The Heterogeneous Impact of Exchange Rate Volatility on Agricultural Export: Evidence from Chinese Food Firm-level Data

Y. Jin[1]; S. Jin[2]

1: Zhejiang University, Agricultural Economics and Management, China, 2: Zhejiang University, China Academy for Rural Development, School of Public Affairs, China

Corresponding author email: 11520059@zju.edu.cn

Abstract:

This paper analyzes the heterogeneous impacts of exchange rate volatility on Chinese food exporters. Previous researches that employed country or sector-level aggregated data has yielded controversy conclusions in estimating effects of exchange rate uncertainty on agricultural trade. In this paper, we construct highly disaggregated Chinese food firm-level census data with destination-specific export data from 2000 to 2013 (215,783 sample firms), to discuss the influence based on firm-level characters. In general, this empirical research illustrates that the exchange rate fluctuation has significant negative effects on both trade prices and volumes. More importantly, we find that different firm-level characters (performance and scale) may reinforce or weaken the impact of this volatility on each firm. And this result is robust to different measures and econometric specifications.

Acknowledegment: The authors gratefully acknowledge the support from the National Natural Science Foundation of China (NNSFC-71273233, 71333011), the Major Program of the Key Research Institute of Chinese Ministry of Education (No. 15JJD790032).

JEL Codes: Q13, Q11

#1311

The Heterogeneous Impact of Exchange Rate Volatility on Agricultural Export: Evidence from Chinese Food Firm-level Data

Abstract

This paper analyzes the heterogeneous impacts of exchange rate volatility on Chinese food exporters. Previous researches that employed country or sector-level aggregated data has yielded controversy conclusions in estimating effects of exchange rate uncertainty on agricultural trade. In this paper, we construct highly disaggregated Chinese food firm-level census data with destination-specific export data from 2000 to 2013 (215,783 sample firms), to discuss the influence based on firm-level characters. In general, this empirical research illustrates that the exchange rate fluctuation has significant negative effects on both trade prices and volumes. More importantly, we find that different firm-level characters (performance and scale) may reinforce or weaken the impact of this volatility on each firm. And this result is robust to different measures and econometric specifications.

Key words: agricultural trade, exchange rates, volatility, China

JEL codes: Q17 Q13 Q11

1. Introduction

With the trends of world economy globalization continuing, the factors influencing the agricultural trade has been received extensive attention by both agricultural products exporters and importers (e.g.: Disdier et al., 2008; Anderson, 2010&2014). Government barriers (e.g.: Anderson et al. 2012) and the preferential trade arrangements (e.g.: Nolte et al., 2010; Grant, 2013), as well as the exchange rate and its volatility are identified as important exogenous factors in existing literatures. Agricultural products are more sensitive to exchange rate fluctuation in the world market due to its high substitutability, low durability and relatively low price (Dornbusch, 1987; Anderson and Garcia, 1989). Many empirical studies have investigated the relationship between the exchange rate volatility and agricultural trade, and ambiguous results are found. Some showed exchange rate volatility has negative effects on trade flow at different degrees, while others provided evidence that influence is not significant or even positive (see more detailed summary in J Di, 2008; Langley et al., 2000; Kim and Koo, 2002; Ivan, 2008). The fact that the literature has not reached a consensus on the impact of exchange rate volatility on agricultural trade leaves an issue which is worth researching and further investigating (Wang & Barrett, 2007).

In the vast literatures on evaluating the effects of exchange-rate volatility on agricultural trade, country or sector-level aggregated data were widely used. Some used country-specific bilateral trade data (Anderson, 1979; Pick, 1990; Kafle and Kennedy, 2013); and a handful of articles applied sectoral data or specific products data (Langley et al., 2000; Kim and Koo, 2002; Cho et al., 2002; Ivan, 2008; Miljkovic,2002; Sheldon et al., 2013; Davis et al., 2014). However, potential differences of this influence across heterogeneous firms are ignored, so that how individual firms react to exchange rate volatility needs to be further examined by more disaggregated firm-level recent data, more reasonable methodology and more specific objective. (Melize,2003; Wang & Barrett, 2007; Mayer et al., 2011). In this article, by using highly detailed disaggregated firm-level trade data, we will consider firm-level characteristics into the framework of studying the trade effect of exchange rate fluctuation.

In this article, by using highly detailed disaggregated firm-level trade data, we will consider firm-level characteristics into the framework of studying the trade effect of exchange rate fluctuation. And we emphasize the direct effects of exchange rate volatility on Chinese food exporters: the unit price of products and trade volume. Specifically, we construct a firm-product-destination trade panel data from 2000 to 2013 by matching Chinese firm-level dataset released by Bureau of Statistics and products-destination trade dataset released by China Costums. To our knowledge, such disaggregated data can help us to investigate the heterogeneous impacts generated by exchange rate volatility on different firms. In a sense, it is a further research on relationship between exchange rate uncertainty and firm-level characters. Besides, discussion on heterogeneity may exist across sub-food industries is also presented in this paper.

Moreover, the majority of the previous literatures focused on developed countries, while few researches concentrate on developing countries. For most developing countries, agricultural trade is considered as an important contributor to their economic growth, poverty alleviation and food security (Reed, 2008; McCorriston & Steve. 2011). In addition, developing countries are facing more serious exchange rate volatility with economic development and reform of the currency system (Easterly et al., 2000; Luis, 2003). Without highly developed financial institutions and protection, Ivan (2008) found a lager negative impact of exchange rate fluctuation on trade in developing countries. Consequently, economic academicians, policy makers, researchers have always raised eyebrows with regards to the impact of exchange rate volatility on agricultural trade (Polodoo et al., 2016). China, as one of the largest exporters of agricultural products, is also with great exchange rate movements during past few decades (Zhang et al.;2017). Therefore, we choose Chinese food firms as representative objectives, to find out how exchange rate volatility affects trade.

The rest of the paper is structure as follows. We first introduce the theoretical framework for our research briefly. And next section is specific empirical analyses, including data description, variable setting and econometric model. Then we will present the result and discuss the heterogeneous impact for different firms. Besides, for robustness checks, alternative measures of performance and size are used to substitute for settled variables. More specific estimations were also applied and the results are still robust. The whole conclusion will come into the last part of this article.

2. The Impact of Exchange Rate Volatility on Trade

The impact of volatility in exchange rate has been lively debated both in theoretical and empirical literatures. (Hooper and Kohlhagen, 1978; Pere and Steinherr 1989; Arize,1998; Cho. et al., 2002; Clark et al., 2004; Donald et al.,2005; Ivan 2008) In the vast literatures, there is still no consensus on either the direction or the size of the relationship between exchange rate volatility and trade. Exchange rate volatility affects trade directly through uncertainty and adjustment costs, and it also has effects on the structure of output, investment and government policy (Cote, 1994). In this paper, we emphasize the direct effects, specifically in trade price and trade volumes.

First, the effect of exchange rate volatility on trade prices is ambiguous. The theoretical argument is as follows: An increase in exchange rate risk will lead to a reduction in trade prices if importers bear the risk. The price will fall as import demand falls. However, if exporters bear the risk, the price will rise as exporters will charge an increasingly higher risk premium. An increase in exchange rate volatility may also have a secondary effect on trade prices, reducing the pass-through of changes in competitiveness (Cote, 1994). Empirical research presents that, exchange risk always has a negative effect on export prices for the United States, suggesting that buyers of U.S. products absorb the risk (Mann,1989; Feenstr and Kendall, 1991).

Besides, there is also no clear-cut relationship between exchange rate volatility and trade flows both in theoretical and empirical literatures. The volatility can negatively influence trade in several ways. Firstly, at the level of firms, researchers motivate the negatively hypothesis indicating that exchange rate uncertainty will inevitably depress the volume of international trade by increasing the riskiness of trading activity in the perspective of exporters (Clark, 1973). Several empirical research showed that even the hedging measures cannot be perfect to avoid the potential revenue risks, particularly for smaller firms in developing countries (Wei,1999; Arize et al.,2000; Sauer and Bohara, 2001). Secondly, an increase in exchange rate volatility increases the variance of profits and shifts the demand curve downwards, leading to a decline in quantity and prices (Hooper and Kohlhagen, 1978). Third, exchange rate volatility deters industries from engaging in international trade and compromises progress in trade negotiations (Cote, 1994).

