.95)	(-0.68)	(-0.92)	(-4.38)
Firm Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	55,987	55,987	55,885	55,885
R-squared	0.003	0.001	0.001	0.001
(B) Dividing year: 2004				
$EXP03_f$	0.040*	0.006*	-0.001	-0.015***
	(1.87)	(1.67)	(-0.15)	(-4.02)
Firm Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	57,536	57,536	57,428	57,428
R-squared	0.001	0.001	0.001	0.001

Note: This table reports the regression results of equation (4), using years before the appreciation as dividing year. Panel (A) use 2002. Panel (B) use 2004. Dependent variable is the difference of innovation. Only one year before and after the dividing year are included. Firm level controls include log employment, log fixed capital, TFP; Industry-level controls include industry import penetration ratio, log industry total exports, log industry total domestic sales. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Table 8 Unbalanced Sample Regressions

	(1)	(2)	(3)	(4)
	Δlog R&D	ΔR&D dummy	Δnew product revenue share	Δnew product dummy
$EXP04_f$	0.193***	0.0258***	0.00977***	0.0148***
	(5.11)	(8.41)	(7.32)	(5.01)
Firm Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	122,629	122,629	121,952	121,952
R-squared	0.042	0.025	0.004	0.004

Note: This table reports the regression results of equation (4), using the unbalanced sample. Dependent variable is the period difference of average innovation. $EXP04_f = 1$, exporter in 2004. $EXP04_f = 0$, non-exporter in 2004. Firm level controls include log employment, log fixed capital, TFP; Industry-level controls include industry import penetration ratio, log industry total exports, log industry total domestic sales. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Table 9 Industry Heterogeneity

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
$EXP04_f$	0.034	0.010***	0.008***	0.012***
	(1.33)	(2.70)	(4.42)	(3.21)
$EXP04_f \times RDint_i$	0.388***	0.030***	0.011**	0.012
	(5.13)	(4.41)	(2.17)	(1.54)
Firm-Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	57,328	57,328	57,004	57,004
R-squared	0.020	0.005	0.004	0.004

Note: This table reports the regression results of equation (4). The interaction term of the exporter dummy and industry R&D intensity is added to investigate the different response across industry. Dependent variable is the period difference of average innovation. Firm level controls include log employment, log fixed capital, TFP; Industry-level controls include industry import penetration ratio, log industry total exports, log industry total domestic sales. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Table 10 Firm Heterogeneity: Continuing Exporters and Export Quitters

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
(A) Continuing Exporters				
Continuing Exporter	0.185***	0.023***	0.016***	0.043***
	(6.36)	(5.35)	(7.97)	(10.20)
Firm-Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	48,063	44,768	44,539	44,539
R-squared	0.021	0.006	0.007	0.012
(B) Export Quitters				
Export Quitter	-0.042	-0.003	-0.007**	-0.021***
	(-1.02)	(-0.48)	(-2.42)	(-3.52)
Firm-Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	31,725	31,725	31,459	31,459
R-squared	0.005	0.001	0.001	0.002

Note: This table reports the regression results of equation (4). Panel (A) reports use sample of continuing exporters as treatment group, Panel (B) use sample of export quitters as treatment group. Continuing exporters: firms exporting in 2004 and continue exporting during 2005-2007. Export quitters: firms that export in 2004 but quit the export market in some year during 2005-2007 and never export afterwards. The comparison group is the firms that do not export in 2004 and afterwards. Firm level controls include log employment, log fixed capital, TFP; Industry-level controls include industry import penetration ratio, log industry total exports, log industry total domestic sales. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Table 11 Processing versus Non-processing Exporters

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
Pure $Exp04_f$	-0.041	0.008	0.010***	0.006
	(-1.30)	(1.29)	(2.90)	(0.77)
Firm-Level Controls	Yes	Yes	Yes	Yes
Industry-Level Controls	Yes	Yes	Yes	Yes
Observations	26,731	26,731	26,621	26,621
R-squared	0.009	0.004	0.004	0.002

