# Exchange Rate Disconnect and Financial Constraint

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Abstract

One puzzling observation in international economics is the lack of response of exports to exchange rate fluctuations. Employing the most comprehensive export data from China during 2000-2007, this paper provides sector- and firm-level evidence that the response of exports to exchange rate movements depends crucially on the level of financial constraint. For sectors with large financial constraint, the response is very small, whereas for less financially constrained sectors, the response can be much larger, with the estimated elasticity decreases in sector's degree of financial constraint. At the firm level, financial constraint affects both the intensive and extensive margins of exports. At the intensive margin, financial constraint dampens the effect of exchange rate on exports by restricting firm's export value to the existing destination market; while at the extensive margin, financial constraint restricts the number of firms participating in exporting, the number of firm-product pairs being exported, and the probability of entering a new destination market.

Keywords: exchange rate elasticity, financial constraint, firm exports

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# 1. Introduction

One puzzling observation in international economics is the lack of response of aggregate exports to exchange rate fluctuations (Fitzgerald and Haller, 2014). Chaney (2016), for example, documents that the euro-dollar fluctuations have only limited impact on trade flows between the Euro Zone and the United States. Li et al. (2015) show that both the price and volume responses of Chinese exporters to RMB appreciation are moderate.[1] In this paper, we show that when firms are financially constrained, their response to exchange rate is attenuated, particularly in those sectors that are more dependent on external funds.

Why does financial constraint matter? In a traditional trade model, currency depreciation reduces price that foreign buyers face and therefore encourages exports. Such effect, however, can be attenuated because financially-constrained firms cannot optimally expand exports. There are at least three channels through which financial constraints can exert effect. First, a firm needs to incur fixed costs, often paid in the currency of the destination country, to enter the foreign market (Chaney, 2016). In this case, a depreciation of home currency would increase the fixed costs of export relative to the value of domestic asset and therefore discourages further entries, offsetting the gaining of competitiveness due to depreciation. Similarly, when exchange rate appreciates, existing exporters reduce their exports, while credit constrained (but productive) firms may start exporting and consequently compensate the reduced exports of incumbents. The aggregate effect of the exchange rate fluctuations on export would consequently be alleviated in the presence of financial constraints. Note that this channel is not limited to firm's entry into foreign markets (i.e., the extensive margin). When the variables costs are also partly paid in foreign currency, the response of export value to exchange rate, that is, the intensive margin, is also affected by financial constraint. Secondly, many firms hold both domestic and foreign assets, thus the exchange rate fluctuations will change their capacity of pledging collateral (Kohn et al., 2015). An appreciation, for example, increases a firm's value of assets in home currency and enables it to borrow more. In this case, exchange rate directly affects firm's financial conditions, and therefore affect their export behavior. Finally, with capital account liberalization, firms may also finance their fixed and/or variable production costs through the international market. In this case, an appreciation makes firm's foreign debt cheaper and so alleviates its

[1] The literature on the event of large devaluations also notes that aggregate exports increase gradually after a devaluation. See, for example, Alessandria et al. (2014) and Kohn et al. (2015). These studies focus on explaining the *slow* response of aggregate exports to exchange rate shocks. In contrast, we focus on the *low* elasticity of exports to exchange rate shocks.

financial burden, which may promote exports.

This paper aims to empirically verify and quantify how financial constraint affects firm's response to exchange rate, in both the extensive margin and the intensive margin. Using the most comprehensive export data at the sector and firm level from China during 2000-2010, we show that the response of exports to exchange rate movements depend crucially on the level of financial constraint. For sectors with larger financial constraint the response is very small, whereas for less financially constrained sectors, the response can be much larger. In the baseline estimation, the exchange rate elasticity varies from 0.12 to 0.71, which decreases in sector's degree of financial constraint measured with Rajan and Zingales's external finance dependence. When we use firm's liquidity needs to measure financial constraint, the sign of the exchange rate elasticity can even be overturned, leading to a wide range of exchange rate elasticity from -0.43 to 1.18. These findings are robust to adding other industry characteristics, such can factor intensity, capital-labor ratio, and an indicator for durable goods.

Sectoral response of exports to exchange rate is a mixed result of the responses by incumbent exporters and new exporters. As described above, financial constraints affect incumbent and new exporters through different channels. This is indeed the case when we further examine firm-level evidence: at the intensive margin, financial constraint dampens the effect of exchange rate on exports by restricting firm's export value to the existing destination market; while at the extensive margin, financial constraint restricts the number of firms participating in exporting, the number of firm-product pairs being exported, and the probability of a firm entering a new destination market. Thus firms may borrow to finance both the fixed costs of exporting and the variable costs, denominated in foreign currency.

In the above examination, we explore sectoral measures of financial constraint of Rajan and Zingales (1998), which has the advantage of being exogenous and reflecting the "technological" part of investments that must be funded externally. However, firms are heterogeneous even within a narrowly-defined industry. Thus, we further examine the same empirical question using firm's information on ownership, size and initial level of financial health, such as leverage ratio, liquidity ratio and interest payment. The results confirm the impact of financial conditions. First, for private firms, which are believed to be more financially constrained than state-owned or foreign firms, we find that financial constraint plays a significant role in mitigating the effect of exchange rate shocks on exports; whereas for state-owned and foreign firms, which have easy access to external finance, the effect of

financial constraint is insignificant. Second, for small and medium sized firms, the mitigating effect of financial constraint is also significant, while for large firms, the effect is insignificant. Finally, firms with high leverage ratio, high interest payment ratio, and low liquidity ratio tend to be more constrained and offsetting the exchange rate elasticity.

The long span of the sector-level data enables us to further investigate the disruption of the 2008-2009 global financial crisis. Marked by major financial institution failures, the financial crisis triggered a sharp escalation in global credit crunch and exert more difficulties on firms' access to external finance. With larger impact of financial constraint, the effect of exchange rate fluctuations on exports is further mitigated.

