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Exchange Rate Volatility, Financial Constraints, and Trade: Empirical Evidence from Chinese Firms[1]

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In this paper, we study how firm-level export performance is affected by Real Exchange Rate (RER) volatility and investigate whether this effect depends on existing financial constraints. Our empirical analysis relies on export data for more than 100,000 Chinese exporters over the 2000–6 period. We confirm a trade-deterring effect of RER volatility. We find that firms' decision to begin exporting and the exported value decrease for destinations with a higher exchange rate volatility and that this effect is magnified for financially vulnerable firms. As expected, financial development seems to dampen this negative impact, especially on the intensive margin of export. These results provide micro-founded evidence suggesting that the existence of well-developed financial markets allows firms to hedge exchange rate risk. The results also support a key role of financial constraints in determining the macro impact of RER volatility on real outcomes. JEL codes: F14, F31, L25

Introduction

The increasing volatility of exchange rates after the collapse of the Bretton Woods agreements has been a source of concern for both policymakers and academics. In a context where firms are risk averse, exchange rate risk increases trade costs and reduces the gains from international trade (Ethier 1973). However, initial macroeconomic evidence on the effect of exchange rate volatility on trade has been quite mixed, identifying an effect that is either significant but small or insignificant (see Greenaway and Kneller (2007) and Byrne et al. (2008) for a survey). Even Rose (2000), who finds a very large effect of currency

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union on international trade, finds a small effect of nominal exchange rate volatility. More recent works have emphasized that these results may occur because of an aggregation bias[2] (Byrne et al. (2008) study the impact of the nominal exchange rate volatility; Broda and Romalis (2011)[3] focus on real exchange rate volatility)[4] and because of an excessive focus on richer countries with highly developed financial markets. More substantial negative effects of the real exchange rate volatility on trade are found for developing countries (Grier and Smallwood 2007).

There is a considerable lack of firm-level evidence on the impact of exchange rate volatility on exporting behavior and how this relationship may be influenced by financial constraints, which are likely to be much stronger and more binding in developing countries. A careful firm-level study of these relationships may provide clearer evidence regarding the exacerbating role of exchange rate volatility for export costs and the role of financial development in alleviating these additional costs. This paper aims to fill these gaps. We study the impact of Real Exchange Rate (RER) volatility on exporting behavior and the role of financial constraints, together with financial development, in shaping this relationship at the firm level.

Our empirical estimations rely on export data for more than 100,000 Chinese exporters over the 2000–6 period. China is a highly relevant case for several reasons. First, the country displays an especially high export rate given its size, leading to substantial exposure to exchange rate fluctuations. Second, China is interesting because it is characterized by low financial development but rather high regional heterogeneity, which isuseful to identify a non-linear effect of exchange rate volatility depending on credit constraints. Finally, the Chinese Yuan was strongly pegged to the US dollar during nearly the entire period considered, implying that the volatility we identify is truly exogenous to Chinese economic developments over the considered period.

More precisely, the Chinese exchange rate policy over the period is best described as a fixed peg versus the US dollar until July 2005. At that time, the Chinese government switched to a reference to a basket of other currencies. However, Frankel and Wei (2007) find that the *de facto* regime remained a peg to a basket that put virtually all of the weight on the dollar. Subsequently, some weight was shifted to a few non-dollar currencies. In any case, the peg remained

2. Because the effects of RER volatility differ across firms or sectors and countries, aggregating across these disparate units can produce weaker or insignificant results.

3. Broda and Romalis (2011) also address the issue of reverse causality between exchange rate volatility and trade. Once the problem is controlled for, they still find a negative, albeit reduced, impact of volatility on trade.

4. Although the volatility of the real exchange rate differs conceptually from that of the nominal exchange rate, as shown by Clark et al. (2004), they do not differ much in reality. In the literature, volatility indicators based on real or nominal exchange rates are used similarly, but with a strong preference for the former.

fairly strong in 2006.[5] The Chinese exchange rate policy is also characterized by limited convertibility and misalignment over the period. Although impediments to convertibility may have decreased as China made tentative attempts to internationalize the yuan by the end of the 2000s, charges of undervaluation developed over the period. Nevertheless, these two dimensions apply to all exporters independently of the destination country; hence, they are not country-specific. Our econometric approach, which focuses on the repercussions of RER volatility, exploits cross-country variations for firm exports and accounts for these common specificities through time fixed effects.

We expect a negative impact of exchange rate volatility on trade through an increase in the variable and sunk costs of exporting. The former effect is implicitly addressed by Ethier (1973) and is the most intuitive one: exchange rate risk creates an uncertainty for the exporter's earnings in her own currency, which is similar to an increase in variable costs. However, exchange rate volatility may also increase the sunk costs of exports, which can be seen as a form of investment in intangible capital. In practice, most investment expenditures are at least partly irreversible; they are made of sunk costs that cannot be recovered if market conditions turn out to be worse than expected. The combination of investment irreversibility and asymmetric adjustment costs induces a negative relationship between price volatility and investment (Pindyck 1988, 1991), especially in developing economies (see Pindyck and Solimano 1993). In such a context, high volatility has consistently proven to reduce growth and investment, especially private investment (Ramey and Ramey (1995), using the volatility of output growth; Aizenman and Marion (1999), focusing on RER volatility; Schnabl (2007), relying on nominal exchange rate volatility). Bloom et al. (2007) find similar results within a firm-level framework with partial irreversibility: higher uncertainty reduces the responsiveness of investment to a firm-level demand shock.

Only recently, however, has the macro literature explicitly identified a relationship between credit constraints and the size of the impact of volatility. Aghion et al. (2009) show that the local financial development plays a key role in the magnitude of the repercussions linked to exchange rate volatility. Relying on a panel of 83 countries over the 1960-2000 period, these authors show that the negative impact of RER volatility on productivity growth decreases with a country's financial development. Within an identical framework, but focusing on foreign currency (dollar) liabilities, Benhima (2012) shows for a panel of 76 emerging and industrial countries between 1995 and 2004 that the higher the share of foreign currency in external debt, the more detrimental RER volatility is to growth. This finding tends to support the idea that the effect of RER volatility depends critically on the existence of credit constraints.

5. In any case, our results are unchanged when excluding the years 2005 and 2006. More details on this robustness check are available upon request.

The link between volatility and export performance has usually been investigated using macro and, less frequently, disaggregated data at the sectoral level.[6] Some papers examine the impact of the RER on exporting firms (e.g., Berman et al. (2012) on France; Li et al. (2012) and Park et al. (2010) on China), but they focus on the impact of the exchange rate level rather than its volatility, and they do not account for the role of financial constraints. Firm-level studies of the impact of exchange rate volatility on economic or trade performance for developing countries are scarce. Carranza et al. (2003) find a negative impact of RER volatility on a sample of 163 Peruvian firms, and Cheung and Sengupta (2012) study the impact of real effective exchange rate variations and volatility on the share of exports-to-sales ratio for a sample of a few thousand Indian nonfinancial sector firms and find support for a negative effect of volatility.

With regard to the role of credit constraints in modeling the impact of RER volatility, especially on export performance, research is almost nonexistent. To our knowledge, Caglayan and Demir's (2012) study is the only firm-level study connecting firm productivity, RER movements, and the issue of access to external finance. Based on a data set of 1,000 private Turkish firms, their results support a negative impact of exchange rate volatility on productivity growth, which is downplayed by better access to external finance.

We depart from these previous works by using a much wider data set of firms, by examining whether firms move their exports away from partners characterized by higher exchange rate volatility, and more importantly, by investigating the presence of a non-linear effect of exchange rate volatility on performance depending on the level of financial constraints in the Chinese context. The latter issue is considered through two complementary dimensions. First, we infer firm-level financial vulnerability from the financial dependence of firms' activities. This approach was pioneered by Rajan and Zingales (1998) and has proven to be a robust methodology to detect credit constraints and assess their evolution (Kroszner et al. 2006, Manova et al. 2011). Second, we exploit Chinese cross-provincial heterogeneity to study how financial development may mitigate both credit constraints and exchange rate volatility.