Note: This table reports the regression results of equation (4), using the pure exporters as treatment group. Pure $Exp04_f = 1$, pure exporter in 2004. Pure $Exp04_f = 0$, non-exporter in 2004.Firm level controls include log employment, log fixed capital, TFP; Industry-level controls include industry import penetration ratio, log industry total exports, log industry total domestic sales. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Figure1 Nominal Exchange Rate of the RMB, 2000-2008

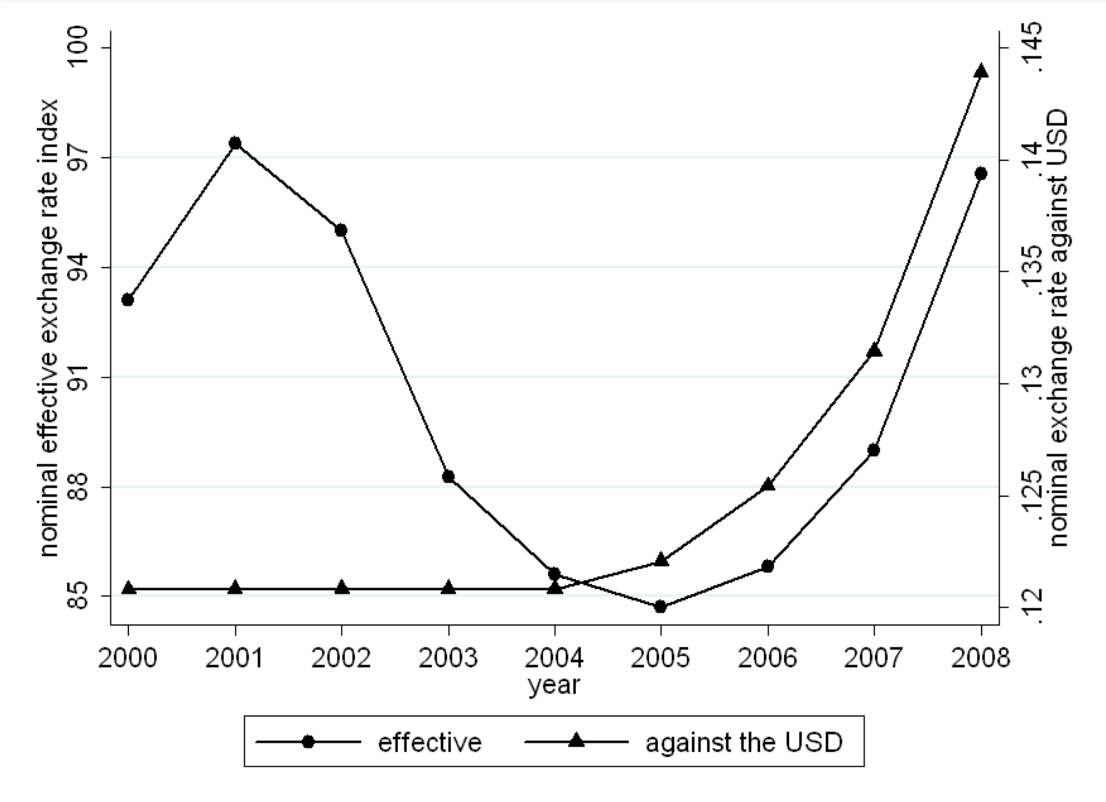