We make several novel contributions to the literature. First, the vast literature such as Manova (2013) has recognized financial constraint as one key determinant for firm's exporting behavior. We further show that financial constraint also plays an important role in affecting firm's response to the exchange rate shocks. There have been many studies on the effect of financial constraint on firm's performances, including export performance. There have also been many studies documenting that exchange rate fluctuations have moderate effect on exports. Our paper is the first that combing the two strands of literature.

The remainder of the paper is structured as follows. Section 2 discusses the theoretical background that how financial constraint might affect the response of exports to exchange rate fluctuations. Section 3 describes the data we use. Section 4 presents the empirical analysis at the sector level. Section 5 conducts firm-level analysis. Section 6 concludes.

## 2. Theoretical Background and Related Work

It is widely believed in the literature that all firms routinely rely on external capital because they incur large upfront cost that cannot be funded out of internal cash flows from operations. Exporters are believed to be even more dependent on outside financing than domestic producers, due to reasons such as entering foreign markets entailing additional upfront expenses, cross-border shipping involving longer time and higher working capital.

A number of papers have examined the effect of frictions in access to external finance on firm's performances, including export performance. Manova (2013) develop a heterogeneous firm model with cross country differences in financial development and cross industry variation in financial vulnerability. She shows that financial frictions impede firm selection into production, producer's entry into exporting, and exporter's foreign sales. Using Chinese firm-level data in 2005, Manova et al. (2015) provides further empirical

evidence that foreign affiliates and joint ventures in China have better export performance than private domestic firms in financially more vulnerable sectors. A finding consistent with multinational subsidies being less credit constrained due to their access to deeper internal capital markets and external capital markets abroad. Kohn et al. (2016) studies the role of financial frictions in explaining the dynamics of new exporters. They introduce a borrowing constraint and working capital requirement into a standard model of international trade, with exports more working-capital intensive than domestic sales. They find that the model can quantitatively account for new exporter dynamics, in contrast to a model with sunk export entry costs.

Meanwhile, a vast body of literature have examined the effect of exchange rate on exports. Depreciation lowers domestic producer's costs relative to their foreign competitors and is believed to stimulate exports. But the estimated exchange rate elasticity of export has been moderate, ranging from insignificant to around unity. For example, studies on developed countries has generally found insignificant or small elasticity of aggregate exports to exchange rate movements (e.g., Hooper, Johnson and Marquez 2000). Recent work using firm-level data find elasticity around 0.4-0.7 (e.g., Berman, Martin and Mayer 2012). With respect to the case of China, existing studies report different estimation results. Using aggregate time-series data, a few studies find the exchange rate elasticity above unity (Aziz and Li, 2007; Ahmed, 2009; Garcia-Herrero and Koivu, 2009; Thorbecke and Smith, 2010). In contrast, Cheung et al. (2009) find no significant effect at all. Firm-level studies, including Li et al. (2015), Tang and Zhang (2012), find an elasticity around 0.4.

This paper connects these two strands of literature proving that financial vulnerability is one reason that why export is less responsive to exchange rate fluctuations. The most relevant theoretical paper is Chaney (2016). Chaney (2016) builds a model of international trade with liquidity constraints. If firms must pay some entry cost in order to access foreign markets, and if they face liquidity constraints to finance these costs, only those firms that have sufficient liquidity are able to export. A set of firms could profitably export, but they are prevented from doing so because they lack sufficient liquidity. The model offers a potential explanation for the lack of sensitivity of exports to exchange rate fluctuations. When the exchange rate appreciates, exporters lose competitiveness, and they reduce their exports. However, since the value of domestic assets in terms of foreign prices increases, liquidity constraints for accessing foreign markets are relaxed. Some firms start exporting. This entry of liquidity constrained exporters dampens the negative competitiveness effect of an exchange rate appreciation.

Chaney's explanation focuses on frictions in the fixed trade cost and therefore adjustments along the extensive margin of trade. If there are also frictions in the funding of variable cost, exporter's scale of operations would be restricted as well. When exchange rate depreciates, exporters tend to increase their export in the foreign market. However, if they are financially constrained, they would be unable to expand their production and therefore export. The effect of a positive exchange rate shock is therefore dampened by financial frictions.

Another relevant paper is Kohn et al. (2015). They construct a dynamic setting in which a firm may borrow both domestic and foreign debts. Then they study the aggregate export response to a large, sudden and unexpected currency devaluation. In their model, a real depreciation affects firms through two channels. One is the expansionary effect that induces firms to produce and export more. The other is the balance-sheet effect. Depreciation tightens the borrowing constraint of firms by increasing the value of foreign-denominated debt relative to firm's net worth. While financial frictions slow down the response of aggregate exports to exchange depreciation, foreign-denominated debt amplifies this effect by decreasing firm's net worth on impact. Their quantitative calibration of the model shows that financial constraint imply an elasticity of exports that is 23% lower than the frictionless economy, and when exporters have foreign-denominated debt, the elasticity decreases further to be 30% lower than the frictionless model.

## 3. Data

Our empirical analysis relies on data that include firm-level information on trade and production, industry-level trade and financial constraint measures, as well as other macroeconomic variables.

### 3.1 Export Data

The main dataset that we rely on is the firm-level export data from the General Administration of Customs of China (GACC), from 2000 to 2007. From this dataset we are able to know whether and what does a firm export to which destination. More specifically, we know each firm's export value and quantity at 6-digit HS product level to each destination country. In addition, we have the Annual Surveys of Industrial Production (ASIP) data which allows us to identify firm's production side information, such as, ownership, number of employees, total assets, and other financial health variables.

The sector-level data has a longer span of time from 2000 to 2010, which allows us to study the impact of 2008 financial crisis. The data is originally available at 6-digit HS

product level. To match with the Rajan-Zingales measure of financial constraint, we aggregate product-level exports into sector-level based on ISIC (Revision 2), employing the concordance provided by UN Statistics Division.

