# Essays on Exchange Rates and International Trade: Firms, Products, and Value-added Trade

為替と国際貿易に関する研究
— 企業、商品と付加価値貿易 —

A dissertation presented

by

Yizhe Xie (謝毅哲)
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*To My Parents, Family, and Teachers*

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Shujiro Urata Yizhe Xie
Kaoru Nabeshima
Atsushi Kato
Kazuhiko Yokota

# Essays on Exchange Rates and International Trade: Firms, Products, and Value-added Trade

## Abstract

This dissertation consists of three empirical studies that examine the relationship between exchange rates and international trade from three different angles: firms, products, and value-added trade. The research is built upon the abundant literature on exchange rates and trade. The ambiguity of empirical findings and the dynamics of the Asia Pacific Region in international trade motivated me to conduct this comprehensive analysis. The results also have several important policy implications, especially during this time in which the current global trade system faces unprecedented challenges and the exchange rate policy could be used again as an instrument by governments to boost domestic export.

The first essay examines currency appreciation and exporter heterogeneity in ASEAN, which is on track to replicate China's export-driven economic miracle amidst rising Chinese labor costs. The study fills a gap in the literature of exchange rates movements and firm heterogeneity in South East Asia and solves the zero-trade problem often found in trade studies. The results suggest that first, contrary to the macro-picture, exchange rate appreciation does discourage ASEAN companies' exports. Second, firms' responses to

currency appreciation varies. While SMEs and new exporters are more vulnerable to exchange rate movements, exporters can mitigate exchange rate risks through foreign and domestic affiliation, but foreign owners are much more helpful. Third, firms whose exports consist of foreign inputs are less affected by the rise of local currency. Lastly, firms in the service sector are more sensitive to currency appreciation than manufacturers.

The second essay examines the relationship between USD/RMB exchange rates and Chinese exports to the US and the dynamics of Chinese exports in connection with its neighbors from 1989 to 2015 using HS 10-digit commodity data. In addition, to solve the aggregation problem, this essay contributes to the literature by providing a comprehensive look at whether China's rise is a threat or a windfall to the region. Employing the Fixed Effects model with clustering effects, the findings are presented as follows. USD/RMB appreciation discourages Chinese exports to the US. The effect is more pronounced at a product level than at an aggregated level. Second, the impact is heterogeneous by sector, time period, and product category; capital-intensive industries and differentiated goods are more sensitive to changes of exchange rate, and exchange rate effects increased after China's WTO accession and during the 2008 Global Financial Crisis. Third, overall, China is competing with almost all Asian countries in the US market, but China may cooperate with some Asian countries in certain sectors through the global production network. Fourth, although exchange rates affect Chinese exports, US demand is by far the most important determinant.

The third essay studies the impact of exchange rate volatility on value-added trade. A traditional approach using gross trade data to measure and study trade faces challenges and criticisms due to "double counting" and multi-country production chains, and some evidence indicates that the rise of Global Value Chains (GVCs) and Global Production Networks (GPNs) has weakened the link. The literature presents no consensus on the relationship between exchange rate volatility and gross trade, and few to no empirical studies have examined the impact of these variables on value-added trade. To fill the gap, this study empirically re-examines the relationship between exchange rate volatility and trade using new value-added bilateral trade data for 41 countries during 1995~2013 in comparison with the gross trade. The results of using the Poisson Pseudo-Maximum-Likelihood (PPML) method provide several findings. First, exchange rate volatility discourages trade in general, but more significantly for value-added trade. Second, trade costs caused by geographical distance, common language, and border effects between two countries becomes less important in value-added trade. Third, like in gross trade, the empirical results of real exchange and nominal exchange on trade are similar in value-added trades, and companies respond to the volatility of previous years in making export decisions for the current year. Fourth, developed countries face lower exchange rate risks. Last, intra-regional trade is less responsive to exchange rate volatility in East Asia and NAFTA, especially in NAFTA.