Figure2a Log R&D expenses by Exporters and Non-exporters

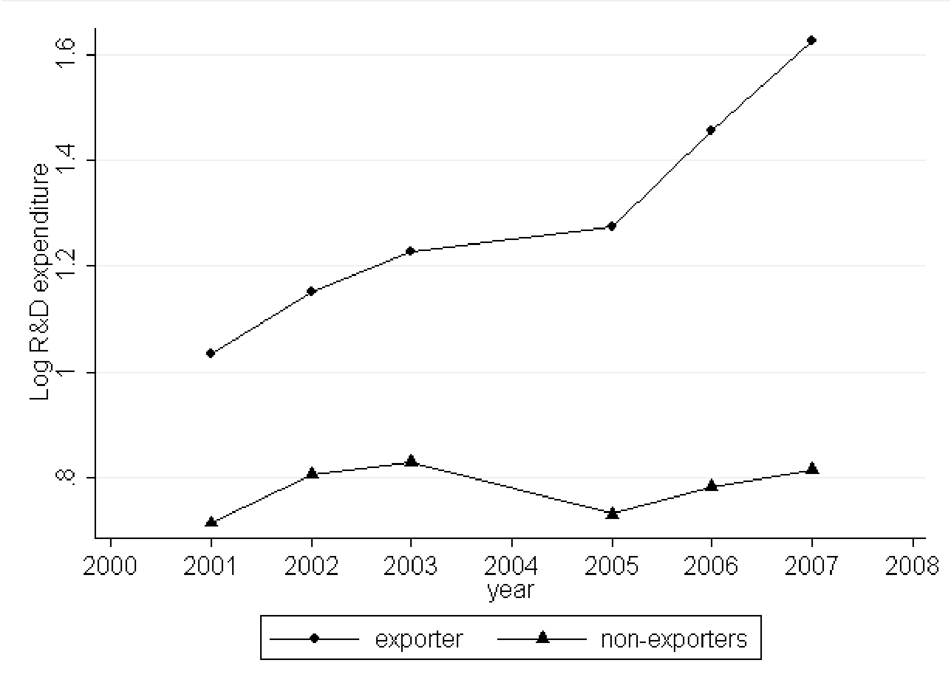


Figure2b New Product Revenue Share by Exporters and Non-exporters

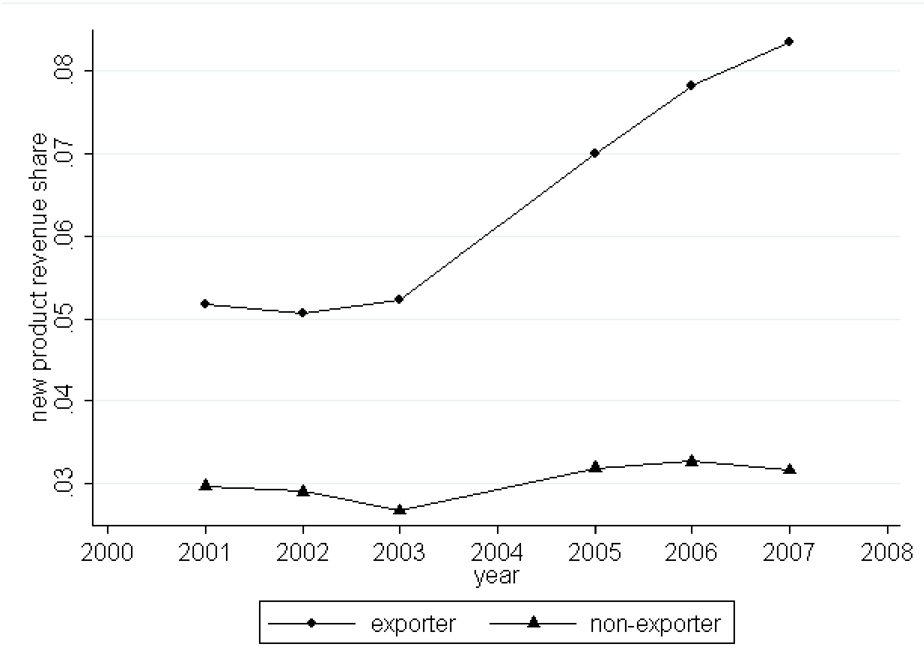
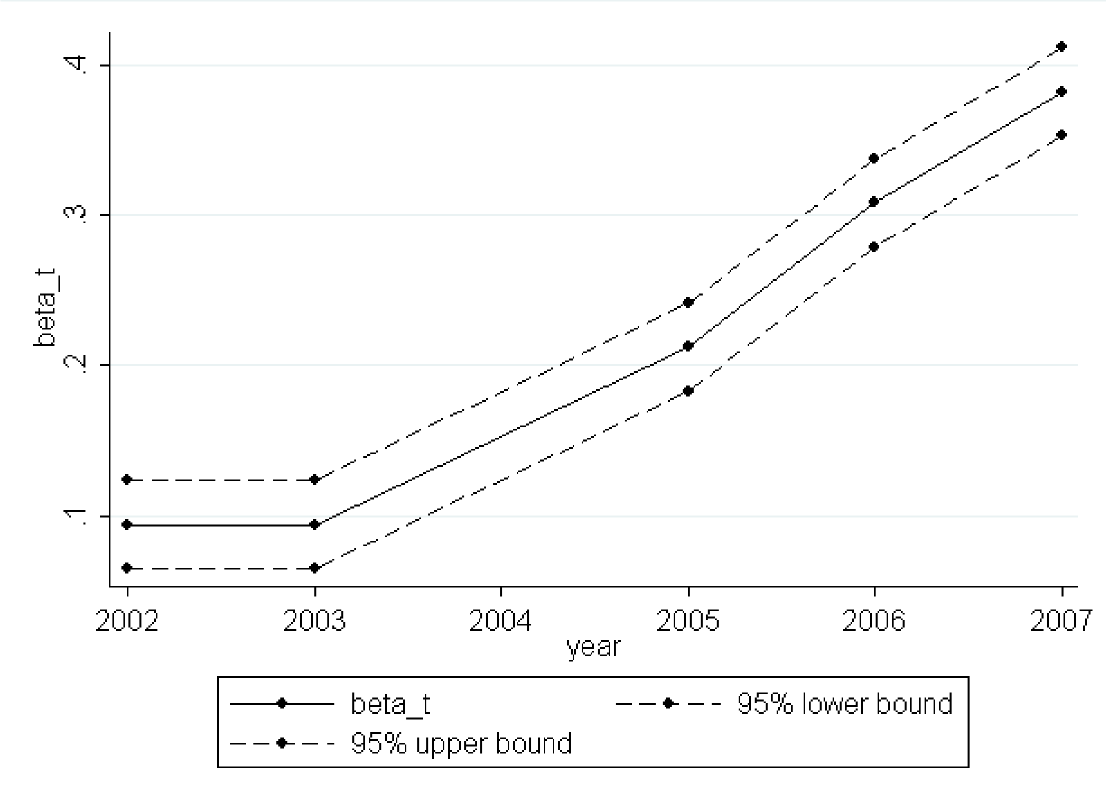


Figure3 β_t, 2002-2007



Appendix A: Augmented Olley-Pakes TFP Measures (Online Only, Not for Publication)

Here we describe in details the Olley-Pakes approach to estimating firm's TFP with some extensions. First, we adopt different price deflators for inputs and outputs. Data on input deflators and output deflators are from Brandt et al. (2012) in which the output deflators are constructed using *reference price* information from China's Statistical Yearbooks whereas input deflators are constructed based on output deflators and China's national input-output table (2002).

Next, we construct the real investment variable using the perpetual inventory method. Rather than assigning an arbitrary number for the depreciation ratio, we use the firm's real depreciation rate provided by the Chinese firm-level dataset.