This paper contributes to the existing literature on various levels. First, we provide a micro-founded investigation of Aghion et al.'s (2009) prediction that exchange rate volatility is especially harmful to firms that have high liquidity needs when local financial development is low. Second, our methodology allows us to circumvent a number of endogeneity problems that may have flawed some related studies. The use of firm-level data mitigates the issue of reverse causality from trade to exchange rate volatility (cf. Broda and Romalis 2011) and the well-known simultaneity bias between exporting behavior and financial proxies for credit constraints at the firm level. It is very unlikely that a Chinese firm shock would impact exchange rate volatility or measures of financial dependence based

6. Some papers examine the impact of RER variations on Chinese trade, including Marquez and Schindler (2007), Ahmed (2009), Freund et al. (2011), and Cheung et al. (2012).

on data from US firms. Furthermore, using cross-regional data within a single country instead of cross-country data reduces the risk of confusion between financial development and other macro characteristics.Third, our results provide insight into the main sources of the apparent lack of a macro impact of exchange rate volatility: the level of financial constraints and financial development appears to be more important than the aggregation bias to explain this puzzle. We find that the repercussions of RER volatility are not unconditional, even at the micro level, and are mainly related to financial factors.

Our results are consistent with the aforementioned macro studies, especially that of Aghion et al. (2009). Both the decision to begin exporting and the exported value decrease for destinations with higher exchange rate volatility. This export-deterring effect is magnified for financially vulnerable firms. For firms that are most dependent on external finance, a 10 percent increase in RER volatility decreases the value exported by 11 percent and the probability of entering by 3 percent. As expected, financial development seems to dampen this negative impact, especially on the intensive margin of export. These results are robust to various definitions of trade margins, measures of exchange rate volatility and financial dependence, subsamples, and the inclusion of additional controls. We therefore provide micro support to the macro literature suggesting that financial development is a key determinant in identifying the impact of RER volatility on real outcomes.

In the next section, we survey the different theoretical mechanisms underlying our approach before discussing our general methodology and presenting our database in section 2. In section 3, we begin by presenting the results on the intensive margin and then on the extensive margin before introducing some robustness checks and a general discussion of our findings. Section 4 concludes.

Exchange Rate Volatility, Financial Constraints, and Exports: Theoretical Underpinnings

Related Literature

Our approach stands at the crossroads of two strands of the literature. First, there is a rapidly increasing number of papers that consider the behavior of firms that manufacture and export several products to several destinations. It is widely known that aggregate exports are concentrated in a small number of major players (Eaton et al. 2004) and that large exporters are involved in exporting more than one product (Bernard et al. 2011; Eckel et al. 2011). Bernard et al. (2011) show that the proportion of multi-product firms that export, the number of destinations for each product, and the range of products they export to each market all increase in response to reduced variable trade costs. Even closer to our work is that of Berthou and Fontagné (2013), who document the impact of the introduction of the euro on the export decisions of French firms, the number of products exported, and average sales per product. Their results point to a

heterogeneous trade creation effect across euro area destinations: for those firms exporting to destinations characterized by lower monetary policy coordination (that is, higher exchange rate volatility) before 1999, exports grew by 12.8 percent following the introduction of the euro, with 20 percent of the effect due to an increase in the number of products exported. By contrast, no effect arises regarding the decision to export. Conversely, they find a negative effect on all three definitions of trade margins for euro area destinations with closer monetary policy coordination before 1999, indicating that the additional competitive pressure more than offset the benefits of zero volatility.

Secondly, there is growing empirical evidence that credit constraints impact exporting behavior (Manova 2013; Greenaway et al. 2007; Berman and Héricourt 2010; Minetti and Zhu 2011). The first paper on this topic by Manova (2013) incorporates financial frictions into a heterogeneous-firm model before applying it to aggregate trade data. She finds that 20 percent to 25 percent of the impact of credit constraints on trade are driven by reductions in total (domestically sold and exported) output. Of the additional trade-specific effect, one-third reflects limited firm entry into exporting, and two-thirds is due to contractions in the sales of exporters. Both extensive and intensive margins are therefore affected by credit constraints. All subsequent papers consistently find that the effect is magnified when firms belong to industries that rely more on external finance (Minetti and Zhu 2011), and in developing countries (Berman and Héricourt 2010) compared to developed ones (Greenaway et al. 2007).

Our paper explores the possibility of a negative impact of exchange rate volatility on trade that is proportionally stronger for financially vulnerable firms and, consequently, weaker with high levels of financial development. This impact can be generated by several mechanisms. One can think of exchange rate risk creating uncertainty for the earnings of the exporter, which is equivalent to uncertainty on variable trade costs. The results of Bernard et al. (2011) and Berthou and Fontagné (2013) show that all trade margins are potentially involved. The existence of well-developed financial markets should allow agents to hedge the exchange rate risk, thus dampening or eliminating its negative effect on trade. This effect has not been clearly established either empirically (Dominguez and Tesar 2001) or theoretically (Demers 1991). Therefore, it is interesting to examine whether micro data can provide clearer insights.

Another mechanism that is more focused on the sunk costs of exports and therefore is especially appropriate for the decision to export to new markets may also be at work. On the one hand, export capacity may be considered a type of investment in intangible capital (such as R&D); on the other hand, exchange rate movements give rise to additional sunk costs (Greenaway and Kneller 2007). The negative impact of exchange rate volatility on exports can be rationalized through the asymmetry of adjustment costs leading to investment irreversibility. When facing a real depreciation of its own currency, the current earnings of a firm rise. The firm may use this additional income to fund the sunk costs of entering new markets. However, once these investments are made, it is impossible to

back out and recover what they cost, even in the case of an abrupt subsequent currency appreciation. If firms are credit constrained, they will face additional difficulties in funding new investments and will be even more reluctant to take the chance of engaging in exports to markets characterized by highly volatile exchange rates.

Several approaches may theoretically rationalize this mechanism. In the study of Aizenman and Marion (1999), the introduction of credit rationing leads to a nonlinearity in the intertemporal budget constraint. In their framework, the supply of credit facing a developing country is bounded by a credit ceiling independently of the level of demand. The credit ceiling hampers the expansion of investment in the high-demand state without moderating the drop in investment in the low-demand state. Thus, this asymmetric pattern implies that higher volatility reduces the average rate of investment, and this effect is magnified with credit constraints. An alternative mechanism is proposed by Aghion et al. (2009). Suppose that an exporter faces fixed wage costs in the local currency. When the bilateral exchange rate vis-à-vis that of the exporting market fluctuates, the exporter cannot completely pass the cost change through to the exporting market because of competitive pressures, for example. Then, exchange rate volatility leads to fluctuations in profits, which can lower investments in an environment where external finance is more costly than internal finance. Following an exchange rate appreciation, the current earnings of firms decline. This reduces their ability to borrow to survive idiosyncratic liquidity shocks and invest in the longer term. Depreciations have the opposite effect. However, the existence of a credit constraint implies that, in general, the positive effects of a depreciation will not fully compensate for the negative effects of an appreciation. By reducing the cost of external finance, financial development relaxes credit constraints and should decrease the impact of volatility on the sunk cost activity—in our case, exports.

Key Testable Predictions

We can summarize the testable predictions from these models for export performance—that is, both the intensive (export value) and extensive (decision to begin exporting) margin.

Testable Prediction 1. *Export performance decreases with exchange rate volatility. We therefore expect the link between volatility, on the one hand, and the exported value and the decision to begin exporting to a market, on the other hand, to be negative.*

Testable Prediction 2. *The negative impact of exchange rate volatility on export performance is magnified for financially vulnerable firms. Export performance is disproportionately decreased by exchange rate volatility for those firms.*

Testable Prediction 3. *By relaxing credit constraints, financial development decreases the impact of exchange rate volatility on export performance proportionally more for financially vulnerable firms.*

Data Sources and Empirical Methodology

Exchange Rate Volatility

Exchange rate volatility is computed as the yearly standard deviation of monthly log differences in the real exchange rate. Because we rely on an indirect quotation (that is, one unit of foreign currency equals X units of yuan), we compute the real exchange rate as the nominal exchange rate of the yuan with respect to the partner's currency multiplied by the partner's consumer price (CPI) level.[7] Thus, we do not divide by Chinese prices because of the likely mediocre quality of Chinese CPI, which would produce useless additional noise in the estimates. Because our empirical specification includes year dummies (see subsection II – "Empirical Specification" below), the impact on our estimates should be negligible; the Chinese CPI is common to all exporters, so most of its variance is absorbed in these time fixed effects.