Contrarily, some empirical findings showed that with operating real options inherent in such an uncertain environment, the volatility of trade flows may have positive impacts upon exporters and importers' decision-making processes. some researchers documented a positive trade flow effect stemming from a volatile exchange rate for dominance of income effects over substitution effects. (Grauwe, 1988; Klein, 1990; Jozsef, 2011). With a strong possibility in exchange rate volatility, it is more likely to increase trade flows and gain unexpected revenue. The value of the option increases when the variability of the exchange rate increases (Arize et al.2008).

Arguably, Bacchetta and van Wincoop (2000) stated that the theoretical results are heterogonous by plausible alternative assumptions and modeling strategies. From an empirical perspective, choices of sample period, forms of proxies for exchange rate volatility, and countries considered (developed versus developing) may cause difficulty in arriving at consistent conclusions. For example, one common argument is that short-run exchange rate volatility can be mitigated through financial markets, such as hedging and credit opportunities. While in the long-term uncertainty, it is hard and costly to hedge against "sustained misalignment" (Peree and Steinherr, 1989; McCorriston, 2002). That is, short-term exchange rate volatility may not significantly affect trades while long-run changes in exchange rate is more likely to influence trade. In developing countries, agriculture is not a notably competitive sector with less hedging instruments than that in developed countries, which could result in different conclusion as well (Frankel, 1993; Calvo and Reinhart, 2001; Kim and Koo, 2002).

While the existing work is largely based on aggregate data, some literatures have indicated that the effect of exchange rate volatility depends on the nature of firm. How heterogeneous characters in firm-level lead to different impacts still needs to be answered.

3. Empirical Analyses

3.1 Data Source

In this paper, we do the empirical research mainly by using a large and comprehensive micro-database of Chinese agro-food sector coming from following sources:

1 The China Customs database for firm-level trade data, which contains detailed international exports and imports information with specific month and destination, also the volume and value are attached. Each commodity is defined with 8-digit number (Harmonized System). This customs database is developed by CEPII, containing the trade information over the period 2000-2013, with 182 reporters, 253 countries and regions, and product categories at six-level HS code. Besides that, this database contains some information of each firm, such as the location and accurate selected customhouse. With the volume and value of every deal, unit price could be easily calculated as the ratio of them.

2 The dataset of specific firm-level information in this study is from the Annual Industrial Survey (AIS) collected by the China National Bureau of Statistics at annual frequency. The firms which achieve over 5 million RMB gross product would be listed on this dataset, and the total export volume has taken up 98% of whole Chinese export volume (Chinese Commerce Ministry). There are large amounts information for every firm, such as name, corporate ID, location, Chinese Standard Industry Classification Code (4-digit CSIC), and abundant financial information. which we use to estimate total factor productivity, labor productivity and construct other significant firm-level vector of control variables. Up to now, it is one of most accurate and widely applied to many empirical study. (Brandt et al. 2012; Jeon et al. 2013; Song et al. 2011; Yu et al. 2013)

3 Besides microdata, we derive macroeconomic variables applied in this article from the Penn World Table（PWT）for exchange-rate number, the International Financial

Statistics (IMF) and the World Bank for other important global macroeconomic data.

Then, we match customs and AIS so that we could get a new dataset, for exporters. The merging process is a tough task. For example, the length of firm codes in customs data is 10 digits, while in AIS firm data is 9, and they are under two utterly different coding rulers. To obtain trade flows by firm, product, destinations, value and firm-level characteristics, we matched them by their names. Those which with same names in the same year would be identified one unified company. Time variable is s subsidiary variable in the process of matching, because they may change their name in different year or some new firm inherited the name of the old one. We apply this matching method of Yu (2013). To solve the collecting error and deal with unreliable or missing sample information of the AIS firm-level database, we use the data coordinating method drawing on the experience of previous research (Jefferson et al., 2008; Cai and Liu, 2009; Levinsohn and Petrin, 2003).

In terms of the classification standard from AIS firm database, the definition of general food industry could be defined into three specific sub-industries: the agro-food processing industry, the food manufacturing industry, and the beverages and alcohol industry (2-digit CSIC code 13,14,15 in sequence) (Jin and Guo, 2017). Concretely, using the two fundamental database, we have constructed a data panel for bilateral trade with a significant presence in international markets for the period 2000 to 2013.

Table 1 and 2 present the statistical result of matched sample in this article. In each transaction, not only firm-level characters such as input, output, employees and other information of that year, but also trade issues, like product name, class, value, quantity and population, real GDP in export destination country are offered simultaneously.

[Insert Table 1 here]

[Insert Table 2 here]

3.2 Measurements

As for measuring exchange rate uncertainty, while a variety of volatility measures have been used in trade literature, it is still controversial to define which way is most suitable (McKenzie and Michael, 1999; Clark et al, 2004). For example, the standard deviation of the percentage changes or the standard deviation of the first differences in the logarithmic exchange-rate is widely used in early literatures (Cho et al,2001; Sheldon and McCorriston, 2000). ARMA and GARCH model is also well supported in empirical analyses of agricultural trade, and got subsequent development (Engle, 1982; Bollerslev, 1986; Jin et al, 2003; Wang and Christopher, 2007). In this article, the following long-term proxy for uncertainty and misalignment is used. Purée and Steinherr (1989) proposed a reliable measurement to weigh the degree of exchange-rate volatility, which is in consideration of previous uncertainty experience for decision makers. They may note changeable exchange rates with other countries separately of past several years, and based on the highs and lows of previous period, subsequent adjustments for current plan or next year would be made. Cho (2002) used this way to study the effects of long-run exchange rate uncertainty on agricultural trade in America.

$$V_{ij,t} = \frac{max\, X_{ij,t-10}^{t} - min\, X_{ij,t-10}^{t}}{min\, X_{ij,t-10}^{t}} + \left[1 + \frac{\left|X_{ij,t} - X_{ij,t}^{p}\right|}{X_{ij,t}^{p}}\right] \quad (1)$$

Where $\max(\min) X_{ij,t-10}^{t}$ is the maximum or minimum value of the real exchange rate over the last ten years between country i and j. On account of previous experience, the first term is the accumulated movements instead of just exchange-rate variation. Over a medium term period it still does affect the volatility even though there is no difference in the last two or three years. The second part of the equation is the duration and the amplitude of misalignment from "equilibrium" exchange rates, which is more likely to represent recent information. And $X_{ij,t}^{p}$ is the equilibrium number, which can be calculated as the mean of exchange rates over the previous ten years. In constructing exchange rate volatility measure there is a certain amount of arbitrariness involved.

This formula illustrates the exchange-rate volatility at time t, say 2005, depends on real exchange rates in the previous 10 years, range from 1995 to 2004. Lastly, we get $V_{ij,t}$, the volatility index between country i and j in year t for every transaction[1].

In addition, the performance of a firm is presented by its total factor productivity or by its labor productivity, while the number of employee is a proxy for size of the firm. we computed TFP by using Olley and Pakes (1996) semi-parametric approach. To conserve space, neither theoretical details nor computational process on this implement. One of our purpose is to find out the heterogeneous features among 2-digit food industries, therefore, the TFP of each 2-digit industry would be estimated independently[2]. Meanwhile, real exchange rate must have been documented accurately. Here we use real exchange rate instead of open nominal real exchange rate[3].