Summary statistics for both sector-level and firm-level samples are reported in Table 1. In general, we have 48132 sectoral export observations and over ten thousand firm export observations. On average, the products exported to each destination country in each year cover 33 sectors; each sector exports to 121 countries in each year; there are 340 firms exporting in each sector to each destination country; a firm exports in 2 sectors to each destination; a firm exports to 4 destinations in each sector.

### 3.2 Macro data

We obtain year-average bilateral nominal exchange rates from the Penn World Table and consumer price indices (CPI) from the International Financial Statistics (IFS).[2] Following the convention, the CPI-based real exchange rate ($RER_{ct}$) is defined as the Chinese RMB against foreign currency, multiplied by foreign CPI and divided by Chinese CPI. By this definition, an increase in $RER_{ct}$ implies a real depreciation of the Chinese RMB against the currency of foreign country *c*.

Other country variables used in the analysis, including real GDP and real GDP *per capita* of the destination countries, are also collected from the Penn World Table. GDP per capita is the real GDP per capita at constant price using Laspeyres index (*RGDPL*). RGDP is the multiplication of the real GDP per capita and population. We keep all China's trade partners that have no missing data from 2000 to 2010, resulting in 154 destination countries. Those countries account for around 98 percent of Chinese exports.

### 3.3 Financial Vulnerability Measures

We employ several financial constraint measures that are commonly used in the literature. Different sectors exhibit varying levels of liquidity needs to cover up-front costs before revenues could be realized. This difference reflects technological features of the manufacturing process inherent in a given sector and is beyond the control of individual firms. They are available for 36 International Standard Industrial Classification (ISIC) 3-digit sectors. We match them to the HS 6-digit products in the trade data using concordance provided by UN Statistics Division.

[2] Taiwan's CPI series are from Taiwan Ministry of Finance.

Our main measure is the sector's external finance dependence, first proposed by Rajan and Zingales (1998). It is defined as the share of capital expenditures not financed with cash flows from operations. Rajan and Zingales construct this index at the industry level for a sample of U.S. firms over the 1980's. They argue that this approach offers a valid and exogenous way to identify the extent of an industry's external finance dependence, and this difference across industries persist for different countries. Kroszner et al. (2007) apply the same method and construct the estimates for US firms over a longer period from 1980 to 1999. We experiment with both Rajan and Zingales's estimates over 1980s and Kroszner et al.'s estimates over 1980-1999. The empirical results are actually very similar. As Manova et al. (2015) has pointed out, external finance dependence identifies the outside funding that firms require for long-term investment projects and thus relates mostly to fixed costs.

Our second measure is the sectors' liquidity needs developed by Raddatz (2004), calculated as the ratio of inventories to sales. This measure captures an industry's short-term need for working capital financing. It proxies the duration of the production cycle and the liquidity needed to maintain inventories and meet demand. Therefore, it is more likely associated with variable costs. Raddatz (2004) calculates this variable for US firms over the 1980s. Kroszner et al. (2007) extends the estimates to 1999.

Our last measure is the tangibility of assets, calculated as the ratio of fixed assets to total assets. A firm's access to external finance greatly relies on its endowment of tangible assets, which can be pledged as collateral. A higher share of tangible asset is associated with higher probability of accessing external funding. We adopt the numbers reported in Kroszner et al. (2007). The statistics of each measure are also reported in Table 1.

[Insert Table 1 Here]

# 4. Empirical Analysis

## 4.1 Baseline Results

Our baseline estimation examines how exchange rate elasticity is subject to sectoral conditions of financial vulnerability. To this end, we examine the link at sector level. If financial constraint dampens the effect of exchange rate shocks on firm's exports, empirically we would observe that sectors that are financially more constrained respond less to exchange rate fluctuations. We investigate this by running the following regression:

$$\ln(\mathrm{EXP}_{sct}) = \alpha + \beta \ln(RER_{ct}) + \gamma \ln(RER_{ct}) \times FinCons_s + Z_{ct} + \mu_{sc} + \varphi_t + \varepsilon_{sct} \quad (1)$$

where $\text{EXP}_{sct}$ is the value of exports to country $c$ by sector $s$ in year $t$.[3] $RER_{ct}$ is the bilateral real exchange rate of RMB against destination currency in country $c$ in year $t$. An increase in RER means a depreciation of RMB. $FinCons_s$ is a measure of financial constraint in sector $s$. We experiment with the three measures described in Section 3. Considering that idiosyncratic demand shocks in destination countries also affect their imports from China, we add control variables $Z_{ct}$ in our regression as well, which include real GDP and real GDP per capita of the destination country c. We perform within estimations by including the sector-country fixed effects ($\mu_{sc}$) to capture any time-invariant un-observables that are specific to sector, country, or their combinations. Year dummies ($\varphi_t$) are also included to control for macro-shocks that are common to all exporters.

The results are reported in Table 2. Column (1) report the estimates for exchange rate elasticity when no financial constraint variables are included.[4] The number is moderate: a 10% appreciation of RMB (a decrease in RER) would lead to a decrease of export value by 5.71%. This estimated elasticity is consistent with what the literature find out. See for example, Tang and Zhang (2012) and Li et al. (2015) for Chinese exports, Berman et al. (2012) for French exports, and Fitzgerald and Haller (2014) for Irish exports.

In columns (2) to (4), we add the interaction between real exchange rate and sector's financial constraint in different measures. Column (2) report the results when financial constraint is measured using external finance dependence. A negative coefficient of the interaction term suggests that the higher the level of external finance dependence of the industry is (i.e., more financially constrained), the lower the estimated exchange rate elasticity is. The idea is that for an appreciation of RMB, some existing exporters lose competitiveness in the foreign market and stop exporting. But at the same time, the value of domestic assets denominated in foreign currency increases, so the financially constrained firms start exporting. Therefore, the net effect on aggregate exports is dampened, and the more financially constrained the industry is, the milder the estimated elasticity we would observe. A more straightforward look is at the range of the estimated elasticity, which is from 0.12 to 0.71. This is computed based on the range of the values of external finance dependence. For the industry which depends on external finance the most, the estimated elasticity is only 0.12, whereas for the industry that depends on external finance the least, the estimated elasticity is 0.71.