To ensure that our results are not dependent on a specific definition of volatility, we perform several robustness checks in which alternative definitions of the exchange rate are used to build our volatility indicator (still using the yearly standard deviation of monthly log differences): the nominal exchange rate, the real exchange rate computed as the nominal exchange rate of the yuan with respect to the partner's currency multiplied by the partner's CPI and divided by Chinese CPI or the HP (Hodrick and Prescott 1997) detrended real exchange rate. We also consider a specification in which the standard deviation of the log-level of the real exchange rate is considered instead of our benchmark measure of volatility.[8]

Because our empirical specification includes firm-destination fixed effects to mitigate the endogeneity issue, the repercussions of RER volatility on firm export performance is identified from the variation within a firm-destination over time. Thus, our results reflect how firms allocate resources to a given market over time. In unreported checks (available upon request), we verify that our findings are not sensitive to the source of variation we exploit for the RER volatility. When estimating a specification that concentrates on the variation across countries, we find that RER volatility is a significant determinant of how firms allocate resources across markets. We obtain a negative effect of RER volatility that is magnified for financially vulnerable firms.

Trade Data

The main data source is a database collected by the Chinese Customs. It contains Chinese firm-level yearly export flows by year, HS6 product, and destination

7. Monthly data on nominal exchange rates and prices are taken from the International Financial Statistics (IFS).

8. Our specification assumes that firms respond rather quickly to changes in RER volatility. This assumption is consistent with the unreported results, available upon request, that indicate that when introducing both the contemporaneous volatility and the one-year lagged volatility to explain export decisions, the former is associated with greater statistical significance.

country over the 2000–6 period. It covers 113,368 exporting firms and 158 destinations

Financial Vulnerability and Financial Development

We compute firm-level financial vulnerability as the weighted average of the financial vulnerability of a firm's activities. The weights are the average share of the sector in the exports by the firm over our sample period.[9]

$$FinVuln^F = \sum_s \left(\frac{Exports_s^F}{\sum_s Exports_s^F} \times FinVuln_s \right) \quad (1)$$

We use three different measures of the financial vulnerability of a sector $FinVuln_s$, in line with other studies on the same topic. These variables are meant to capture the technological characteristics of each sector that are exogenous to the financial environment of firms and to determine the degree of reliance of the firms in each sector on external finance. Although firms in all industries may face liquidity constraints, there are systematic differences across sectors in the relative importance of up-front costs and the lag between the time when production expenses are incurred and revenues are realized. We capture these differences with a measure of the external finance dependence in a sector (referred to hereafter as "financial dependence"), constructed as the share of capital expenditures not financed out of cash flows from operations. For robustness, we also use an indicator of the asset intangibility of firms. This measure is the ratio of intangible assets to fixed assets. Thus, it captures another dimension of the dependence of a firm on access to external financing: the difficulty of using assets as collateral in obtaining financing. As a third indicator, we follow Manova et al. (2011), who use the share of R&D spending in total sales (R&D) based on the fact that as a long-term investment, research and development often implies greater reliance on external finance.

As is standard practice in the literature, these indicators are computed using data on all publicly traded US-based companies from Compustat's annual industrial files. The value of the indicator in each sector is obtained as the median value among all firms in each sector. Indicators of the financial vulnerability of a sector are available for 27 three-digit ISIC sectors.[10] We borrow the values

9. In the unreported results, which are available upon request, we also verify that our results hold when measuring the financial vulnerability of a firm as the financial vulnerability of its main (ISIC) sector of activity, identified as the one with the greatest export share over the period. Furthermore, our findings hold when the main sector of activity or the weights are based on the first year for which the firm reports exports instead of the average over 2000–6. In subsection III, "Additional Robustness Tests and General Discussion", we discuss the results of Table S.8 reported in the online appendix (available at http://wber.oxfordjournals.org/), in which margins of trade are defined at the firm-sector-destination level, and the measure of financial vulnerability is a sector characteristic as in the prior literature.

10. We use a correspondence table between the international trade nomenclatures and the ISIC Rev. 2 categories, developed at the CEPII to match the Chinese HS 6-digit product codes with the ISIC three-digit sector categories.

computed by Kroszner et al. (2006). As explained by Manova et al. (2011), the use of US data is not only motivated by the lack of data for most other countries, including China, but it also has several advantages. Rajan and Zingales (1998) note thatthe United States has one of the most advanced and sophisticated financial systems, so the values for US firms reflect the technology-specific component of external finance needs, or what can be called the finance content of an industry. Measuring these indices in the Chinese context would likely lead to different values, reflecting the fact that firms organize production differently in a credit-constrained environment. Thus, such measures would be endogenous to financial development in China, whereas measures based on data from US firms can be seen as exogenous in this respect.

In addition to these firm-sector indicators of financial vulnerability, we use the level of financial development at the regional level. We thus adapt the methodology first used by Rajan and Zingales (1998), which consists of filtering the impact of financial liberalization by financial vulnerability to isolate its direct finance-related causal effect. We measure local financial development as the share of total credit over GDP in the province.[11]

Finally, descriptive statistics of key variables are given in Tables 1 and 2 below.

Empirical Specification

We estimate the following specification:

$$\begin{aligned} ExportPerf_{ijt}^{F} = {} & \alpha\, RERVolatility_{jt} + \beta\, RERVolatility_{jt} \times FinVuln^{F} + \gamma\, RERVolatility_{jt} \\ & \times FinDev_{jt} + \delta\, RERVolatility_{jt} \times FinVuln^{F} \times FinDev_{it} \\ & + \tau\, FinVuln^{F} \times FinDev_{it} + \eta\, FinDev_{it} + \phi Z_{jt} + \lambda_{j}^{F} + \theta_{t} + \varepsilon_{ijt}^{F} \end{aligned} \tag{2}$$

where $ExportPerf_{ijt}^{F}$ is a measure of the export performance of firm F in province i for export destination j in year t. We use two alternative measures of export performance to capture the intensive and extensive margin of exports, respectively, the log of the total free-on-board export sales towards destination j in year t, and the decision to begin exporting to market j in year t. The latter is constructed as a change of export status at the firm-country level; it takes the value 1 when a firm exports to country j at time t but did not at time $t-1$.[12]

Our regressions (performed with the linear within estimator for the intensive margin and the conditional logit model for the extensive margin) include firm-country fixed effects λ_{j}^{F} and year dummies θ_{t}. Firm fixed effects capture the

11. In robustness checks, we verify that our results are similar when using the ratio of deposits over GDP.

12. In that set of regressions, our sample consists of a firm-country series of zeros followed by a decision to begin exporting. For a given firm-country, we can have several beginnings. For example, the subsequent export statuses 011001 become . 1 . . 01 in our sample, with . denoting a missing value.

TABLE 1. Summary Statistics: Key Variables

Variable	Mean	Std. Dev.	Min	Max
Firm-country export value (million US $)	0.75	11.9	0.1	7,440
Nb of products exported (firm-country)	4.66	13.95	1	1329
RER volatility	0.02	0.02	.01	0.44
GDP (trillion US $)	1.54	2.98	0.1	13.7
Price index (effective exchange rate)	234.4	309.8	0.003	3549
Country-sector imports (billion US $)	14.0	28.8	0.1	271
External dependence	0.37	0.26	−0.45	1.14
Intangibility	0.08	0.05	0	0.43
R&D	0.02	0.02	0	0.09
Financial development (total credit/GDP, %)	1.14	0.47	0.58	3.31
Export start dummy (firm-country)	0.226	0.42	0	1

Notes: The summary statistics are computed on the 3,731,351 firm-country-year observations that make up our final regression sample used in Table 3 to study the intensive margin. The only exception is the statistics for the start dummy which are computed for the sample (8,801,335 observations) used in Table 7.