Figure 1 and 2 display the real exchange rate and exchange-rate volatility between Chinese current (CNY) and some important currencies (AUD, EUR, GBP, JPY, USD and KRW) which can be charged more than 70% trading value of Chinese exporters. Although the RMB/U.S. dollar nominal exchange rate has not changed much during 1994 to 2005(rigid pegging period), there still have been substantial variation across different destinations along the years. It is obviously showed the exchange rate against other currencies have been remarkably changing all the time(Fig.1). Figure 2 shows that high level of volatility among currencies is intuitive without exceptions. Nearly all curves are above 1.6, which showed great fluctuation in comparison with others. In former literature, which used the same measurement, presented an average volatility at

---

[1] In a sense, this statistic is not accurate for some dealers from small and unsteady countries, we use US dollars instead of their domestic currencies.

[2] Olley and Pakes (1996) semi-parametric methodology has been widely used in previous literature (Mayer et al.,2011; Bernard et al.,2011; Arkolakis and Muendler, 2011). In the process of calculation, we used firms' gross output value for output(Y), fixed assets for capital(K), number of employees for labor(L) and intermediate inputs for raw material inputs. Following Yu (2011) and Amiti and Konings(2007), all proxies have been deflated. After all the preparations have been done, the OP methodology worked to estimate parameters of each 2-digit food industries.

[3] We calculate real exchange rate between China and other destination country using the method following the convention: $RER_{ct} = NER_{ct} \cdot \frac{CPI_{ct}}{CPI_{CHN,t}}$. Where consumer price indices (CPI) index is from the International Financial Statistic(IFS) and original bilateral nominal exchange-rate comes from the Penn World Table (PWT). CPI-based real exchange rate is calculated by the nominal exchange-rate multiplying destination country's CPI and dividing by Chinese CPI. After comparing nominal and real exchange rates of all the years, we assure that differences between them cannot be ignored.

the degree under 0.2 of U.S.$/Yen and U.S.$/DM (Cho et al.2002).

Following Table 3 shows descriptive statistics for all variables in the subsequent econometric models. All the information has been provided four samples: Overall food industry, agro-food processing, food manufacturing, and beverages and alcohol. In panel A, we provide the summary statistic of exporting information per firm-destination-year pair including sum quantities and sum value. we regard a firm-destination pair in a year as an observation unit. The unit price, defined as sum value divided by sum quantities, serves as a proxy for the average value of a firm-destination pair. Transaction per firm-destination means the number of concluded deals in each pair. In the three subdivided sectors of food industry, agro-food processing industry exceeds the other two sectors both on values and quantities.

[Insert Figure 1 here]

[Insert Figure 2 here]

The firm information is shown in panel B for firm-destination pair also. The exchange rate volatility, total factor productivity and numbers of employees are exhibited in logarithmic form. Firms in beverages & alcohol industry are with the biggest exchange rate volatility in average and agro-food processing industry is of best performance level in average via TFP index. The last row reports the numbers of firm-destination-year pair. Obviously, agro-food processing sector occupied more than half of the transactions, which is around 56%.

[Insert Table 3 here]

3.3 Econometric Specifications

In this section, we try to find out the heterogeneous influences of exchange rate volatility on unit price and quantities with the discussion by Chinese food firm-level specific data.

3.3.1 Impact of Exchange Rate Volatility on Unit Price

In order to demonstrate the impact of exchange rate volatility on unit price of products in Chinese food industry, we estimate a linear regression model to measure the effects of real exchange rate volatility on producer price. Our benchmark is specified as follows:

$$ln(\tilde{p}_{jtc}) = \alpha_1 \, ln(\varphi_{jt}) + \alpha_2 \, ln(L_{jt}) + \alpha_3 \, ln(RER_{ct}) + \alpha_4 ln(Vola_{ct}) + \mu_{jct} + \varepsilon_{jct} + \Phi_t \quad (2)$$

Where $\tilde{p}_{jtc}$ is the explained variable and donates the unit price of exporter j to trade with destination c in year t. We use firm-destination pair in different years to create a penal data over the period 2000-2013. The number of φ_{jt} represents the productivity for firm j, and L_{jt} is a proxy for the size of firm j. RER_{ct} is the average real exchange rate between China and country c during year t. The most important variable $Vola_{jt}$, is the exchange rate volatility measure of RMB and country c in year t. And in this model, the real exchange rates are assumed to follow an exogenous process. μ_{jct}, a vector of firm characteristics j to destination c in year t, is a firm-destination-year fixed effect to control affect price depends on destinations like trade cost, specific tariff policy or something else. Likely, Φ_t is a time-specific variable and ε_{jct} is a regular error term.

To test how different firms adjust prices to exchange rate fluctuation in more detailed estimation, we interact $\ln(Vola_{ct})$ with $\ln(\varphi_{jt})$ and $\ln(L_{jt})$ respectively, which are the proxies for characters of firms. Note that interaction is meaningful only comparing with average degree, therefore, $\ln(\dot{\varphi}_{jt})$ and $\ln(\dot{L}_{jt})$ have been normalized before regressing. Such that the coefficients on volatility measure represent the effect for a firm with the mean level of TFP and size in the matched sample.

$$Ln(\tilde{p}_{jtc}) = \beta_1 \, ln(\dot{\varphi}_{jt}) + \beta_2 \, ln(\dot{L}_{jt}) + \beta_3 \, ln(RER_{ct}) + \beta_4 ln(Vola_{ct}) + \beta_5 \, ln(\dot{\varphi}_{jt}) \times$$

$$ln(Vola_{ct}) + \beta_6 \, ln(\dot{L}_{jt}) \times ln(Vola_{ct}) + \sigma_{jct} + \varepsilon_{jct} + \Phi_t \quad (3)$$

Where $\tilde{p}_{jtc}$, φ_{jt}, $Vola_{ct}$ have same meanings as in equation(3), and the $\dot{\varphi}_{jt}$, $\dot{L}_{jt}$ are normalized of former corresponding variables.

3.3.2 Impact of Exchange Rate Volatility on Export Volumes

The gravity model has been widely applied in empirical economics on international trade (Cho et al., 2002; Kandilov, 2008; Ivan, 2008; Wang et al., 2010). In its basic form, the gravity model explains bilateral trade flows between countries as depending positively on the product of their GDPs and negatively on their geographical distance from each other. Countries with larger economies tend to trade more in absolute terms, while distance can be viewed as a proxy for transportation costs which act as an impediment to trade. In addition, population is often included as an explanatory variable as an additional measure of country size (see, e.g., Helpman; Clark). This application also fits for specific sectors and firm-level analyses for known to be compatible with theoretical frameworks (Berman et al., 2012). After adding a measure of exchange rate variability to see if this proxy for exchange rate risk has a separate, identifiable effect on trade flows. Mathematically,

$$Trade_{ijt} = \alpha_0 \cdot \frac{(GDP_{ijt})^{\alpha_1} \cdot (Pop_{ijt})^{\alpha_2}}{(Vola_{ijt})^{\alpha_3} \cdot (Dist_{ijt})^{\alpha_4}} \quad (4)$$

Where $Trade_{ijt}$ represents bilateral agricultural export flows between country i and j in year t. GDP_{ijt}, Pop_{ijt}, $Vola_{ijt}$ and $Dist_{ijt}$ are the variables of the GDP, populations , exchange rate volatility of the two currencies and the geographical distance. We define economic mass of the country i in year t as EM_{it}, which also includes multiple variables, such as geographical proximity (if the countries share a border) and cultural proximity (the existence of historical or cultural ties, such as a colonial relationship or a common language).

$$EX_{ijt} = \exp(\beta_0) \cdot \frac{(EM_{it})^{\beta_1} \cdot (EM_{jt})^{\beta_2}}{exp(\beta_3 Vola_{ijt}) \cdot (Dist_{ijt})^{\beta_4}} \cdot {Lang_{ij}}^{\beta_5} \cdot {Border_{ij}}^{\beta_6} \quad (5)$$

Applying logarithms, the functional from of the equation is as follows, which is consistent with Kashi and Kennedy (2013), but in firm level:

$$\ln(EX_{ijt}) = \gamma_0 + \gamma_1 \ln EM_{it} + \gamma_2 \ln EM_{jt} + \gamma_3 Vola_{ijt} + \gamma_3 RER_{ijt} + \varepsilon_{ijt} \quad (6)$$

Where EX_{ijt} is the trade volume of firm-destination pair data in year t, γ_0 is defined as β_0+a_{ij}. a_{ij} is the proxy variable for the firm-country pair fixed effects[4]. In the later regression, the country i is China and the country j is the destination country c. We also use DEM as economic mass of China to replace EM_{it} in Eq. (6).