[3] We also experiment with the quantity of exports as the dependent variable. The results are qualitatively the same.

[4] The estimated coefficients for control variables are suppressed for simplicity.

The evidence is even striking when we use liquidity needs as the measure of financial constraint. As Section 3 describes, external finance dependence identifies mostly the outside funding requirement for long-term investment projects; liquidity needs captures mostly an industry's short-term need for working capital financing. The negative coefficient of the interaction term confirms further the offsetting effect of financial constraint. Moreover, the sign of the estimated elasticity is even overturned for industries that are highly financially constrained: for an appreciation of RMB, despite the loss in competitiveness, aggregate exports actually increase. On the contrary, for industries that are not or relatively less financially constrained, exchange rate movement does a big effect on firm exports. The estimated elasticity is more than unity.

Similar results are obtained when using asset tangibility as a measure of financial constraint. The higher the level of asset tangibility, the higher the probability of obtaining external finance, and therefore the less financially constrained. The positive coefficient of the interaction term confirms that the less financially constrained, the higher the elasticity of exchange rate. The estimated elasticity is now as high as 1.39 for industry that is the least financially constrained.

[Insert Table 2 Here]

**4.2 Sensitivity Analysis**

To further examine the robustness of the estimated results, we also consider controlling other industry characteristics, such as, capital intensity of the industry, indicator whether the industry manufactures mainly durable goods. These characteristics might be related with industries' financial vulnerability and at the same time affecting the response of export value to exchange rate movements. To check for this, we expand our specification to include the interactions of real exchange rate of these industry characteristics. Our results in Table 3 show that the coefficients for financial constraint are unaffected. They are still significant and offsetting the effect of exchange rate on export.

[Insert Table 3 Here]

**4.3 Financial Crisis**

Another interesting issue we examine at the sector-level is the interactive effect of the 2008-2009 global financial crisis, marked by several major financial institution failures and bailouts, including Lehman Brothers and AIG, that triggered a sharp escalation in the global credit crunch. This tightening of global credit exert more difficulty on firms' access

to outside finance, which would therefore affect their exports and as well as response to exchange rate fluctuations. To check for this, we define $D_{crisis}$ as a binary variable, which equals to 1 for year 2008 and year 2009, and interact it with the real exchange rate and financial constraint interaction in specification (1). This triple interaction term therefore tests whether the dampening effect of financial constraint on exchange rate elasticity is enhanced during the crisis period. Since it is harder for firms to obtain outside funding during the crisis, we expect that even if there is a positive exchange rate shock, its effect on exports would be limited. Financial constraint would further dampen the effect of exchange rate during crisis period.

Estimation results reported in Table 4 confirm our hypothesis. The coefficient for the triple interaction term is negative for external finance dependence measure (column 1) and liquidity needs measure (column 2) of financial constraint. This suggests that during period of crisis, the effect of exchange rate fluctuations on exports is further mitigated by financial constraint. The more financially constrained the industry is, the less the exchange rate elasticity of exports is. If we calculate the range of exchange rate elasticity according to the range of financial constraint, we observe a relatively wider range of elasticity during the period of crisis. The result for asset tangibility measured financial constraint is a bit different from our expectation. The triple interaction term is negative, which decreases the effect of financial constraint during crisis period. This might be related to the fact that tangibility is not a good measure of financial constraint during period of financial crisis, even firms with high level of tangibility cannot get outside funding because of the overall credit crunch. Besides, the magnitude of the coefficient (0.065) is quite small (0.065 compared with 2.695), so the resulting elasticity range is not narrowed much.

[Insert Table 4 Here]

## 5. Firm-level Evidence: Intensive and Extensive Margins

We next explore the evidence at the firm-level. We look at the impact of financial constraint on the responses of different margins of exports to exchange rate fluctuations. As described in Section 2, frictions in the financing of variable costs would affect firms' intensive margin adjustments by limiting their export value to the existing destination market upon a positive exchange rate shock. Frictions in the financing of the fixed costs would affect firms' extensive margin adjustments by reducing the probability of entering a

new destination market or the number of destination markets to enter upon a positive exchange rate shock.

### 5.1 Intensive Margin

We first analyze the impact on the intensive margin. Consider firm *f*'s export in sector *s* to country *c* in year *t*, $\text{EXP}_{fsct}$, we run the following regression:

$$\ln(\text{EXP}_{fsct}) = \alpha + \beta \ln(RER_{ct}) + \gamma \ln(RER_{ct}) \times FinCons_{fs} + Z_{ct} + \mu_{fsc} + \varphi_t + \varepsilon_{fsct} \quad (2)$$

We perform within estimation by controlling firm-sector-country fixed effects. Note that firms' financial constraints $(FinCons_{fs})$ are measured using the exogenous sector-level financial constraint variables described in Section 3. So the coefficient for the interaction term identifies the differences in the responses of the existing firms in sectors with different financial constraints to exchange rate shocks. In the later section, we also explore firm heterogeneity in financial constraint using information on ownership, size, and financial variables.

Results are reported in Table 5. It confirms our previous findings at the sector-level. Financial constraint dampens the effect of exchange rate on exports by restricting firms' intensive margin adjustments upon exchange rate movements. Suppose there is a positive exchange rate shock, i.e., RMB depreciates, firms' competitiveness in the destination market increase, however, due to financing frictions in the variables costs, firms are unable to expand their production and export to the market. This result holds for all three measures of financial constraint.