Source: Authors' calculations based on Chinese customs and other data described in the text.

TABLE 2. Descriptive Statistics for Financial Vulnerability Indicators

Distribution	External dependence	Intangibility	R&D
5%	0.01	0.01	0.004
10%	0.061	0.019	0.009
50%	0.326	0.074	0.019
90%	0.770	0.149	0.065
95%	0.838	0.160	0.070

Notes: The summary statistics are computed on the 3,731,351 firm-country-year observations that make up our final regression sample used in Table 3 to study the intensive margin.

Source: Authors' calculations based on Chinese customs and other data described in the text.

impact of both local endowments and sector-specific characteristics (including financial vulnerability). Our conditioning set Z consists of destination-year specific variables. In standard models of international trade, exports depend on the destination country's market size and price index. We use country j's GDP[13] and effective real exchange rate.[14] We also account for country j's demand for goods from the main sector of the firms (identified as the one with the highest export share over the period). Following Berman et al. (2012), we use the log of the total import value for the country-sector in the year taken from BACI.[15]

13. GDP data come from the World Development Indicators.

14. The effective exchange rate is computed using CEPII and IFS data as an average of the real exchange rates of destination country j toward all of its trade partners, weighted by the share of each trade partner in country j's total imports.

15. This data set, which is constructed using COMTRADE original data, provides bilateral trade flows at the product level (Gaulier and Zignago 2010). BACI is downloadable from http://www.cepii.fr/anglaisgraph/bdd/baci.htm (last accessed: October 10, 2013). Trade flows are aggregated to the 27 three-digit ISIC sectors for which our indicators of the financial vulnerability of a sector are available.

We first focus on the unconditional effect of volatility on export performance, i.e., on a benchmark specification with β, γ, δ, and τ all restricted to 0. Consistent with prediction 1 from section 2, we expect α to be negative. In a second step, we condition the impact of volatility on the financial vulnerability of a firm by introducing an interaction term between these two variables: prediction 2 leads us to expect β to be negative. Note that the financial vulnerability variable alone does not appear because it is captured by the firm-country fixed effects. We further modify our empirical specification in a third and final step to allow α and β to vary depending on the development of the local financial sector. In this case, our main parameters of interest are those on the double interaction between RER volatility and financial development (γ) and on the triple interaction between RER volatility, financial vulnerability, and financial development (δ). Following prediction 3, both parameters should be positive.

Note also that the relative size and significance of α in comparison with the other parameters provides interesting insight into the respective roles of the aforementioned aggregation bias and heterogeneity in terms of financial development. More precisely, a non-significant α compared to β, γ, and δ suggests that the impact of exchange rate volatility on exports is not unconditional but emerges mainly because of the credit constraints of firms and low financial development.

Finally, Moulton (1990) shows that regressions with more aggregate indicators on the right-hand side could induce a downward bias in the estimation of standard errors. All regressions are thus clustered at the province level[16] using the Froot (1989) correction.

Results

We study the joint effects of exchange rate volatility and financial constraints on both margins of trade separately: the size of exports by firm (the intensive margin) and the decision to begin exporting (the extensive margin).[17]

Intensive Margin

Table 3 presents the estimations of the impact of RER volatility on the value exported by firms. Column (1) reports the estimates of a specification based only on the two proxies for the destination countries' market size and price index (which are significant and display the expected positive signs), and column (2) presents the unconditional relationship between RER volatility and export performance. Column (3) includes an alternative measure of market size, the country-sector imports, which appears positive and significant. The following columns add a

16. Because the province level is the most aggregated one (i.e., with the smallest number of clusters) in our case, it gives the most possible conservative standard errors and appears to be the safest choice. Note that our results are mostly unchanged when standard errors are clustered at the destination country level.

17. Robustness checks relying on alternative definitions for both margins are presented in the Appendix.

TABLE 3. Intensive Margin, Exchange Rate Volatility and Financial Constraints

Dependent variable	Log export value (firm-destination-year)					
	(1)	(2)	(3)	(4)	(5)	(6)
Financial indicator				Ext dep	Intang.	R&D
RER volatility (α)		−0.439[a]	−0.305[a]	0.402	0.123	0.153
		(0.119)	(0.106)	(0.246)	(0.183)	(0.172)
Ln country GDP	0.321[a]	0.312[a]	0.061	0.061	0.060	0.061
	(0.068)	(0.066)	(0.068)	(0.068)	(0.068)	(0.068)
Ln country price index	0.027[c]	0.027[c]	0.050[c]	0.050[c]	0.050[c]	0.050[c]
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Ln country-sector imports			0.357[a]	0.356[a]	0.357[a]	0.356[a]
			(0.014)	(0.014)	(0.014)	(0.014)
RER volatility × Fin. vulnerability (β)				−1.900[a]	−5.686[a]	−18.574[a]
				(0.478)	(1.466)	(4.379)
Fixed effects			Firm-country and year			
R-squared	0.03	0.03	0.03	0.03	0.03	0.03
Observations			3,731,351			
Nb of firm-country pairs			1,128,873			

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. Standard errors are clustered at the province level; [a], [b], and [c], respectively, denote significance at the 1 percent, 5 percent, and 10 percent levels.

Source: Authors' calculations based on Chinese customs and other data described in the text.

variable interacting RER volatility with a measure of firm-level financial dependence. Columns (2) and (3) show that exchange rate volatility appears to be negatively associated with export performance (i.e., the α parameter of Equation 2 is significant and negative).

We check the robustness of this negative relationship when volatility is computed based on the yearly standard deviation of monthly log differences of various definitions of the exchange rate. The results reported in Table S.1 in the online appendix (available at http://wber.oxfordjournals.org/) confirm that the unconditional impact of exchange rate volatility on the intensive margin is negative and significant (and quantitatively very close to our main definition of volatility, i.e., the standard deviation of the RER defined as the nominal exchange rate of the yuan with respect to the partner's currency multiplied by the partner's CPI) whether we consider a "full" RER in which the Chinese CPI is introduced as the denominator (columns (1) and (2)), the nominal exchange rate (columns (3) and (4)), the log-level of RER (columns (5) and (6)), or the HP detrended version of our benchmark RER (columns (7) and (8)).[18]

The subsequent results suggest that the magnitude of this effect depends on the extent of the financial constraints. Columns (4) to (6) of Table 3 show that the interaction with financial vulnerability enters with a negative and significant

18. These results are also robust in specifications based on variables measured using two-year windows. This additional set of results is available upon request.

coefficient regardless of the indicator of financial dependence used: external dependence in column (4), asset intangibility in column (5), and R&D intensity in column (6). Across our three indicators, we consistently observe that the negative impact of RER volatility on exports grows with financial vulnerability. These results suggest that the negative impact of exchange rate volatility on export performance is not unconditional but is instead proportional to the degree of financial vulnerability.

These results are robust to various robustness checks. First, Table S.1 confirms an export-deterring effect of RER volatility that rises with financial vulnerability regardless of the definition of volatility that is used. Second, in the unreported results (available upon request), we check that the estimates of Equation 2 are robust to the inclusion of sector-year fixed effects, where the sector corresponds to the firm's main sector of activity, identified as the one with the greatest export share over the period. This allows us to verify that although a large component of the variance in exchange rate volatility may be year-specific, our results do not solely reflect the sector-specific trends. The results are qualitatively identical.[19]

To illustrate these results, we can compare the decrease in the export performance due to RER volatility for firms at the 10^{th} and 90^{th} percentiles of the distribution of financial vulnerability. Table 2 above reports summary statistics on the distribution of the three indicators of financial vulnerability. Using coefficients from column (4) in Table 3 for the intensive margin, all things being equal, the effect of a 10 percent increase in RER volatility on export value is $0.1 \times \alpha + 0.1 \times \beta \times$ FinVuln. Hence, our results ($\alpha = 0.402$ and $\beta = -1.90$) suggest that the export value is reduced by 10.6 percent [$0.1 \times 0.402 - 1.9 \times 0.1 \times 0.770$] at the 90^{th} percentile of financial dependence. At the 10^{th} percentile, the export value seems slightly increased, by 2.9 percent [$0.1 \times 0.402 - 1.9 \times 0.1 \times 0.061$]. The key point is that the differential impact between the 90^{th} and 10^{th} percentiles of financial dependence is equal to -13.5 percent [$0.1 \times (-1.9) \times (0.77 - 0.061)$], which is strongly negative and significant.