Then, following the same method to exploite the exchange rate volatility and trade price, we examine the role of firm heterogeneity by adding an interaction term of firm performance with real exchange rate in our empirical specification. In this model, we drop the economic mass variables from the gravity model and use more detailed firm data into it. Therefore, our equation can be seen as a firm-level application of the gravity model known to be similar with most of the existing theoretical framework (Berman et al., 2012).

$$\ln(EX_{ijt}) = \mu_0 + \mu_1 Vola_{ijt} + \mu_1 RER_{ijt} + \mu_3 \ln(\dot{\varphi}_{Jt}) + \mu_4 \ln(\dot{L}_{Jt}) + \mu_5 \ln(\dot{\varphi}_{Jt}) \times \ln(Vola_{jt}) + \mu_6 \ln(\dot{L}_{Jt}) \times \ln(Vola_{jt}) + \varepsilon_{ijt} + \Phi_t \quad (7)$$

Compared to equation (3), we only use agricultural export volume as a substitute for former dependent variable (trade unit price) in equation (7), so that we could apply the same way to explain the results.

---

[4]The time invariant variables, $Dist_{ijt}$, $Lang_{ij}{}^{\beta_5}$, $Border_{ij}{}^{\beta_6}$ are dropped out of the gravity equation by a fixed-effect model. Meanwhile, natural log of an economics mass of a country at time t is equivalent to summation of natural log of GDP and population of the same country at time t.

4. Result and Discussion

In this article, we discuss the impact of exchange rate volatility on international agricultural trade by using the firm-level data from Chinese food exporters through the period year 2000 to 2013. Firstly, we divided Chinese food firms into three sub-industries by 2-digit industries of CSIC classification standard: Agro-food processing (code 13), food manufacturing (code 14) and beverages & alcohol (code 15). Then we respectively study the impact on trade prices and volumes. In order to investigate the heterogeneity across different industries and different companies, we regress three sub-industries separately and set interaction terms to find out heterogeneous impact on firms with different characters.

4.1 Unit Price

Table 4 shows the results of the relationship between exchange rate volatility and unit price of Chinese food exporters. To begin with, we do a baseline regression to get an intuitive sense of how exchange rate volatility affects food firms trade, with only measures of volatility and exchange rate value as independent variables. Firm-year dummy variables and Firm specific fixed effects has been considered also. Column (1) shows a negative effect of both exchange rate volatility and real exchange rate on trade unit value significantly. Besides, we regress overall food industry and each sub-industry separately of Eq. (2). Fixed effects model and random effects model are all estimated respectively. For each regression, Hausman statistics for testing the random against fixed effects model were significant at the 1% level, therefore in all reported estimates we decided to choose fixed effects model instead of random effects model. In overall food industry level, column (2) and (3) indicates that both total factor productivity (TFP) and firm size (L), which present performance and size of a firm, have positive effect on unit value. Firms with higher productivity or larger scale could have higher unit goods price than those with relatively lower productivity or smaller size. In consistent with baseline regression, the effect of exchange rate volatility on unit price is negative and statistically significant at the 1% level: following a 10% exchange rate volatility increase, the average unit export price decrease by 0.24%.

In column (4), (5) and (6), we do the regression for three times in three different sub-industries of food industry, exporters are found to decrease their price significantly following an exchange rate volatility in all samples. Specifically, the coefficient represents that a 10% increase in the exchange rate volatility measures are associated with 0.26%, 0.17% and 0.35% decrease in their unit prices significantly at the 1 percent level. The estimated coefficient on the exchange rate volatility in table 4 has indicated the heterogeneity in different sub-industries. By comparing the three coefficients, it turns out that the exchange rate volatility has the most negative impact on unit value in beverage and alcohol industry. Based on the results and former theoretical analysis, we would assume that it is the importers who bear the exchange rate risks while have transactions with Chinese food firms. As the import demand falls, thereupon prices decline.

[Insert Table 4 here]

According to Eq. (3), by adding interaction terms of characters of firms and volatility measures, we provide a quantitative assessment on how within-firm characters affects the relationship of exchange rates volatility and unit prices. For convenience of interpretation, the variable of firms' characters: ln(TFP) and ln(L) has been normalized. And fixed effects model was more appropriate in this estimation after tests.

Column (1) indicates in overall food firms sample, the interaction term between the exchange rate fluctuation and TFP is systematically negative and significant at the 1 % level. That means higher TFP strength the negative impact of exchange rate volatility on export price, and it is also proved in food manufacturing industry (column 4). On the contrary, the interaction term between the exchange rate volatility and ln (L), which is a proxy for size, is positive and significant in both overall sample columns and sub-industrial sample columns at the same 1% level. In overall sample, while the size variable weakens the negative impact of exchange rate volatility on unit value, the TFP variable aggravates the negative impacts. Specifically, the results in column (1) presents the change of impact on the unit trade price following a one standard deviation increase in ln (TFP) and ln (L) (from the mean TFP level and L level). With one standard deviation increase in ln (TFP), 10% increasing in exchange rate volatility would lead the unit price decrease goes from 0.32% to 0.40%. However, if ln (L) increases one standard deviation, 10% increasing in exchange rate volatility would lead the unit price decrease goes from 0.32% to -0.21%.

It can be easily explained that firms with bigger size would have more endurance to uncertainty of international market. The risk of exchange rate volatility has been minimized and dispersed the whole business process, not just in pricing. As higher TFP resulting in more negative impact of volatility risk, one possible reason is that only those with high performance have the capacity to decrease its price to be more competitive in the world trade. With the assumption in Eq. (1), it is the importers who likely bear majority of exchange rate risk while transacting business with Chinese food firms. In the perspective of buyers (destination country), the exchange rate fluctuation is same problem as the exporters. They have to choose the products with lower price or better quality to offset the venture of price-setting currencies. Under this circumstance, only firms of better performance can complete the deals as usual by lower price and better quality. Contrarily, existing firms with low TFP would have to stick their prices and lose market share during period of serious exchange rate volatility. On account of only completed deals could be observed, we get the conclusion that higher TFP leads to greater unit price decreasing and bigger size causes smaller effect.

[Insert Table 5 here]

4.2 Trade Volume

Regarding trade volume in Table 6, Chinese food firms are found to decrease their exporting volumes significantly following an increasing exchange rate volatility. Column (1) presents the baseline estimation. In overall food industry, exchange rate volatility has a significant and negative impact on trade flows. Column (2), (3) and (4) offers estimations of fixed effects model, random effects model and OLS model on gravity model in Eq. (6). After Hausman test, fixed model seems the most suitable, so as to sub-industries results in right part of Table 6. In column (2), a 10% increment in exchange rate volatility decreases agricultural exports volumes by approximately 0.09% at the 5% level. In all, the result is consistent with most of the recent researches, where they found a significant negative effect of exchange rate volatility on export flows. (Ivan, 2008; Cho et al., 2002).

From estimations of sub-industries in column (5), (6) and (7), the coefficients of volatility variables are negative but significant, except for agro-processing industry. Possible reason is that agro-food industry is with rigid demand to importers. As a result, trade flow is hard to reduce despite the exchange rate uncertainty in world market. While other sub-industries are still facing risk and the demand curve downwards, leading to a decline in quantities.