[Insert Table 5 Here]

To make sure the estimated effect is on the intensive margin of exports, we perform several robustness checks on subsamples that avoid firm entry and exit, and product scope adjustments. In columns (1)-(3) of Table 6, we focus on incumbent firms only, excluding observations in the entry/exit years. In columns (4)-(6), we restrict our sample to each firm's major 4-digit HS sector, to avoid within-firm adjustment along the product scope. We also restrict our sample to single-product firms only (columns 7-9), where single product is defined as those exporting only one product to a destination. The results are all similar, confirming that financial constraints restrict firms' response at the intensive margin to exchange rate fluctuations.

[Insert Table 6 Here]

### 5.2 Extensive Margin

We next examine the impact of financial constraints on the responses of the extensive margin of exports to exchange rate fluctuations. The detailed structure of the data allow us to define the extensive margin in several ways. The first way is the number of firms that export at the sector-country level in each year. We run a regression specification that is similar to equation (2), except that now the dependent variable is log of the number of firms that export in sector *s* to country *c* in year *t* ($\ln\#Firms_{sct}$). The second way is the number of firm-product pairs that export at sector-country level in each year ($\ln\#Firm\text{-}Product_{sct}$). Table 7 reports the results. As expected, exchange rate depreciation would increase both the number of firms and the number of firm-products exported. However, this effect is mitigated by financial constraint. The higher the constraint is, as measured by a high external finance dependence, a high liquidity needs, or a low asset tangibility, the lower the effect of depreciation on the extensive margin of exports.

[Insert Table 7 Here]

We also take a look at the probability of entry. Let $I_{fsct}$ be an indicator that equals 1 if firm *f* exports to destination country *c* in year *t*. New entry is defined as $I_{fsct}=1$ while $I_{fsct-1}=0$. We estimate how exchange rate fluctuations affect the probability of entry $\text{Prob}(I_{fsct} = 1|I_{fsct-1} = 0)$ and how financial constraint affects this response by running a regression similar to specification (2). To avoid possible incidental parameter problem caused by firm-sector-country fixed effects, we estimate using the method of Logit and Linear Probability Model (LPM). Table 8 reports the results. The logit and LPM estimates give similar results. Exchange rate depreciation increases the probability of firm export in all specifications. However, this increase in probability is mitigated by the effect of financial constraint, as can be seen from the estimates on the interaction term. The higher the financial constraint is, the lower the effect of exchange rate shocks on the probability of entry.

[Insert Table 8 Here]

### 5.3 Firm Heterogeneity

In the above examination, we explore sectoral measures of financial constraint, which has the advantage of being exogenous and reflecting the "technological" part of investments that must be funded externally. However, firms are heterogeneous even within a narrowly-defined industry. Thus, in this section we go further to examine the role of within-sector

firm heterogeneity in the relationship between financial constraint and export's response to exchange rate shocks.

We start with the most exogenous ownership. It is generally believed that Chinese state owned enterprises (SOEs), which have preferential access to financing from state-owned banks, are less financially constrained than private firms. Foreign owned firms, which can obtain additional funding from their parent company or access foreign capital markets, are also believed to be less financially constrained than private firms (Manova et al. 2015). Therefore, we distinguish exporters by their ownership and examine whether private firms are more constrained than SOEs and foreign firms. Ownership information is obtained from the ASIP data. We follow Brandt et al. (2012) and use firms' registration type information to classify ownership into SOEs, private, and foreign. Foreign firms include those from Hong Kong, Macau, Taiwan, and other countries. When the registration structures are combined, we use additional information on the major contributors of paid-in-capital to determine the ownership of firms. The results are reported in Table 9 column (1). Compared with SOEs and foreign firms, private firms show a significant offsetting effect of financial constraint. The response to exchange rate shocks depends crucially on the sector-level financial constraint. The higher the dependence of external finance, the lower the exchange rate elasticity. For SOEs and foreign firms, this mitigating effect of financial constraint is insignificant, consistent with the general view that they can access external finance easily.

We then examine the effect of firm size. We believe that the effect of financial constraint is likely to be particularly relevant for small and medium sized firms, which tend to be more financially constrained than large firms.[5] We create a dummy variable for firms that have an average number of employees less than 200 and call them small and medium sized firms. We interact this dummy variable with the real exchange rate and sector financial constraint measure. Results are reported in the second column of Table 9. It confirms our hypothesis. Compared with large firms, small and medium sized firms show a significant offsetting effect of financial constraint. While for large firms, financial constraint has no significant effect.

Lastly, we explore firm heterogeneity in terms of firm-level financial variables. The literature has generally used some financial variables such as liquidity ratio, leverage ratio, and interest payment to measure firm's financial health (see for example, Greenaway et al.

[5] There are findings in the literature that financial frictions can account for salient features of the dynamics of small firms (Arellano et al 2012, Clementi and Hopenhayn 2006, Cooley and Quadrini 2001).

(2007), Bellone et al. (2010) and others). The higher its liquidity ratio, the lower its leverage ratio and interest payment, the better the firm's financial health. We use the ASIP data to obtain the information. The liquidity ratio is calculated as the firm's current assets minus its current liabilities over its total assets. The leverage ratio is the firm's ratio of current liability to current assets. The interest payment is interest payment over total sales. Each variable is normalized by the sector average. Importantly, to avoid the endogeneity problem, we use each firm's initial level of financial health and interact it with the sectoral external finance dependence and real exchange rate.[6] Table 9 columns (3)-(5) report the estimated results. Besides the exogenous effect of the sector-level financial constraint, we find that firms in the same sector but with different financial health conditions also exert an extra impact on the response of exports to exchange rate shocks. The triple interaction terms all have the expected signs. The better the firm's financial health, the smaller the offsetting effect of financial constraint on exchange rate elasticity. However, for both liquidity ratio and leverage ratio, the extra effect is statistically insignificant, while for interest payment, the effect is significant.