In Table 4, we check the robustness of our results to the inclusion of additional controls. Financial vulnerability is measured using external dependence. The first five columns check that our measured impact of RER volatility does not simply capture the impact of the RER level. In column (1), the explanatory variables are restricted to RER volatility and RER level. Because we rely on an indirect quotation, an increase in the level of the exchange rate, implying a depreciation, is expected to have a positive impact on export performance. This intuition is confirmed: RER volatility and RER level enter with reverse signs, negative and positive, respectively, which are significant in both cases. In column (2), the positive impact of the level of RER becomes insignificant once we adopt the benchmark specification from column (4) in Table 3 and add the macroeconomic variables for the destination country (GDP, import price, demand). In column

19. In other unreported checks, we show that our results hold when adding interactions between year dummies and our proxy for financial vulnerability.

TABLE 4. Intensive Margin: Including RER in Level and Income Volatility

Dependent variable	Log export value (firm-destination-year)									
Financial indicator	External dependence									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
RER volatility (α)	−0.636[a]	−0.308[a]	−0.036	0.399	0.223	−0.548[a]	−0.238[c]	0.272	0.520[c]	0.504[c]
	(0.151)	(0.103)	(0.255)	(0.243)	(0.217)	(0.184)	(0.125)	(0.314)	(0.282)	(0.278)
Ln country GDP		0.054		0.054	0.057		0.064		0.063	0.063
		(0.075)		(0.075)	(0.075)		(0.077)		(0.077)	(0.077)
Ln country price index		0.048[a]		0.048[a]	0.048[a]		0.037[b]		0.037[b]	0.037[b]
		(0.013)		(0.013)	(0.013)		(0.017)		(0.017)	(0.017)
Ln country-sector imports		0.357[a]		0.356[a]	0.355[a]		0.407[a]		0.406[a]	0.406[a]
		(0.014)		(0.014)	(0.014)		(0.017)		(0.017)	(0.017)
RER Volatility × Fin. vulnerability (β)			−1.612[a]	−1.901[a]	−1.427[a]			−2.187[a]	−2.025[a]	−1.981[a]
			(0.391)	(0.479)	(0.400)			(0.494)	(0.537)	(0.523)
Ln RER × Fin. vulnerability			0.477[a]		0.465[a]					
			(0.137)		(0.141)					
Ln RER	0.316[a]	0.013	0.142[c]	0.014	−0.158[a]					
	(0.037)	(0.020)	(0.081)	(0.020)	(0.046)					
GDP volatility						−2.453[a]	−1.721[a]	−2.004[a]	−1.721[a]	−1.338[a]
						(0.226)	(0.234)	(0.303)	(0.234)	(0.316)
GDP Volatility × Fin. vulnerability								−1.232[b]		−1.057[c]
								(0.532)		(0.565)
Fixed effects					Firm-country and year					
R-squared	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Observations			3,731,351					3,158,760		
Number of firm-country pairs			1,128,873					952,132		

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. Standard errors are clustered at the province level; [a], [b], and [c], respectively, denote significance at the 1 percent, 5 percent, and 10 percent levels.

Source: Authors' calculations based on Chinese customs and other data described in the text.

(3), we add the interactive terms between financial vulnerability and both the level of RER and the volatility of RER. The former interactive term attracts a positive and significant coefficient. The reasoning is symmetrical to the one concerning RER volatility: financially constrained firms disproportionately take advantage of a depreciating exchange rate. However, this is contrary to the findings of Desai et al. (2008), which suggest that lower financial constraints increase firms' ability to expand activity during currency crises.

Our results in columns (3) to (5) confirm that including the level of RER does not affect our main result of a negative β. In the remaining columns (6 to 10), we verify that RER volatility does not act as a mere proxy for economic fluctuations. We consider the repercussions of the volatility of the partner's GDP, which is computed as the standard deviation of year-to-year changes in quarterly GDP taken from the IFS. As argued by Baum et al. (2004) and Grier and Smallwood (2007), foreign income uncertainty may equally matter for trade. Consistent with their findings, GDP volatility enters with a negative sign: income volatility has a significant deterrent effect on the value exported. However, this inclusion does not affect our benchmark result of a negative impact of RER volatility that grows with financial vulnerability. In columns (8) and (10), we further include the interactive term between GDP volatility and financial dependence. In column (10), it is significant only at the 10 percent level (the negative impact of income volatility seems to vary, but only weakly, with the level of credit constraints for a firm), whereas our main finding on the impact of RER volatility is not altered; the interaction between RER volatility and financial dependence remains negative and significant.

Table 5 verifies that our results are robust to various changes in the sample. Again, financial vulnerability is measured using external dependence. Column (1) restricts the sample to firms exporting to more than one country, whereas column (2) concentrates on multi-product firms. The point estimates are virtually unaffected. In column (3), we exclude observations for Macao and Hong Kong because we are concerned that RER volatility may have different implications in the case of these two "Greater China" territories than for other international partners. Once again, the negative coefficient on the interactive term between RER volatility and financial vulnerability remains. In columns (4) to (7), we investigate whether our results vary across firm-level productivity, proxied as the number of products or the number of product-country pairs that a firm exports. We investigate this by regressing our main specification on subsamples divided around the median of our productivity proxies. Our main findings remain unchanged in all specifications, indicating that they apply to both low- and high-productivity firms.

We now ask whether recent developments in China's financial system have helped reduce the export losses from real exchange rate uncertainty. As previously mentioned, Aghion et al. (2009) suggest that the effect of RER volatility depends critically on the level of local financial development. We modify our

TABLE 5. Intensive Margin: Controlling for Various Subsamples

Dependent variable	Log export value (firm-destination-year)						
Financial indicator	External dependence						
	(1) Country Nb > 1	(2) Product Nb > 1	(3) No HK or Macao	(4) High Nb products	(5) Low Nb products	(6) High Nb prod-dest	(7) Low Nb prod-dest
RER volatility (α)	0.384	0.359	0.435[c]	0.799[c]	0.179	0.507	0.391
	(0.244)	(0.270)	(0.228)	(0.394)	(0.204)	(0.336)	(0.250)
Ln country GDP	0.051	0.101[c]	0.031	0.170[b]	0.004	0.201[a]	0.057
	(0.064)	(0.058)	(0.079)	(0.066)	(0.085)	(0.071)	(0.068)
Ln country price index	0.048[a]	0.035[b]	0.032[b]	0.040[b]	0.056[a]	0.043[b]	0.048[a]
	(0.015)	(0.014)	(0.013)	(0.017)	(0.014)	(0.018)	(0.015)
Ln country-sector imports	0.355[a]	0.333[a]	0.342[a]	0.312[a]	0.409[a]	0.313[a]	0.355[a]
	(0.013)	(0.013)	(0.015)	(0.013)	(0.020)	(0.012)	(0.014)
RER volatility ×	−1.866[a]	−1.722[a]	−1.921[a]	−3.314[a]	−0.968[b]	−2.545[a]	−1.892[a]
Fin. vulnerability (β)	(0.467)	(0.602)	(0.466)	(0.927)	(0.382)	(0.722)	(0.478)
Fixed effects	Firm-country and year						
R-squared	0.03	0.04	0.03	0.02	0.04	0.03	0.03
Observations	3,659,052	2,019,033	3,472,215	1,836,309	1,895,042	1,862,175	3,719,937
Number of firm-country pairs	1,106,403	781,138	1,059,036	532,927	595,946	527,300	1,128,139

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. Standard errors are clustered at the province level; [a], [b], and [c], respectively, denote significance at the 1 percent, 5 percent, and 10 percent levels.

Source: Authors' calculations based on Chinese customs and other data described in the text.

empirical specification to allow β in Equation 2 to vary depending on the development of the local financial sector.