[Insert Table 6 here]

By using the same strategy as above, interaction terms are included in Eq. (7). Here, in overall food industry (column 1), interaction term of ln (TFP) and volatility measure has positive coefficient while ln (L) and volatility measures interaction term shows negative coefficient. Interestingly, that is completely opposite from results in 4.2. If ln (TFP) increases one standard deviation, 10% increasing in exchange rate volatility would lead the trade flows goes from decreasing 0.13% to increasing 0.01%. The increase of TFP would weaken the negative impact on trade volumes. It can be also explained based on the discussions of unit value. Firms of higher performance have the capacity to reduce the price as the response to serious exchange rate volatility, which may lead to take up relatively more market share from those firms with low TFP, produce more goods as much as possible and achieve higher profit. However, bigger firms would decline their exporting volumes in a larger ratio than small firms. Here we infer that bigger firms may be affected by this volatility to a larger extent if they had occupied majority of market share before.

[Insert Table 7 here]

4.3 Robustness Check

After the analyses of the empirical results, we need proceed to different sets of robustness checks. First, we test how robust our main result by more specific estimation. Second, alternative measures of performance and size are used to check the robustness of the results.

Considering the heterogeneity of firms is the central discussion of our research, a further consideration that have been addressed below. We divide samples to three sub-samples group by tri-sectional quantile of TFP and L separately: Low, Median and High level of characters, which belonging to 0-33%, 34%-66% and 67%-100% interval of the whole sample. Then we apply the same econometric model as Eq. (3) and (7), estimate each sub-sample and try to find out the relationship between exchange rate volatility and trade with discussion based different firms.

Table 8 shows the impact of Exchange Rate Volatility on trade by TFP quantile regression. Column (2) and (3) presents estimation on sub-samples group where firms with low and median level of TFP. The coefficient of exchange rate volatility variable in low group is smaller than median group by comparing absolute value. Both of them is negative and significant. Meanwhile, thought the interaction term coefficient in low and median group is not significant, the absolute value in full sample is 0.008, which is smaller than that in high TFP group and both of them is significant at the 1% level in column (1) and (4). In a sense, the result is consistent with discussion above, higher TFP would strengthen the negative impact of exchange rate volatility on trade price. In table 9, the results of exchange rate volatility affecting trade by L quantile regression have been presented. As the discussion of unit price, by comparing the significant coefficients of full sample and low L group in column (1) and (2), we conclude that bigger firms would weaken the negative impact of volatility on trade volume.

As for second robustness test, specifically, labor productivity[5] would be used as a

[5] Here, labor productivity is computed as the ratio of value added per worker.

performance indicator for total factor productivity. Total assert is a substitute for the number of employees to represent size of the firm. In table 10, all alternative measures keep the same positive and negative effects as former independent variables.

5. Conclusion

In this article, we study the impact of exchange rate volatility on Chinese food firms trade. We provided a detailed firm-level analysis with large amount of discussion about the heterogeneous impact on firms with different characters. Firms are main participators in the world market. The further investigation from a firm-level perspective is the most contributing improvement in this article. Also, for many developing countries, the relationship between exchange rate volatility and agricultural exporting is worth researching. By constructing highly disaggregated firm-level panel data ranges from 2000 to 2013, we find that exchange rate volatility has significant negative impact on trade prices and quantities. Further, the results also suggest the heterogeneity of firms (TFP and size) may reinforce or weaken the impact of this volatility.

According to our estimation, exchange rate volatility has a significant negative impact on trade price, which indicates that it is the importers that take majority of risks during transaction of Chinese food products. Among our samples, the exchange rate volatility has a larger negative impact on trade unit price for firms of higher TFP than firms of lower TFP. And bigger firms would help weaken the negative impact of exchange rate volatility. We infer that companies with better performance (high TFP) would have the capacity to reduce price and provide commodities of better quantity to help make the transactions with foreign importers. While those with relatively worse performance (low TFP) cannot bear price decreasing to hedge the risks for importers, so that subsequent deals would be canceled. On account of only completed deals could be observed, we get the conclusion that higher TFP leads to greater unit price decreasing and bigger size causes smaller effect.

Interestingly, for trade volume, firm-level characters have reverse and significant effects on the impact of exchange rate fluctuation. The results present smaller negative impact for firms of higher TFP while greater negative influence for firms of bigger size. We conclude that although whole trade quantities fall, better performance would help companies relatively take up more share of existing market. However, bigger firms can disperse the risks to avoid violent prices decreasing, but would face lager ratio in trade volumes decreasing.

Tables and Figures

Table 1. Matching results in period 2000-2013. (T=14 years)

Year	Transaction	Observations	Exports(U.S.$/Billion)
2000	33202	3566	2.680
2001	51448	5064	3.816
2002	58102	6512	4.289
2003	76525	9454	5.531
2004	105698	13228	6.959
2005	118639	14801	9.741
2006	129029	16597	11.445
2007	36272	18632	13.524
2008	41105	22341	17.580
2009	37219	19433	15.117
2010	28208	15048	14.250
2011	36834	17994	18.744
2012	57893	25959	31.221
2013	52843	27154	33.815
Sum	863017	215783	188.713

Note: The last column: Exports represents the overall export value in the sample, which is deflated using Chinese Consumer Price Index, announced by NBS.

Source: China Customs Database and Chinese Annual Industrial Survey (AIS)

Transaction: A deal is considered firm-destination-year-product-lever pair.

Observations: A number is considered firm-destination-year-level pair. (Merging different deals of same firm and destination in the same year as one number.)

Table 2. Matching results of rubdivided Chinese food industry. (T=14 years)

CSIC code	Transaction	Observations	Firms
(13) Agro-food processing Industry	532830	120126	47272
(14) Food manufacturing Industry	278035	80373	33896
(15) Beverages & Alcohol Industry	52152	15284	6133
Overall	863017	215783	85108

Note: Two-digit CSIC code correspondence from AIS firm database.

Source: Chinese Customs Database and Chinese Annual Industrial Survey (AIS)

Firms: A firm is considered to be a firm-destination pair. (The observation in different years is regards to be the same firm.)

Table 3. Descriptive of firm-destination level detailed information.

Variable	13-15 Overall Food Industry				13 Agro-food processing Industry				14 Food Manufacturing Industry				15 Beverages & Alcohol Industry			
	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max	Mean	Std.Dev	Min	Max
# Exporting Information																
Sum Quantity	537152	2851838	1.000	2.69e+8	613606	3243753	1.000	2.69e+8	371355	1835940	1.000	1.74e+8	808115	3759973	1.000	1.24e+8
Sum Value	874551	3363674	1.000	2.92e+8	1092853	3968572	1.000	2.92e+8	552230	1955910	1.000	7.99e+7	853750	3862079	1.000	1.40e+8
Unit price	427	129410	9.47e-6	5.97e+7	613.812	172926	0.0001	5.97e+7	219.118	16343.0	9.47e-6	3441985	47.663	2056.67	0.00001	150000
Transaction per firm-destination	3.999	9.255	1.000	411.000	4.435	10.433	1.000	344.000	3.459	7.682	1.000	411.000	3.412	6.334	1.000	254.000
# Firm Information																
ln Volatility	0.388	1.203	-8.123	21.292	0.384	1.164	-8.125	17.978	0.383	1.241	-8.125	21.292	0.440	1.299	-8.1252	17.9777
ln TFP	0.860	0.355	-5.865	8.443	0.920	0.334	-5.865	7.007	0.791	0.354	-2.789	8.443	0.753	0.424	-3.1970	6.1736
Labor	417.394	830.000	10.000	55378	376.494	807.446	10.000	55378	459.163	840.050	10.000	21000	519.202	926.470	10.000	10945.000
N	215783				120126 (56%)				80373 (37%)				15284 (7%)			

Note: All variables are measured in overall food industry and three subdivided industries separately.

N represents the number of observations of different sub-industries in the last row, and the percentage in brackets is the sample ratio of each sub-industry.

Sources: Original data is from Annual Industrial Survey and China Customs, and measurements are calculated by author.