[Insert Table 9 Here]

## 6. Conclusion

Exchange rate fluctuations are believed to be highly associated with export performance, but historical data reveals inelasticity of export, which arouses our attention. One way to explain the puzzle is introducing financial constraint in traditional trade model. Prior literature illustrates possible channels through which financial constraint affects response to real exchange rate shocks. Local currency depreciation tends to stimulate exports, but the ability to seize that opportunity could be restricted by limited access to external funding. Firstly, depreciation lowers the value of domestic assets, thus increasing fixed cost. The most financial constrained exporters are forced out of market. Secondly, financial constraint hinders exporters from expanding their production to meet rising demand in the case of depreciation. And while currency appreciation harms competitiveness, some exporters benefit from lower fixed cost. This mitigation effect of financial constraint exhibits both at sector level and firm level. Utilizing export data from Chinese Customs, we find that depreciation increases export on both intensive margin and extensive margin, and both effects are dampened in financial vulnerable sectors. Further analysis of exploring firm

[6] We also try interact with the initial finance health variable with the real exchange rate alone. The results are qualitatively similar.

heterogeneity by ownership, size, and initial financial health suggests that the mitigating effect of financial constraint are more relevant for private firms, small firms, and firms with high interest payment ratio.

A desirable extension would be exploiting the variation in the quality of financial institutions across countries to explore whether financial institution affects a country's performance under currency crisis. And while financial constraints appear to alleviate the effect of real exchange rate fluctuations on export, the impact on macroeconomic outcomes remains an open question.

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Table 1: Data Summary Statistics

| | N | Mean | Median | Std | p10 | p90 |
|---|---|---|---|---|---|---|
| *Export Variables* | | | | | | |
| $ExportValue_{sct}$ | 48132 | 1.7e+08 | 4597705 | 1.21e+09 | 37911 | 2.14e+08 |
| # of sectors per country-year | 1452 | 33 | 34 | 4 | 29 | 36 |
| # of countries per sector-year | 396 | 121 | 128 | 18 | 100 | 132 |
| $ExportValue_{fsct}$ | 13448824 | 320411 | 14879 | 8253522 | 687 | 308800 |
| # of firms per sector-country-year | 39544 | 340 | 55 | 896 | 3 | 871 |
| # of sectors per firm-country-year | 6766905 | 2 | 1 | 2 | 1 | 4 |
| # of countries per firm-sector-year | 3066172 | 4 | 2 | 7 | 1 | 11 |
| *Country Variables* | | | | | | |
| $RER_{ct}$ | 1232 | 4.109 | 1.131 | 6.757 | 0.012 | 11.350 |
| $RGDP_{ct}$ | 1232 | 3.16e+08 | 3.43e+07 | 1.09e+09 | 2007129 | 6.42e+08 |
| $RGDPPC_{ct}$ | 1232 | 12387.55 | 6863.72 | 13845.26 | 931.76 | 33625 |
| *Sector Financial Vulnerability Measures* | | | | | | |
| External Finance Dependence | 36 | -0.01 | -0.03 | 0.57 | -0.42 | 0.54 |
| Liquidity Needs | 36 | 0.16 | 0.15 | 0.04 | 0.10 | 0.21 |
| Asset Tangibility | 36 | 0.31 | 0.28 | 0.13 | 0.14 | 0.46 |
| *Firm Characteristics* | | | | | | |
| Liquidity Ratio | 65551 | 0.005 | 0.009 | 0.322 | -0.366 | 0.385 |
| Leverage Ratio | 65551 | -0.036 | -0.237 | 3.225 | -0.916 | 0.664 |
| Interest Payment | 65551 | -0.008 | -0.009 | 0.066 | -0.022 | 0.010 |

Notes: this table reports the summary statistics of the datasets we use. The sector-level data contains export information of 6-digit HS product from 2000 to 2010. To match with the sectoral measure of financial constraint, we aggregate product-level exports into ISIC (Revision 2) level, employing the concordance provided by UN Statistics Division. The firm-level export data contains export information at firm-sector-country level from 2000 to 2007. Firm-level characteristics are from the Annual Surveys of Industrial Production (ASIP) over 2000 to 2007.

Table 2: Financial Constraint and Exchange Rate Elasticity of Exports

| Dependent Variable: $\ln(\text{ExportValue}_{sct})$ | | | | |
|---|---|---|---|---|
| | Benchmark | External Finance Dependence | Liquidity Needs | Asset Tangibility |
| | (1) | (2) | (3) | (4) |
| $\ln\text{RER}_{ct}$ | 0.517*** | 0.519*** | 1.741*** | -0.307* |
| | (0.080) | (0.080) | (0.332) | (0.178) |
| $\ln\text{RER}_{ct} \times \text{FinCons}_{s}$ | | -0.165* | -7.771*** | 2.744*** |
| | | (0.098) | (1.935) | (0.576) |
| Fixed Effects | sector-country fixed effects + year dummies | | | |
| # of Observations | 48,132 | 48,132 | 48,132 | 48,132 |
| # of Sector-Country Pairs | 4,690 | 4,690 | 4,690 | 4,690 |
| FinCons Range | | (-1.14, 2.43) | (0.07, 0.28) | (0.12, 0.62) |
| Elasticity Range | | (0.12, 0.71) | (-0.43, 1.18) | (0.02, 1.39) |
| Elasticity Mean | | 0.52 | 0.5 | 0.52 |