Our main parameter of interest is that of the triple interaction between RER volatility, financial vulnerability, and financial development (δ in Equation 2). We first split the provinces into two groups depending on whether their financial development is below or above the national median or the national mean in 2000 (the initial year of our sample). The corresponding results are reported in columns (1) and (2) of Table 6. The positive coefficient attracted by the

TABLE 6. Intensive Margin: The Role of Financial Development

Dependent variable	Log export value (firm-destination-year)				
Financial indicator	External dependence				
	(1)	(2)	(3)	(4)	(5)
RER volatility (α)	0.455[c]	0.467[c]	0.312	0.292	0.299
	(0.259)	(0.272)	(0.248)	(0.238)	(0.228)
Ln country GDP	0.059	0.059	0.057	0.059	0.049
	(0.069)	(0.069)	(0.068)	(0.068)	(0.069)
Ln country price index	0.050[a]	0.050[a]	0.050[a]	0.049[a]	0.050[a]
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)
Ln country-sector imports	0.357[a]	0.357[a]	0.356[a]	0.354[a]	0.358[a]
	(0.014)	(0.014)	(0.014)	(0.014)	(0.013)
RER Volatility × Fin. vulnerability (β)	−2.824[a]	−2.875[a]	−1.718[a]	−1.622[a]	−1.614[a]
	(0.433)	(0.462)	(0.611)	(0.475)	(0.462)
RER Volatility × Financial vulnerability × High Fin. Devt (above median)	2.062[a]				
	(0.589)				
RER Volatility × Financial vulnerability × High Fin. Devt (above mean)		2.177[a]			
		(0.568)			
RER Volatility × High Fin. Devt (above median)	−0.015				
	(0.271)				
RER Volatility × High Fin. Devt (above mean)		−0.047			
		(0.260)			
RER Volatility × Financial vulnerability × Fin. Devt (δ)			7.069[a]	3.034[b]	2.878[b]
			(1.981)	(1.234)	(1.160)
RER Volatility × Fin. Devt (γ)			−2.170[a]	−0.666	−0.770
			(0.658)	(0.457)	(0.572)
Financial vulnerability × Fin. Devt				0.263[c]	0.260[c]
				(0.146)	(0.138)
Financial Development			0.087	−0.016	
			(0.061)	(0.056)	
Province-year fixed effects	no	no	no	no	yes
Fixed effects	Firm-country and year				
R-squared	0.03	0.03	0.03	0.03	0.03
Observations	3,731,351				
Number of firm-country pairs	1,128,873				

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. Standard errors are clustered at the province level; [a], [b], and [c], respectively, denote significance at the 1 percent, 5 percent, and 10 percent levels.

Source: Authors' calculations based on Chinese customs and other data described in the text.

interactive terms between RER volatility and financial vulnerability in the case of provinces thatare highly financially developed indicates that the negative effect of RER volatility on the export value of firms is less present when credit is abundant. In the following columns, we use the time-varying proxy for financial development and interact it directly with RER volatility and financial dependence. The interaction between local financial development and financial dependence is also included. We also add the level of financial development and its interaction with RER volatility (the γ parameter) in columns (4) and (5). In column (5), we include province-year fixed effects to account for the time-varying characteristics of the local economy (including financial development, which drops as a consequence). In this way, any variable correlated with financial development that could impact the export performance of firms are captured by these fixed effects but should not affect our coefficients of interest (β, γ, and δ), unless its effect runs through a financial channel.

The results confirm our previously measured negative interaction between RER volatility and financial vulnerability but suggest that the losses are mitigated by high local financial development. In all columns, we find that financial development dampens the negative impact of real exchange rate volatility on exports and that the relaxation effect increases with the level of sectoral financial dependence of firms. The triple interaction among RER, financial dependence, and financial development is positive and significant. In other words, the positive offsetting effect of financial development on RER volatility is magnified by the financial constraints for firms. This result is in line with Aghion et al.'s (2009) observation that financial development reduces the magnitude of performance deterioration induced by RER volatility. Conversely, there is no evidence of an unconditional effect on financial constraints; the interaction between RER volatility and financial development (γ) is insignificant.

As an additional check, we verify in Table S.3 in the online appendix that our main results hold when measuring the intensive margin based on the average export value for the firm-country pair, computed as the ratio of total export value over the number of products exported (expressed in natural logarithms). All of our key results remain: the negative impact of RER volatility on the intensive margin increases with the credit constraints for firms regardless of the definition of financial vulnerability that is used (columns (2) to (4)). Finally, the relaxing effect of financial development also persists (columns (5) to (8)), with an even stronger significance compared to our preferred specification.

Extensive Margin

In this section, we assess the joint effect of RER volatility and financial constraints on the extensive margin of trade at the firm-country level (i.e. how they affect entry decisions). Columns (1) to (6) of Table 7 replicate Table 3. The explained variable is now the decision for a firm to begin exporting to market *j*. It is constructed as a change of export status at the firm-country level; it takes the value 1 when a firm exports to country *j* in year *t* but did not in year $t-1$. Once

TABLE 7. Extensive Margin, Exchange Rate Volatility, and Financial Constraints

Dependent variable	$Pr(X^F_{i,j,t} > 0 \mid X^F_{i,j,t-1} = 0)$									
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Financial indicator				Ext dep	Intang.	R&D	External dependence			
RER volatility (α)		−0.864[a]	−0.735[a]	0.094	0.019	−0.454[a]	−0.779[a]	−0.197	−0.702[a]	0.024
		(0.099)	(0.080)	(0.226)	(0.190)	(0.153)	(0.079)	(0.209)	(0.130)	(0.230)
Ln country GDP	0.072	0.051	−0.219[a]	−0.218[a]	−0.220[a]	−0.219[a]	−0.267[a]	−0.237[a]	−0.252[a]	−0.252[a]
	(0.055)	(0.055)	(0.057)	(0.057)	(0.057)	(0.057)	(0.070)	(0.072)	(0.072)	(0.072)
Ln country price index	0.099[a]	0.102[a]	0.125[a]	0.124[a]	0.125[a]	0.124[a]	0.109[a]	0.108[a]	0.077[a]	0.077[a]
	(0.020)	(0.020)	(0.021)	(0.021)	(0.021)	(0.021)	(0.019)	(0.019)	(0.029)	(0.029)
Ln country-sector imports			0.379[a]	0.378[a]	0.379[a]	0.379[a]	0.379[a]	0.372[a]	0.395[a]	0.394[a]
			(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.033)	(0.053)	(0.053)
RER volatility × Fin. vulnerability (β)				−2.233[a]	−9.852[a]	−11.731[a]		−1.462[a]		−1.923[a]
				(0.431)	(1.973)	(3.612)		(0.374)		(0.370)
Ln RER × Fin. vulnerability								1.252[a]		
								(0.231)		
Ln RER							0.101[a]	−0.377[a]		
							(0.036)	(0.100)		
GDP volatility									0.076	0.950[c]
									(0.193)	(0.574)
GDP volatility × Fin. vulnerability										−2.433[b]
										(1.178)
Fixed effects	Firm-country and year									
Pseudo-R-squared	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Observations				8,801,335			8,801,335		6,996,782	
Nb of firm-country pairs				1,867,840			1,867,840		1,492,028	

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. Standard errors are clustered at province level; [a], [b], and [c], respectively, denote significance at the 1 percent, 5 percent, and 10 percent levels.

Source: Authors' calculations based on Chinese customs and other data described in the text.

again, the unconditional impact of RER volatility (α parameter) appears negative and significant (columns (2) and (3)), but adding interactive terms to each of our measures of firm-level financial dependence shows that the magnitude of this effect is usually conditioned by the extent of the financial constraints (columns (4) to (6)): the β parameter appears negative and highly significant, and α becomes insignificant except when the financial dependence indicator is the share of R&D spending in total sales. Quantitatively, the impact of an unconditional 10 percent increase in exchange rate volatility (the α parameter in column (3)) decreases the probability of beginning to export by 1.29 percent.[20] Similarly, if we distinguish between firms at the 10^{th} and 90^{th} percentiles of the distribution of financial vulnerability, we can compare the decrease in the extensive margin due to RER volatility conditioning on financial vulnerability. Using coefficients $\alpha = 0.094$ and $\beta = -2.233$ from column (4), this means that, all things being equal, the negative effect of an additional 10 percent in RER volatility on the probability of entering is -2.8 percent $[(0.094 \times 0.1) \times (0.226) \times (1-0.226) + (0.1 \times (-2.233) \times 0.77) \times 0.226 \times (1-0.226)]$ at the 90^{th} percentile of financial dependence. The effect is practically 0 $[-0.07$ percent $= (0.094 \times 0.1) \times (0.226) \times (1-0.226) + (0.1 \times (-2.233) \times 0.061) \times 0.226 \times (1-0.226)]$ at the 10^{th} percentile. The net differential effect on the 90^{th} percentile relative to the 10^{th} percentile is thus equal to -2.8 percent.