Table 4. Exchange rate volatility and unit price of food firms

	Overall Food Industry			**Sub-industries**		
	(1)	(2)	(3)	(4)	(5)	(6)
	Baseline	FE	RE	Agro-food Processing	Food Manufacturing	Beverages & Alcohol
Ln(Volatility)	-0.0261***	-0.0239***	-0.0410***	-0.0257***	-0.0177***	-0.0346***
	(0.00203)	(0.00204)	(0.00181)	(0.00265)	(0.00356)	(0.00687)
Ln(RER)	-0.844***	-0.820***	0.0151***	-1.021***	-0.566***	-0.337***
	(0.0167)	(0.0168)	(0.00154)	(0.0214)	(0.0313)	(0.0517)
		(0.00676)	(0.00608)	(0.00883)	(0.0120)	(0.0206)
Ln(L)	-	0.0311***	0.0249***	0.0293***	0.0291***	0.0439***
（size）		(0.00312)	(0.00242)	(0.00380)	(0.00601)	(0.0110)
Constant	0.594***	0.416***	0.535***	0.381***	0.525***	0.113*
	(0.00305)	(0.0179)	(0.0147)	(0.0219)	(0.0348)	(0.0620)
Observations	215,783	215,783	215,783	120,126	80,373	15,284
R-squared	0.021	0.022		0.037	0.009	0.012
Number of id	85,108	85,108	85,108	47,272	33,896	6,133
Firm FE	YES	YES		YES	YES	YES
Year FE	YES	YES		YES	YES	YES

***Notes*:** The dependent variable is logarithm average unit price, which is calculated by trade quantity divides trade sum value. The exchange rate, exchange rate volatility measures and fixed effects are included in column (1) as a baseline regression. Robust standard errors adjusted for clustering at the firm-level are reported in parentheses. *, **, ***indicate significance at the ten, five and one percent levels, respectively.

Table 5. Exchange rate volatility and unit price of food industry with the heterogeneity of firms

	Overall Food Industry		**Sub-industries**		
	(1)	(2)	(3)	(4)	(5)
	FE	RE	Agro-food Processing	Food Manufacturing	Beverages & Alcohol
Ln(Volatility)	-0.0323***	-0.0507***	-0.0298***	-0.0380***	-0.0377***
	(0.00256)	(0.00217)	(0.00319)	(0.00523)	(0.00865)
Ln(RER)	-0.817***	0.0148***	-1.021***	-0.563***	-0.328***
	(0.0168)	(0.00154)	(0.0214)	(0.0313)	(0.0518)
S.d(lnTFP)	0.00986***	0.0247***	0.0129***	0.00545	0.0167**
	(0.00265)	(0.00236)	(0.00352)	(0.00474)	(0.00791)
S.d(lnL)	0.0316***	0.0222***	0.0318***	0.0263***	0.0458***
	(0.00390)	(0.00305)	(0.00476)	(0.00754)	(0.0135)
Ln(Vola)*S.d(lnTFP)	-0.00770***	-0.00591**	0.00158	-0.0208***	0.0124
	(0.00269)	(0.00232)	(0.00393)	(0.00461)	(0.00853)
Ln(Vola)*S.d(lnL)	0.0134***	0.0177***	0.00819**	0.0187***	0.0160**
	(0.00271)	(0.00229)	(0.00360)	(0.00500)	(0.00769)
Constant	0.601***	0.726***	0.572***	0.681***	0.401***
	(0.00316)	(0.00439)	(0.00422)	(0.00569)	(0.00993)
Observations	215,783	215,783	120,126	80,373	15,284
R-squared	0.022		0.037	0.010	0.013
Number of id	85,108	85,108	47,272	33,896	6,133
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES
Quantification: change in the effect of exchange rate volatility (%), for					
Mean lnTFP→ Mean+s.dlnTFP	-0.32%→ -0.40%	-	Not Significant	-0.38%→ -0.59%	Not Significant
Mean lnL→ Mean+s.dlnL	-0.32%→ -0.21%	-	-0.30%→ -0.22%	-0.38%→ -0.17%	-0.38%→ -0.22%

Note: The changes of unit prices by the exchange rate volatility, TFP and L has been shown in last two rows. Robust standard errors adjusted for clustering at the firm-level are reported in parentheses. *, **, ***indicate significance at the ten, five and one percent levels, respectively.

Table 6. Exchange rate volatility and export volumes of food industry using gravity model

	Overall Food Industry				**Sub-industries**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Baseline	FE	RE	OLS	Agro-food Processing	Food Manufacturing	Beverages & Alcohol
Ln(Volatility)	-0.0139***	-0.00852**	-0.0148***	0.00369	0.00483	-0.0233***	-0.0235*
	(0.00347)	(0.00349)	(0.00310)	(0.00447)	(0.00493)	(0.00533)	(0.0130)
Ln(RER)	0.320***	0.132***	-0.0558***	-0.0731***	0.183***	0.0305	0.105
	(0.0308)	(0.0281)	(0.00290)	(0.00192)	(0.0388)	(0.0457)	(0.0949)
LnEM	-	0.598***	0.111***	0.147***	0.474***	0.699***	0.642***
		(0.0248)	(0.00272)	(0.00179)	(0.0375)	(0.0369)	(0.0800)
LnDEM	-	0.207***	0.284***	0.158***	0.122**	0.349***	0.0913
		(0.0409)	(0.0365)	(0.0520)	(0.0588)	(0.0666)	(0.128)
Constant	-59.68***	-4.129***	1.848**	4.693***	0.185	-9.427***	-1.803
	(3.170)	(1.001)	(0.869)	(1.237)	(1.461)	(1.608)	(3.114)
Observations	208,797	208,797	208,797	208,797	116,903	77,280	14,614
R-squared	0.004	0.006		0.040	0.003	0.011	0.010
Number of id	81,435	81,435	81,435	-	45,486	32,294	5,811
Firm FE	YES	YES	YES	-	YES	YES	YES
Year FE	YES	YES	YES		YES	YES	YES

Note: The dependent variable is logarithm trade quantity. LnEM and LnDEM are natural log of economic mass of destination country and domestic country (China). The exchange rate, exchange rate volatility measures and fixed effects are included in (1) as a baseline regression. Robust standard errors adjusted for clustering at the firm-level are reported in parentheses. *, **, ***indicate significance at the ten, five and one percent levels, respectively.

Table 7. Exchange rate volatility and export volumes of food industry with the heterogeneity of firms

	Overall Food Industry		**Sub-industries**		
	(1)	(2)	(3)	(4)	(5)
	FE	RE	Agro-food Processing	Food Manufacturing	Beverages & Alcohol
Ln(Volatility)	-0.0126***	-0.0507***	0.00302	-0.0284***	-0.0441***
	(0.00419)	(0.00217)	(0.00571)	(0.00747)	(0.0154)
Ln(RER)	0.0796***	0.0148***	0.176***	-0.0411	-0.0503
	(0.0276)	(0.00154)	(0.0383)	(0.0447)	(0.0923)
S.d(lntfp)	0.0199***	0.0247***	0.0317***	0.0128*	0.00847
	(0.00435)	(0.00236)	(0.00630)	(0.00677)	(0.0141)
S.d(lnL)	0.102***	0.0222***	0.0913***	0.137***	0.00759
	(0.00639)	(0.00305)	(0.00851)	(0.0108)	(0.0241)
Ln(Vola)*Sd(lntfp)	0.0140***	-0.00591**	0.00725	0.0101	0.00136
	(0.00440)	(0.00232)	(0.00704)	(0.00657)	(0.0152)
Ln(Vola)*Sd(lnL)	-0.0179***	0.0177***	-0.0221***	-0.0101	-0.0206
	(0.00445)	(0.00229)	(0.00644)	(0.00714)	(0.0137)
Constant	10.96***	0.726***	11.26***	10.52***	10.95***
	(0.00518)	(0.00439)	(0.00755)	(0.00811)	(0.0177)
Observations	215,783	215,783	120,126	80,373	15,284
R-squared	0.003		0.002	0.006	0.003
Number of id	85,108	85,108	47,272	33,896	6,133
Firm FE	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES

Overall Food Industry

Quantification: change in the effect of exchange rate volatility (%), for:

Mean lnTFP→	-0.13%→	Mean lnL→	-0.13%→
Mean+s.dlnTFP	0.01%	Mean+s.dlnL -	-0.3%

Note: The changes of trade volumes by the exchange rate volatility, TFP and L has been showed in last row for overall food industry sample. Robust standard errors adjusted for clustering at the firm-level are reported in parentheses. *, **, ***indicate significance at the ten, five and one percent levels, respectively.