We work with the standard Cobb-Douglas production function：

$$Y_{it} = \pi_{it} L_{it}^{\beta_l} K_{it}^{\beta_k} M_{it}^{\beta_m}, \qquad \text{(A.1)}$$

where Y_{it} is the output of firm *i* in year *t*, K_{it}, L_{it} and M_{it} denotes labor, capital, and intermediate inputs, respectively. By assuming that the expectation of future realization of the unobserved productivity shock, v_{it}, relies on its contemporaneous value, the firm *i*'s investment is modeled as an increasing function of both unobserved productivity and log capital, $k_{it} = \ln K_{it}$. Following previous works, such as Van Biesebroeck (2005) and Amiti and Konings (2007), we add the firm's export decision as an extra argument of the investment function since most firms' export decisions are determined in the previous period (Tybout, 2003):

$$I_{it} = \tilde{I}(k_{it}, v_{it}, X_{it}) \quad , \qquad \text{(A.2)}$$

where X_{it} is a dummy to measure whether firm *i* exports in year *t*. Therefore, the inverse function of I_{it} is

$$v_{it} = \tilde{I}^{-1}(k_{it}, I_{it}, X_{it}) \qquad \text{(A.3)}$$

The unobserved productivity also depends on log capital and the firm's export decisions. Accordingly, the estimation specification can now be written as:

$$y_{it} = \beta_0 + \beta_m m_{it} + \beta_l l_{it} + g(k_{it}, I_{it}, X_{it}) + \varepsilon_{it} \quad , \qquad \text{(A.4)}$$

where $g(k_{it}, I_{it}, X_{it})$ is defined as $\beta_k k_{it} + \tilde{I}^{-1}(k_{it}, I_{it}, X_{it})$. Following Olley and Pakes (1996) and Amiti and Konings (2007), fourth-order polynomials are used in log-capital, log-investment and firm's export dummy to approximate $g(.)$. In addition, we also include a WTO dummy (*i.e.*, one for a year after 2001 and zero for before) to characterize the function g(.) as follows:

$$g(k_{it},\ I_{it}, X_{it}, WTO_t) = (1 + WTO_t + X_{it}) \sum_{h=0}^{4} \sum_{q=0}^{4} \delta_{hq} k_{it}^{h} I_{it}^{q} \quad . \qquad \text{(A.5)}$$

After finding the estimated coefficients $\hat{\beta}_m$ and $\hat{\beta}_l$, we calculate the residual R_{it} which is defined

$$R_{it} \equiv y_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_l l_{it} \qquad \text{(A.6)}$$

The next step is to obtain an unbiased estimated coefficient of β_k. We assume firm's productivity follows an exogenous Markov process, $v_{it} = h(v_{it-1}) + \eta_{it}$. To correct the selection bias due to firm exit, Amiti and Konings (2007) suggested estimating the probability of a survival indicator on a high-order polynomial in log-capital and log-investment. One can then accurately estimate the following specification:

$$R_{it} = \beta_k k_{it} + h(\hat{g}_{it-1} - \beta_k k_{it-1}, \hat{p}r_{it-1}) + \varepsilon^*_{it} , \qquad \text{(A.7)}$$

where $\hat{p}r_{i,t-1}$ denotes the fitted value for the probability of the firm 's exit in the next year, and $\varepsilon^*_{it} = \varepsilon_{it} + \eta_{it}$ denotes the composite error. Since the specific *true* functional form of the inverse function h is unknown, it is appropriate to use fourth-order polynomials in g_{it-1} and $k_{i,t-1}$ to approximate that. In addition, (A.6) also requires the estimated coefficients of the log-capital in the first and second term to be identical. Therefore, non-linear least squares is used (Pavcnik, 2002; Arnold, 2005). Finally, the Olley-Pakes type of TFP for each firm *i* in industry *j* is obtained once the estimated coefficient $\hat{\beta}_k$ is obtained:

$$TFP^{OP}_{ijt} = y_{it} - \hat{\beta}_m m_{it} - \hat{\beta}_k k_{it} - \hat{\beta}_l l_{it} \quad . \qquad \text{(A.8)}$$

Appendix B: Construction of industry import penetration ratio (Online Only, Not for Publication)