As before, in Table S.2 in the online appendix, we check the robustness of these results using the yearly standard deviation of monthly log differences from various definitions of the exchange rate (with the RER deflated by the Chinese CPI in columns (1) and (2), the NER in columns (3) and (4), and the HP-filtered RER in columns (7) and (8)).

In columns (5) and (6), we verify that similar qualitative results are obtained when volatility is computed as the yearly standard deviations of the log-level of RER. In unreported additional checks, we show that our results also hold when adding interactions between year dummies and our proxies for financial vulnerability.[21] Overall, the negative impact of RER volatility on the probability of beginning to export is magnified by financial vulnerability. In columns ((7) to (10)) of Table 7, as before, we check the robustness of our results to the inclusion of additional macro controls, namely the log of RER and GDP volatility. The RER level enters positively and significantly (column (7)), and its interaction with

20. This figure is obtained from the derivative of the choice probabilities (Train 2003). The change in the probability that a firm F will choose alternative X (begin exporting) given a change in an observed factor $Z_{F,X}$ entering the representative utility of that alternative (and holding the representative utility of other alternatives (no exporting) constant) is $\beta Z \times P_{F,X}(1 - P_{F,X})$, with $P_{F,X}$ being the average probability that firm i will choose alternative X (begin exporting). Based on an average probability to begin exporting of 22.6 percent, our estimates suggest that the derivative of beginning to export with respect to an additional 10 percent in RER volatility is -1.29 percent $= 0.1 \times - 0.735 \times 0.226 \times (1 - 0.226)$.

21. We were not able to implement regressions using sector-year dummies to control more systematically for sector-specific trends because the latter are too numerous to allow the maximization of the log-likelihood function.

financial vulnerability is also positive and significant (column (8)); financially constrained firms disproportionately take advantage of a depreciating exchange rate to enter the export market. In columns (9) and (10), GDP volatility fails to enter significantly, but its interaction with financial dependence is negative and significant; financially constrained firms are more harmed by the instability of foreign demand. In any case, these additional estimates do not affect our benchmark result of a negative impact of RER volatility that grows with financial vulnerability.

Table 8 checks the robustness of these results across various subsamples. Financial vulnerability continues to be measured using external dependence. The results are unchanged for multi-destination (column (1)) and multi-product (column(2)) firms and when the observations for Macao and Hong Kong are excluded (column (3)): the β parameter remains negative and significant, and entry into the export market is still disproportionately more harmed by exchange rate volatility in the case of financially constrained firms. This result also holds when we divide the sample by the median of our proxies for firm-level productivity, the number of products exported (columns (4) and (5)), or the number of product-destinations by firm (columns (6) and (7)). Interestingly, the unconditional impact of RER volatility on entry (coefficient α) also remains negative and significant for firms with a low number of products or a low number of product-destinations. The probability that low-diversified firms will begin exporting is also harmed by RER volatility, even for zero financial vulnerability.

We complete this overview by examining the impact of local financial development heterogeneity on these results. Once again, we measure local financial development as the share of total credit over GDP in the province, and we perform estimations replicating the ones presented in Table 6.[22] We find that the triple interaction among exchange rate volatility, financial dependence, and financial development (the δ parameter) is positive and significant in most specifications, whether we consider groups above the national mean/median of financial development in 2000 (columns (1) and (2)) or use the time-varying proxy for financial development (column (3)). The entry into export markets of financially constrained firms is less hampered by RER volatility when financial development is high. However, in column (4), the significance switches from the δ to the γ parameter. Financial development still reduces the negative impact of RER volatility but does so independently of the level of financial constraints for firms. Overall, the evidence seems less strong than for the intensive margin, but the presumption that financial development reduces the magnitude of performance deterioration induced by RER volatility remains, along the lines of Aghion et al. (2009).

We check how our results behave when considering the export status at the firm-country level instead of the decision to *begin* exporting to understand the

22. However, we cannot provide estimations including province-year fixed effects; the maximization of the log-likelihood function proved to be impossible.

TABLE 8. Extensive Margin: Controlling for Various Subsamples

Dependent variable	$Pr(X^F_{i,j,t} > 0 \mid X^F_{i,j,t-1} = 0)$						
Financial indicator	External dependence						
	(1) Country Nb > 1	(2) Product Nb > 1	(3) No HK or Macao	(4) High Nb products	(5) Low Nb products	(6) High Nb prod-dest	(7) Low Nb prod-dest
RER volatility (α)	−0.295	−0.067	−0.274	−0.145	−0.616[b]	−0.137	−0.570[b]
	(0.198)	(0.317)	(0.194)	(0.287)	(0.278)	(0.295)	(0.226)
Ln country GDP	0.297[a]	0.308[a]	0.305[a]	0.352[a]	0.475[a]	0.444[a]	0.413[a]
	(0.052)	(0.049)	(0.077)	(0.070)	(0.053)	(0.076)	(0.040)
Ln country price index	0.064[a]	0.063[a]	0.056[a]	0.054[a]	0.020	0.043[a]	0.028
	(0.014)	(0.016)	(0.012)	(0.016)	(0.019)	(0.012)	(0.020)
Ln country-sector imports	0.417[a]	0.356[a]	0.403[a]	0.335[a]	0.491[a]	0.384[a]	0.451[a]
	(0.036)	(0.041)	(0.036)	(0.040)	(0.026)	(0.039)	(0.033)
RER volatility ×	−1.622[a]	−2.086[b]	−1.607[a]	−1.904[a]	−1.067[a]	−2.041[a]	−1.167[a]
Fin. vulnerability (β)	(0.378)	(0.814)	(0.384)	(0.594)	(0.367)	(0.578)	(0.410)
Fixed effects	Firm-country and year						
Pseudo-R-squared	0.10	0.11	0.10	0.07	0.13	0.07	0.12
Observations	4,617,726	1,684,176	4,496,413	2,276,599	2,341,127	2,304,527	2,313,199
Number of firm-country pairs	1,193,670	489,613	1,159,777	559,590	634,080	546,015	647,655

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. Standard errors are clustered at province level; [a], [b], and [c], respectively, denote significance at the 1 percent, 5 percent, and 10 percent levels.

Source: Authors' calculations based on Chinese customs and other data described in the text.

extensive margin. Our dependent variable is therefore defined as a dummy variable taking the value 1 when a firm exports to country j at time t. The results, which are still based on a conditional logit specification with firm-country fixed effects, are reported in Table S.4 in the online appendix. These results are qualitatively identical to those presented in Tables 7 and 9. We find some evidence of an unconditional negative impact of RER volatility (column (1)). This negative impact is again magnified by firm-level financial dependence (columns (2) to (4)). Finally, there is still some evidence that financial development produces a significant relaxation effect in this context (columns (5) to (8)).