Table 8. Impact of exchange rate volatility on trade by quantile regression (Total Factor Productivity)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln(unit price)	**Percentiles of TFP**			**Ln(sum quantity)**	**Percentiles of TFP**		
	Full	0%-33% Low	34-67% Median	67%-100% High	Full	0%-33% Low	34-67% Median	67%-100% High
Ln(Volatility)	-0.0249***	-0.0150**	-0.0267***	-0.00534	-0.0225***	-0.0229**	-0.0155**	-0.039
	(0.00206)	(0.00663)	(0.00434)	(0.00622)	(0.00338)	(0.0109)	(0.00724)	(0.0101)
Ln(L)	0.0312***	0.0235***	0.0487***	0.0136**	0.0795***	0.146***	0.0858***	0.0305***
	(0.00312)	(0.00688)	(0.00651)	(0.00609)	(0.00512)	(0.0113)	(0.0109)	(0.00994)
In(TFP)	0.0287***				0.0547***			
	(0.00747)				(0.0122)			
Ln(Vola)* InTFP(full)	-0.00816***				0.0146***			
	(0.00269)				(0.00440)			
InTFP(Low 0%-33%)		0.0375*				-0.148***		
		(0.0211)				(0.0346)		
Ln(Vola)* InTFP(low)		0.00292				-0.00120		
		(0.00642)				(0.0105)		
InTFP(Low 34%-67%)			0.0941				0.656***	
			(0.0926)				(0.154)	
Ln(Vola)* InTFP(med)			-0.0331				0.0819**	
			(0.0249)				(0.0416)	
InTFP(Low 67%-100%)				0.00229				-0.00773
				(0.0160)				(0.0261)
Ln(Vola)* InTFP(high)				-0.0296***				0.0292**
				(0.00710)				(0.0116)
Constant	0.408***	0.433***	0.212**	0.550***	10.50***	9.954***	10.00***	10.92***
	(0.0181)	(0.0389)	(0.0877)	(0.0370)	(0.0297)	(0.0637)	(0.146)	(0.0603)
Observations	215,783	72,374	71,619	71,790	215,783	72,374	71,619	71,790
Fixed effects	YES	YES	YES	YES	YES	YES	YES	YES

Note: The left part: column (1) - (4), shows the quantile regression on unit price. The right part: column (5) - (8), shows the quantile regression on trade volumes. Robust standard errors adjusted for clustering at the firm-level are reported in parentheses. *, **, ***indicate significance at the ten, five and one percent levels, respectively.

Table 9. Impact of exchange rate volatility on trade by quantile regression (Size)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ln(unit price)	**Percentiles of L**			**Ln(sum quantity)**	**Percentiles of L**		
	Full	0%-33% Low	34-67% Median	67%-100% High	Full	0%-33% Low	34-67% Median	67%-100% High
Ln(Volatility)	-0.0316***	-0.00551	-0.025***	-0.021***	-0.0139***	0.00463	-0.0188**	-0.0137
	(0.00254)	(0.0210)	(0.00480)	(0.00824)	(0.00417)	(0.0280)	(0.00831)	(0.0146)
In(TFP)	0.0186***	0.0408***	0.0409***	-0.0218	0.0726***	0.0871***	0.0967***	0.0745***
	(0.00675)	(0.0146)	(0.0118)	(0.0139)	(0.0111)	(0.0195)	(0.0205)	(0.0246)
Ln(L)	0.0263***				0.0861***			
	(0.00326)				(0.00535)			
Ln(Vola)*InL(full)	0.0136***				-0.0184***			
	(0.00271)				(0.00445)			
InL (Low 0%-33%)		-0.0647***				0.0318*		
		(0.0125)				(0.0167)		
Ln(Vola)*InL(low)		0.0726***				0.0190		
		(0.0192)				(0.0257)		
InL(Low 34%-67%)			0.0382**				0.182***	
			(0.0186)				(0.0321)	
Ln(Vola)*InL(med)			0.0171				-0.000288	
			(0.0180)				(0.0311)	
InL(Low 67%-100%)				0.109***				0.216***
				(0.0115)				(0.0203)
LnVola*InL(high)				0.00115				-0.0172
				(0.00616)				(0.0109)
Constant	0.445***	0.736***	0.409***	-0.0381	10.44***	10.66***	9.858***	9.650***
	(0.0189)	(0.0537)	(0.0998)	(0.0770)	(0.0309)	(0.0717)	(0.173)	(0.136)
Observations	215,783	72,374	71,619	71,790	215,783	72,374	71,619	71,790
Fixed effects	YES	YES	YES	YES	YES	YES	YES	YES

Note: The left part: column (1) - (4), shows the quantile regression on unit price. The right part: column (5) - (8), shows the quantile regression on trade volumes. Robust standard errors adjusted for clustering at the firm-level are reported in parentheses. *, **, ***indicate significance at the ten, five and one percent levels, respectively.

Table 10. Robustness results of alternative measures

	Unit Price			Trade Volume		
	(1)	(2)	(3)	(4)	(5)	(6)
	FE	Labor Prod.	Asset Total	FE	Labor Prod.	Asset Total
Ln(Volatility)	-0.0239***	-0.0142***	-0.0163***	0.0243***	0.0147***	-0.0214***
	(0.00204)	(0.00202)	(0.00202)	(0.00334)	(0.00334)	(0.00334)
Ln(RER)	-0.820***	-0.661***	-0.848***	0.0837***	0.229***	0.0222
	(0.0168)	(0.0169)	(0.0166)	(0.0276)	(0.0278)	(0.0273)
Ln(TFP)	0.0190***		0.102***	0.0720***		0.135***
	(0.00676)		(0.00695)	(0.0111)		(0.0115)
Ln(L)	0.0311***	0.172***		0.0796***	0.217***	
	(0.00312)	(0.00403)		(0.00512)	(0.00666)	
Ln(LP)		0.182***			0.180***	
		(0.00333)			(0.00551)	
Ln(AT)			0.137***			0.118***
			(0.00295)			(0.00487)
Constant	0.416***	-1.429***	(0.00295)	10.48***	8.710***	9.553***
	(0.0179)	(0.0379)	(0.0346)	(0.0294)	(0.0626)	(0.0571)
Observations	215,783	215,678	215,768	215,783	215,678	215,768
R-squared	0.022	0.044	0.037	0.003	0.044	0.037
Number of id	85,108	85,029	85,104	85,108	85,029	85,104
Fix Effect	YES	YES	YES	YES	YES	YES

Note: The left part: column (1) - (3), shows the quantile regression on unit price and the right part: column (4) - (6), shows the quantile regression on trade volumes. Robust standard errors adjusted for clustering at the firm-level are reported in parentheses. *, **, ***indicate significance at the ten, five and one percent levels, respectively.

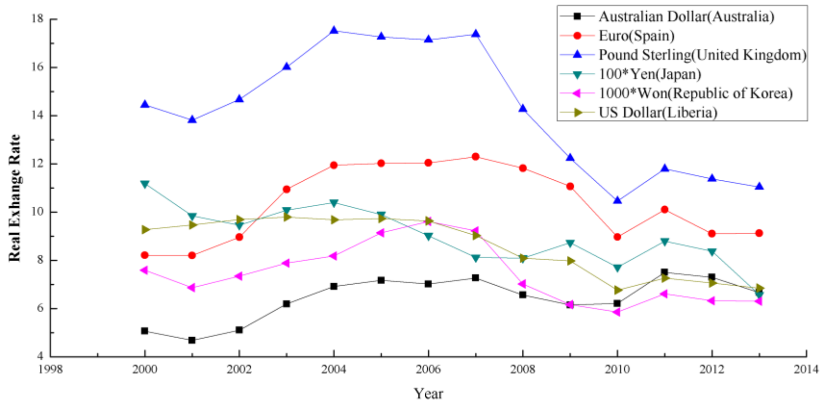

Figure 1: The exchange rate between AUD/CNY， EUR/ CNY， GBP / CNY， JPY/CNY, KRW /CNY and USD/CNY from 1990 to 2014.