Notes: This table reports the estimation results at the sector level during 2000-2010. The dependent variable is the log export value. The independent variables also include a constant, real GDP and real GDP per capita for destination countries to control for demand factors. The results are not reported here to save space. All regressions include sector-country fixed effects and year dummies. Financial constraint is measured as indicated in columns (2) to (4). External finance dependence is defined as the share of capital expenditures not financed with cash flows from operations. Liquidity needs is the ratio of inventories to sales. Asset tangibility is the ratio of fixed assets to total assets. All measures come directly from Kroszner et al. (2007), who follow the methodology of Rajan and Zingales (1998). They are the median level for ISIC industries in the US for the period 1980-1999. We also use their numbers calculated over the period 1980s. The results are very similar and available upon request. Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3: Sensitivity Analysis

| Dependent Variable: $\ln(\text{ExportValue}_{sct})$ | | | | | | |
|---|---|---|---|---|---|---|
| | External Finance Dependence | | Liquidity Needs | | Asset Tangibility | |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\ln\text{RER}_{ct}$ | 0.312*** | 0.281*** | 1.431*** | 1.797*** | -0.334* | -0.789*** |
| | (0.102) | (0.098) | (0.439) | (0.336) | (0.184) | (0.222) |
| $\ln\text{RER}_{ct}\times\text{FinCons}_{s}$ | -0.177* | -0.224** | -6.404*** | -10.264*** | 2.929*** | 3.302*** |
| | (0.098) | (0.092) | (2.317) | (2.139) | (0.758) | (0.616) |
| $\ln\text{RER}_{ct}\times\text{KLratio}_{s}$ | 0.006*** | | 0.003 | | -0.001 | |
| | (0.002) | | (0.002) | | (0.003) | |
| $\ln\text{RER}_{ct}\times\text{Durable}_{s}$ | | 0.474*** | | 0.670*** | | 0.625*** |
| | | (0.134) | | (0.154) | | (0.148) |
| Fixed Effects | sector-country fixed effects + year dummies | | | | | |
| # of Observations | 48,132 | 48,132 | 48,137 | 48,138 | 48,134 | 48,135 |
| # of Sector-Country Pairs | 4,690 | 4,690 | 4,695 | 4,696 | 4,692 | 4,693 |

Notes: This table reports the estimation results at the sector level after controlling more industry characteristics. The dependent variable is the log export value. The independent variables also include a constant, real GDP and real GDP per capita for destination countries to control for demand factors. Besides the interactions between real exchange rate and financial constraint variables described in table 2, we also add interactions of real exchange rate with other industry characteristics. KLratio is the ratio of fixed assets over number of employees. Durable is an indicator that takes a value of one if the sector manufactures predominantly durable goods. Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 4: Financial Crisis

| Dependent Variable: $\ln(\text{ExportValue}_{sct})$ | | | |
|---|---|---|---|
| | External Finance Dependence | Liquidity Needs | Asset Tangibility |
| | (1) | (2) | (3) |
| $\ln\text{RER}_{ct}$ | 0.519*** | 1.740*** | -0.309* |
| | (0.080) | (0.332) | (0.178) |
| $\ln\text{RER}_{ct} \times \text{FinCons}_{s}$ | -0.176* | -7.850*** | 2.695*** |
| | (0.099) | (1.934) | (0.577) |
| $D_{crisis} \times \ln\text{RER}_{ct} \times \text{FinCons}_{s}$ | -0.015* | -0.103*** | -0.065** |
| | (0.008) | (0.030) | (0.016) |
| Fixed Effects | sector-country fixed effects + year dummies | | |
| # of Observations | 48,132 | 48,132 | 48,132 |
| # of Sector-Country Pairs | 4,690 | 4,690 | 4,690 |
| Elasticity Range (Non-crisis) | (0.09, 0.72) | (-0.46, 1.19) | (0.014, 1.36) |
| Elasticity Range (Crisis) | (0.05, 0.74) | (-0.49, 1.19) | (0.01, 1.32) |

Notes: This table adds the interaction of a crisis dummy with the real exchange rate and financial constraint measures. The crisis dummy $D_{crisis}$ equals to 1 for if year 2008 or 2009, and 0 otherwise. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 5: Firm-level Estimates - Intensive Margin

| Dependent Variable: $\ln(\text{ExportValue}_{fsct})$ | | | | |
|---|---|---|---|---|
| | Benchmark | External Finance Dependence | Liquidity Needs | Asset Tangibility |
| | (1) | (2) | (3) | (4) |
| $\ln\text{RER}_{ct}$ | 0.425*** | 0.424*** | 0.755*** | 0.206*** |
| | (0.009) | (0.009) | (0.042) | (0.023) |
| $\ln\text{RER}_{ct} \times \text{FinCons}_s$ | | -0.035* | -1.908*** | 0.838*** |
| | | (0.018) | (0.239) | (0.078) |
| Fixed Effects | sector-country fixed effects + year dummies | | | |
| # of Observations | 13,448,824 | 13,448,824 | 13,448,824 | 13,448,824 |
| # of firm-sector-country pairs | 7,378,306 | 7,378,306 | 7,378,306 | 7,378,306 |
| Elasticity Range | | (0.34, 0.46) | (0.22, 0.62) | (0.31, 0.73) |

Notes: This table reports the estimation results for firm level intensive margin adjustments during 2000-2007. The independent variables also include a constant, real GDP and real GDP per capita but not reported here. Financial constraint measures in columns (2)-(4) are as described in table 2. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 6: Intensive Margin - Robustness on Subsamples

| Dependent Variable: $\ln(\text{ExportValue}_{fsct})$ | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | No Entry/Exit | | | Major Products | | | Single Product | | |
| | External Finance | Liquidity Needs | Asset Tangibility | External Finance | Liquidity Needs | Asset Tangibility | External Finance | Liquidity Needs | Asset Tangibility |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| $\ln RER_{ct}$ | 0.471*** | 0.770*** | 0.280*** | 0.469*** | 0.840*** | 0.200*** | 0.447*** | 0.926*** | 0.074** |
| | (0.015) | (0.068) | (0.036) | (0.013) | (0.061) | (0.032) | (0.015) | (0.069) | (0.036) |
| $\ln RER_{ct} \times FinCons_s$ | -0.073** | -1.714*** | 0.745*** | -0.055** | -2.112*** | 1.063*** | -0.098*** | -2.750*** | 1.437*** |
| | (0.029) | (0.382) | (0.125) | (0.026) | (0.342) | (0.110) | (0.028) | (0.387) | (0.123) |
| Fixed Effects | sector-country fixed effects + year dummies | | | | | | | | |
| # of Observations | 3,277,139 | | | 5,195,630 | | | 4,525,130 | | |
| # of f-s-c pairs | 1,446,672 | | | 2,357,999 | | | 2,619,103 | | |