TABLE 9. Extensive Margin: The Role of Financial Development

Dependent variable	$Pr(X^F_{i,j,t} > 0 \mid X^F_{i,j,t-1} = 0)$			
Financial indicator	External dependence			
	(1)	(2)	(3)	(4)
RER volatility (α)	−0.506	−0.577	0.029	−0.067
	(0.466)	(0.492)	(0.232)	(0.215)
Ln country GDP	−0.225[a]	−0.226[a]	−0.222[a]	−0.220[a]
	(0.052)	(0.051)	(0.053)	(0.053)
Ln country price index	0.122[a]	0.122[a]	0.124[a]	0.124[a]
	(0.021)	(0.021)	(0.021)	(0.021)
Ln country-sector imports	0.380[a]	0.380[a]	0.379[a]	0.375[a]
	(0.032)	(0.032)	(0.033)	(0.032)
RER Volatility × Fin. vulnerability (β)	−4.762[a]	−4.885[a]	−2.137[a]	−1.777[a]
	(1.268)	(1.277)	(0.724)	(0.360)
RER Volatility × Financial vulnerability × High Fin. Devt (above median)	4.385[b]			
	(2.060)			
RER Volatility × Financial vulnerability × High Fin. Devt (above mean)		4.487[b]		
		(2.025)		
RER Volatility × High Fin. Devt (above median)	1.556			
	(1.091)			
RER Volatility × High Fin. Devt (above mean)		1.633		
		(1.087)		
RER Volatility × Financial vulnerability × Fin. Devt (δ)			6.503[b]	−0.072
			(3.000)	(1.679)
RER Volatility × Fin. Devt (γ)			−0.866	1.552[c]
			(0.981)	(0.813)
Financial vulnerability × Fin. Devt				0.590
				(0.383)
Financial Development			0.358	0.127
			(0.230)	(0.186)
Fixed effects	Firm-country and year			
Pseudo-R-squared	0.20	0.20	0.20	0.20
Observations	8,801,335			
Number of firm-country pairs	1,867,840			

Notes: Heteroskedasticity-robust standard errors are reported in parentheses. Standard errors are clustered at province level; [a], [b], and [c], respectively, denote significance at the 1 percent, 5 percent, and 10 percent levels.

Source: Authors' calculations based on Chinese customs and other data described in the text.

Finally, Table S.5 in the Appendix reports the results of an alternative definition of the extensive margin, namely the (log) number of HS6 products shipped to a country, in the spirit of Manova et al. (2011). We still find a negative impact of RER volatility on export performance, which is magnified for financially vulnerable firms. The evidence is much weaker regarding the relaxing impact of financial development; the δ coefficient is correctly signed (positive) but fails to be significant.

Additional Robustness Tests and General Discussion

Our empirical work so far has exploited the variation in export performance over time and across destinations for firms of different sectors. Because a great proportion of the firms in our sample export goods to more than one ISIC three-digit sector, in what follows, we also use the variation across sectors within firms. Our proxy for the intensive margin becomes the (log) export value of the firm for a given sector/country pair in a year. The extensive margin is defined as the (log) number of HS6 products for a given sector/country pair in a year. Otherwise identical to Equation 2, these regressions include firm-sector-country fixed effects, so the coefficients are identified from the time-series variation within firm-sector-country triplets over time. Therefore, our estimates consider the way in which firms choose to allocate their limited financial resources in the various sector-country export markets in which they operate over time.[23] The results are reported in Tables S.6 and S.7 in the online appendix for the intensive and extensive margins, respectively. In both cases, exchange rate volatility impacts export performance negatively, disproportionately more for financially vulnerable firms. There is still a relaxing impact of financial development for this specific definition of the intensive margin. However, no evidence of such an effect of financial development can be identified for the range of products exported.

Defining the margins of trade at the firm-sector-country level also allows us to check how our results behave when we define financial vulnerability relying on pure sectoral indicators. That is, a firm's financial dependence is identified without using any kind of weighting schemes based on firm-level exports; the measure of financial vulnerability is therefore a pure sector characteristic and is hence exogenous to firm-level developments. The results are reported in Table S.8 in the online appendix. The results are generally qualitatively similar to the ones presented above, with a somewhat weaker significance (especially for the intangibility indicator). This not surprising because we are considering a quite aggregated sectoral level with limited variance compared to our firm-level variables. Overall, however, the reading of Tables S.6 and S.7 is not fundamentally altered by this modification.

In additional unreported checks (available upon request), we assess the robustness of our results to the exclusion of the US as an export destination in the

23. In unreported results that are available upon request, we verify that our main message holds when including both firm-sector-year fixed effects and country fixed effects—that is, when focusing on how firms allocate resources across countries for a given sector-year.

sample. This allows us to ensure that our results are not biased by the presence of the country toward which volatility is reduced by construction during most of the period considered. Similarly, we perform additional estimates excluding the years 2005 and 2006 to verify that the switch from pegging the US dollar only to a basket of several currencies in July 2005 does not impact our results. In both exercises, our results remain qualitatively identical.

Moreover, we verify that our results hold for exporters irrespective of their ownership structure (whether domestic or foreign) and irrespective of the export regime (whether ordinary or processing). We also perform estimations on a subsample excluding intermediary firms. Our measure of financial constraints may be less relevant for those firms that do not produce the goods they sell because it is computed from information based on production technology. We follow Ahn et al.'s (2011) approach to identify these firms based on Chinese characters in the name of the firm that mean "importer", "exporter", and/or "trading" in English.[24] We also estimate specifications adding firm-country level imports from the countries where the firm is also exporting. In all of these checks, once again, the negative impact of exchange rate volatility appears magnified for financially vulnerable firms and relaxed by a high level of financial development.

Finally, we verify that the differentiated impact of RER volatility depending on financial development does not simply reflect a correlation between financial development and trade costs. It may be that provinces with a more developed financial system also benefit from easier and cheaper international access. In this case, our results may identify an uncertainty related to distance. We replicate our benchmark result by examining the double interaction between RER volatility and financial dependence (column (4) of Tables 3 and 7) and the triple interaction depending on financial development (columns (3) and (4) of Tables 6 and 9) when adding interactive terms with three proxies for the geographical trade advantages of coastal location, western location, and distance to partner country,[25] respectively. Our findings of a trade-deterring effect of RER volatility that is proportional to financial constraints and that is relaxed by financial development appear fully robust to these controls for geography.

Together, Tables 3 to 9 shed new light on the joint role of exchange rate volatility and financial constraints on exporting behavior. Our results suggest that exchange rate volatility negatively impacts both the intensive (total value exported by firm and destination) and extensive (decision of a firm to begin exporting to destination) margin but that this impact is mainly conditioned on the extent of firm-level financial constraints. Our findings also support the idea that higher financial development offsets this negative impact, both for the intensive margin and the probability of entering a new export market,but not for the range of

24. In pinyin (Romanized Chinese), these phrases are "jin4chu1kou3", "jing1mao4", "mao4yi4", "ke1mao4", and "wai4jing1".

25. We use the GeoDist dataset (Mayer and Zignago 2011), available at http://www.cepii.fr/francgraph/bdd/distances.htm (last accessed: October 10, 2013).

products exported. Overall, these results provide insight into the main sources for the apparent lack of macro impact of exchange rate volatility: the level of financial constraints and financial development clearly dominate the aggregation bias hypothesis because β and δ are consistently more significant than α. By doing so, we provide micro support to the macro literature that points to financial development as a key determinant of the impact of RER volatility on real outcomes.

Conclusion

This paper relies on a firm-level database covering exporters from China to study how export performance is affected by real exchange rate volatility. Our empirical strategy investigates how RER volatility affects the extensive and intensive margins of firm-level exports to their international partners. The features of the Chinese exchange rate system that are common to all exporters and all destination markets, such as limited convertibility and misalignment, are controlled for through fixed effects. Our results suggest that even in the specific context of China's restricted and misaligned ER regime, volatility is a significant barrier to Chinese exporters' performance. We find a trade-deterring effect of RER volatility, the magnitude of which depends mainly on the extent of financial constraints. Although firms tend to export less and to reduce their entry into destinations with higher exchange rate volatility, this negative effect is even stronger for financially vulnerable firms. Furthermore, financial development appears to dampen this negative impact, especially on the intensive margin of export.

These results suggest that the development of credit markets would help firms overcome the additional export (both variable and sunk) costs related to RER volatility. This finding could support the expansion of exports by firms, particularly to those destinations characterized by RER-related uncertainty. More generally, our study emphasizes that emerging countries should be careful when relaxing their exchange rate regime. Hard-fixed pegs for developing countries are certainly not always a panacea, but moving to a fully floating regime without an adequate level of financial development could also prove to be very hazardous for trade performance.

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