Note: JPY(Yen) and KRW(Won) has magnified 100 and 1000 times respectively, so that all previewed exchange-rate can be easily found in same scope.

Source: Penn World Table (PWT, 2017)

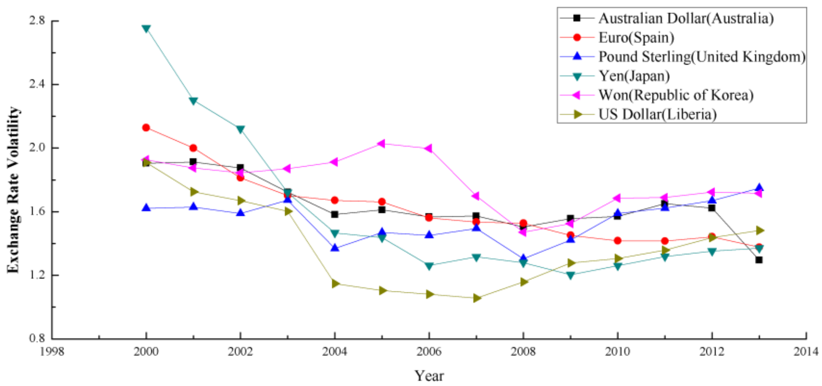

Figure 2. The exchange-rate volatility between AUD/CNY， EUR/ CNY， GBP / CNY， JPY/CNY, KRW /CNY and USD/CNY from 2000 to 2014 using Purée and Steinherr measure method.

Source: Penn World Table (PWT)and World Bank.

References

Anderson, Kym. 2010. Globalization's effects on world agricultural trade, 1960–2050. Philosophical Transactions: Biological Sciences 365 (1554): 3007-21.

Anderson, Kym. 2014. Globalisation and agricultural trade. Australian Economic History Review 54 (3): 285-306.

Arize, Augustine C. 1997. Conditional exchange-rate volatility and the volume of foreign trade: Evidence from seven industrialized countries. Southern Economic Journal 64 (1): 235-54.

Arize, A. C., Osang, T., & Stottje, D. J. 2000. Exchange-rate volatility and foreign trade: Evidence from thirteen LDC's. Journal of Business & Economic Statistics, 18(1), 10-17.

Anderson, Margot, and Philip Garcia. 1989. Exchange rate uncertainty and the demand for U.S. soybeans. American Journal of Agricultural Economics 71 (3): 721-9.

Bacchetta, Philippe, and Eric van Wincoop. 2000. Does exchange-rate stability increase trade and welfare? The American Economic Review 90 (5): 1093-109.

Baum, Christopher F., and Mustafa Caglayan. 2010. On the sensitivity of the volume and volatility of bilateral trade flows to exchange rate uncertainty. Journal of International Money and Finance 29 (1): 79-93.

Berman, Nicolas, Philippe Martin, and Thierry Mayer. 2012. How do different exporters react to exchange rate changes? The Quarterly Journal of Economics 127 (1): 437-92.

Cote A. 1994.Exchange Rate Volatility and Trade[J]. Working Papers.

Cho, Guedae, Ian M. Sheldon, and Steve McCorriston. 2002. Exchange rate uncertainty and agricultural trade. American Journal of Agricultural Economics 84 (4): 931-42.

Clark P, Tamirisa N, Wei S J, et al. 2004. Exchange rate volatility and trade flows-some new evidence[J]. IMF Occasional Paper: 235.

Disdier, Anne-Celia, Lionel Fontagne, and Mondher Mimouni. 2008. The impact of regulations on agricultural trade: Evidence from the SPS and TBT agreements. American Journal of Agricultural Economics 90 (2): 336-50.

Frankel, Jeffrey A. 1987. Expectations and commodity price dynamics: The overshooting model: Reply. American Journal of Agricultural Economics 69 (4): 856-.

Frankel J A, and Wei S J. 1993. Trade blocs and currency blocs NBER Working Paper No.4335.

Grant, Jason H. 2013. Is the growth of regionalism as significant as the headlines suggest? lessons from agricultural trade. Agricultural Economics 44 (1): 93-109.

Hooper, Peter, and Steven W. Kohlhagen. 1978. The effect of exchange rate uncertainty on the prices and volume of international trade. Journal of International Economics 8 (4): 483-511.

Ho, Kin-Yip, Yanlin Shi, and Zhaoyong Zhang. 2017. Does news matter in china's foreign exchange market? chinese RMB volatility and public information arrivals.

International Review of Economics and Finance.
Jing, D. 2008. Does Real Exchange Rate Volatility Affect Sectoral Trade Flows? The University of Sheffield, Department of Economics.
Kandilov, Ivan T. 2008. The effects of exchange rate volatility on agricultural trade. American Journal of Agricultural Economics 90 (4): 1028-43.
Kafle, Kashi, and P. Lynn Kennedy. 2013. exchange rate volatility and agricultural trade flows: The case of the united states and oecd countries. Journal of International Agricultural Trade and Development 9 (2): 211.
Kim, M., & Koo, W. W. (2002). How Differently Do the Agricultural and Industrial Sectors Respond to Exchange Rate Fluctuation? Fargo, ND: Center for Agricultural Policy and Trade Studies, Department of Agribusiness and Applied Economics, North Dakota State University.
Langley, Suchada V., Marcelo Giugale, William H. Meyers, and Charles Hallahan. 2000. International financial volatility and agricultural commodity trade: A primer. American Journal of Agricultural Economics 82 (3): 695-700.
Langley, Suchada V., Marcelo Giugale, William H. Meyers, and Charles Hallahan. 2000. International financial volatility and agricultural commodity trade: A primer. American Journal of Agricultural Economics 82 (3): 695-700.
Melitz, M.J. 2003, The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity", Econometrica, vol. 71, no. 6, pp. 1695-1725.
McCorriston, Steve. 2011. Competition, agricultural trade reform and developing countries. Margin: The Journal of Applied Economic Research 5 (1): 31-46.
Miljkovic, Dragan, John M. Marsh, and Gary W. Brester. 2002. Japanese import demand for U.S. beef and pork: Effects on U.S. red meat exports and livestock prices. Journal of Agricultural and Applied Economics 34 (3): 501-12.
Reed, Michael R. 2008. Reforming agricultural trade for developing countries (vol. 1): Key issues for a pro-development outcome of the doha round edited by McCalla, alex F. and john nash. American Journal of Agricultural Economics 90 (3): 859-61.
Perée, Eric, and Alfred Steinherr. 1989. Exchange rate uncertainty and foreign trade. European Economic Review 33 (6): 1241-64.
Polodoo, V., B. Seetanah, and Sannassee R. V. 2016. Exchange rate volatility and manufacturing trade: Evidence from africa. The Journal of Developing Areas 50 (5): 241-56.
Sheldon, I., S. Khadka Mishra, D. Pick, and S. R. Thompson. 2013. Exchange rate uncertainty and US bilateral fresh fruit and fresh vegetable trade: An application of the gravity model. Applied Economics 45 (15): 2067-82.
Servén, Luis. 2003. Real-exchange-rate uncertainty and private investment in LDCS. The Review of Economics and Statistics 85 (1): 212-8.
Wang, Kai-Li, and Christopher B. Barrett. 2007. Estimating the effects of exchange rate volatility on export volumes. Journal of Agricultural and Resource Economics 32 (2): 225-55
Zhang, Xiaoheng, Yingheng Zhou, Xianhui Geng, and Xu Tian. 2017. The intensive and extensive margins of china's agricultural trade: THE DUAL MARGINS OF

CHINA'S AGRICULTURAL TRADE. Canadian Journal of Agricultural Economics/Revue Canadienne d'Agroeconom