Notes: This table reports robustness checks for firm-level intensive margin adjustments on different subsamples. Columns (1)-(3) look at incumbent firms only, excluding observations in the entry/exit years. Columns (4)-(6) restrict to each firm's major 4-digit HS sector. Columns (7)-(9) restrict to single-product firms only, where single product is defined as those exporting only one product to a destination. Other independent variables and financial constraint measures are as described in table 2. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 7: Firm-level Estimates - Extensive Margin

| | DepVar: ln#firms$_{sct}$ | | | DepVar:ln#firm-products$_{sct}$ | | |
|---|---|---|---|---|---|---|
| | External Finance | Liquidity Needs | Asset Tangibility | External Finance | Liquidity Needs | Asset Tangibility |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| lnRER$_{ct}$ | 0.295*** | 0.939*** | -0.186** | 0.287*** | 0.965*** | -0.210** |
| | (0.045) | (0.158) | (0.088) | (0.048) | (0.167) | (0.094) |
| lnRER$_{ct}$ × FinCons$_{s}$ | -0.169*** | -4.086*** | 1.604*** | -0.198*** | -4.299*** | 1.658*** |
| | (0.049) | (0.903) | (0.289) | (0.054) | (0.957) | (0.306) |
| Fixed Effects | Sector-Country fixed effects + year dummies | | | | | |
| # of Observations | 39,544 | 39,544 | 39,544 | 39,544 | 39,544 | 39,544 |

Notes: This table reports estimation for firm-level extensive margin adjustments. The extensive margin is defined in columns (1)-(3) as the log number of firms exported in sector *s* to country *c* in year *t*, in columns (4)-(6) as the log number of firm-product pairs exported in sector s to country c in year t. Financial constraint measures are as described in table 2. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 8: Extensive Margin - Probability of Entry

| Dependent Variable: $Pr(I_{fsct}=1\|I_{fsct-1}=0)$ | | | | | | |
|---|---|---|---|---|---|---|
| | Logit | | | LPM | | |
| | External Finance | Liquidity Needs | Asset Tangibility | External Finance | Liquidity Needs | Asset Tangibility |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $lnRER_{ct}$ | 0.440*** | 0.650*** | 0.189*** | 0.048*** | 0.060*** | 0.026*** |
| | (0.005) | (0.023) | (0.012) | (0.001) | (0.003) | (0.001) |
| $lnRER_{ct} \times FinCons_s$ | -0.100*** | -1.208*** | 0.937*** | -0.003** | -0.075*** | 0.081*** |
| | (0.011) | (0.130) | (0.041) | (0.001) | (0.015) | (0.005) |
| Fixed Effects | firm-sector-country fixed effects + year dummies | | | | | |
| # of Observations | 39,841,924 | | | 42,553,293 | | |

Notes: This table reports estimation for the probability of a firm in sector *s* entering a new destination market *c*. $I_{fsct}$ is a binary variable that equals 1 if firm f in sector *s* exports to destination country *c* in year t, and 0 otherwise. The independent variables also include a constant, real GDP and real GDP per capita, firm-sector-country fixed effects and year dummies are also included. Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.

Table 9: Firm Heterogeneity

| Dependent Variable: $\ln(\text{ExportValue}_{fsct})$ | | | | | |
|---|---|---|---|---|---|
| | Ownership | Size | Liquidity Ratio | Leverage Ratio | Interest Payment |
| | (1) | (2) | (3) | (4) | (5) |
| $\ln\text{RER}_{ct}$ | 0.516*** | 0.572*** | 0.572*** | 0.572*** | 0.571*** |
| | (0.033) | (0.017) | (0.022) | (0.022) | (0.022) |
| $\ln\text{RER}_{ct} \times \text{FinCons}_s$ | -0.063 | -0.057 | -0.174*** | -0.174*** | -0.184*** |
| | (0.054) | (0.043) | (0.036) | (0.036) | (0.036) |
| $\ln\text{RER}_{ct} \times \text{FinCons}_s \times \text{Private}_f$ | -0.147** | | | | |
| | (0.062) | | | | |
| $\ln\text{RER}_{ct} \times \text{FinCons}_s \times \text{SME}_f$ | | -0.148*** | | | |
| | | (0.043) | | | |
| $\ln\text{RER}_{ct} \times \text{FinCons}_s \times \text{FinHealth}_f$ | | | 0.028 | -0.007 | -1.319*** |
| | | | (0.080) | (0.014) | (0.504) |
| Fixed Effects | firm-sector-country fixed effects + year dummies | | | | |
| # of Observations | 3,122,981 | 3,122,981 | 3,122,981 | 3,122,082 | 3,122,981 |
| # of firm-sector-country pairs | 1,306,419 | 1,306,419 | 1,306,419 | 1,306,063 | 1,306,419 |

Notes: This table reports firm-level estimation results after taking into account firm heterogeneity. Column (1) examines the role of ownership. Column (2) explores the size information. Columns (3)-(5) examines firm's financial health. Ownership is classified according to firm's registration type information. Size is classified according to firm's average number of employees. SMEs are small and medium sized firms whose average number of employees less than 200. The liquidity ratio is calculated as the firm's current assets minus its current liabilities over its total assets. The leverage ratio is the firm's ratio of current liability to current assets. The interest payment is interest over total sales. Each variable is normalized by the sector average. To avoid the endogeneity problem, we use each firm's initial level of financial health. In all regressions, the independent variables also include a constant, real GDP and real GDP per capita but not reported here. Financial constraint is measured with external finance dependence. Robust standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$.