We control for industry-level import competition by the industry import penetration ratio. The import penetration ratio is defined as industry import value over industry total absorption. Total absorption is measured by "Production-Export+Import". Expressed in equations:

$$IMP\_PEN_{it} = \frac{IM_{it}}{Y_{it} - EX_{it} + IM_{it}} \qquad (1)$$

Where IMP_PEN_{it} is the import penetration ratio of industry i in year t, IM_{it} is China's import from world, EX_{it} is China's export to the world, Y_{it} is domestic gross output. Import and export data is taken from COMTRADE at the 6-digit HS level. We map the HS6 products to 2-digit Chinese Industry Classifications (GB/T 4754-2002), and aggregate the import and export value to 2-digit CIC industry-level. Finally, we calculate the import penetration ratio in each 2-digit CIC industry over 2001-2007, using (1). The domestic gross output data is taken from China Statistical Yearbook.

Appendix C: The impact of the appreciation on firms with different export intensity (Online Only, Not for Publication)

Table C1 Growth Difference of employment, profit and total sales(%)by export intensity

Export Intensity	Employment	Profit	Sales
0<expint<0.1	-7.501	-18.609	-18.608
0.1< expint <0.4	-8.842	-37.040	-16.482
0.4< expint <1	-11.258	-42.231	-18.191
expint =1	-13.562	-14.354	-13.390

Note: This table reports the growth difference of employment, profit and sales between the appreciation period and pre-appreciation period by export intensity. Each entry=growth rate in the appreciation period- growth rate in the pre-appreciation period.

Table C2 Regression results of equation (4), by export intensity

	(1) Δlog R&D	(2) ΔR&D dummy	(3) Δnew product revenue share	(4) Δnew product dummy
$EXPINT04_f$	0.032*	0.017***	0.008***	0.018***
	(1.85)	(3.07)	(3.75)	(3.33)
TFP	0.091***	0.011***	0.003***	0.010***
	(8.84)	(6.63)	(4.63)	(6.73)
Log employment	0.098***	0.005***	0.001**	0.004**
	(7.72)	(2.66)	(2.00)	(2.35)
Log capital	0.065***	0.006***	0.001***	0.002**
	(9.96)	(5.90)	(3.69)	(2.06)
Import penetration	0.092***	0.004	0.003***	0.001
	(4.57)	(1.42)	(2.92)	(0.49)
Industry export	0.017	0.003*	0.002***	0.003**
	(1.51)	(1.93)	(5.00)	(2.33)
Industry dom.sales	-0.019	-0.002	-0.001**	-0.003**
	(-1.22)	(-1.16)	(-2.52)	(-2.04)
Constant	-1.296***	-0.138***	-0.028***	-0.033
	(-6.23)	(-6.17)	(-3.25)	(-1.59)
Observations	51,510	51,510	51,249	51,249
R-squared	0.019	0.005	0.003	0.004

Note: This table reports the estimation results for firms with different export intensity in 2004. Dependent variable is the difference of average innovation between the appreciation period and pre-appreciation period. $EXPINT04_f$ is export intensity in 2004. T values in parenthesis. *,**,*** refers to significant at 10%, 5% and 1% level.

Appendix D Firm Heterogeneity
(Online Only, Not for Publication)

Table D1 Firm Characteristics of Continuing Exporters and Export Quitters

Firm characteristics	Continuing Exporters	Export Quitters
TFP	4.132	4.019
Log employment	5.721	5.250
Log sales	10.963	10.591

Note: This table compares firm characteristics for continuing exporters and export quitters, in 2004. Continuing exporters: firms that export in 2004 and continue to export during 2005-2007. Quitters: firms that export in 2004 but quit the export market in some year during 2005-2007 and never export again.

Table D2 Export growth and export intensity for continuing exporters in 2005

year	Export Growth	Export Intensity
2001	-	59.293
2002	59.012	60.131
2003	44.994	63.909
2004	81.987	63.912
2005	20.198	64.273
2006	9.072	63.966
2007	3.143	63.128