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I am always curious and hungry for knowledge, but I never imagined I would do a PhD. Even a master's degree to me was unnecessary. That shows how shallow my understanding of graduate school and economics was when I graduated from college eight years ago. Soon, I am about to end my doctorate journey, but my exploration of the world will continue. Now, I can echo many professors and PhD holders: "*The PhD is difficult, but it offers an invaluable experience in learning and life that you wouldn't trade for anything*".

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## Chapter 1. Introduction

Exchange rate movement and international trade is a classic topic in international economics. It is an extremely important topic because it directly measures the price competitiveness of a country's exports. Since the collapse of the Bretton Woods system, researchers and policymakers have tried to analyze the impact of exchange rate movements (appreciation and depreciation) and volatility on international trade. Most recently, world leaders at the G20 Hangzhou and G7 Ise-Shima summits issued statements regarding this topic, and President Trump's abrupt comments on trade and on the exchange rate policies of China and Japan reignited the exchange rate and trade debate in the policy circle.

The importance of Asia and the ambiguity of empirical findings motivated me to research the relationship between exchange rate movements and trade with a focus on the Asia Pacific region. Many Asian countries rely on exporting to achieve economic growth, and the high dependence on trade and exposure to external markets means the movements of exchange rates are particularly important in Asia. The exchange rate has often been used as a policy tool to boost exports and economic growth. In the vast literature, the effect of exchange rate movements on export volume is mixed. While most theoretical and empirical papers suggest a negative relationship, some have found an opposite result, and some did not find a significant association. Evidence also indicates that the link between exchange rates and trade has been weakened due to the rise of Global Value Chains (GVCs) or Regional Production Networks (RPNs), special features of intra-regional trade in Asia.

## 1.1 Theories of exchange rate volatility and trade

### 1.2.1. Risk-averse firms

One by-product of the breakdown of the Bretton Woods system is the birth of a large number of theories on the impact of exchange rate volatility on international trade. That historical event in the early 1970s signaled the start of a floating exchange rate regime that the world was not familiar with. The immediate concern was that the increased commercial risk and uncertainty associated with exchange rate variability would dampen global trade.

Two influential theoretical papers were produced in 1973 when the Bretton Woods regime officially ended. Despite a different approach, both reached the same conclusion: the increase in exchange rate volatility means more uncertainty of future profits and thus reduces trade flows. In Ethier's (1973) model, an importer makes two decisions: the quantity of goods denominated in an exporter currency to import and how much forward cover to obtain at the time of ordering without knowledge about the future exchange rates, on which the importer's profits depend. In a realistic situation, a representative firm will reduce the level of trade to mitigate the risk exposure in a trade-off between profits and risks. However, such an effect is diminished when the firm is more speculative or has a higher risk profile. The results are consistent regardless of the choice of currency denomination.

Clark (1973) modelled an exporter in a competitive market which produces one homogenous commodity without foreign inputs and sells only to a foreign market. The production is non-stochastic, and the export is paid by foreign currency. In both imperfect and perfect forward scenarios, the firm without the flexibility to change export markets has to make a production decision upfront, and the profits depend on the future exchange rate when the firm sells the goods. The increased uncertainty of future profit linked with higher exchange rate volatility will lead firms to cut their production, hence export less to reduce the profit risk.

### 1.2.2. Different degrees of risk aversion

From the 1970s to the 1990s, many researchers tried to improve the theory by extending the model and removing unrealistic assumptions. Hooper and Kohlhagen (1978) built a model that considers both the import demand and the export supply sides of exchange rate volatility on trade. While allowing for differences in risk-bearing or risk preference between two sides, the refined model made the simultaneous analysis of price and volume of trade possible. The model predicts that the increase of exchange rate risk will clearly reduce trade if traders are risk averse regardless of who bears the risk. Different from earlier studies, Demers (1991) built on Arrow's model and proved that even risk-neutral competitive firms will make cautious investment and production decisions when the future is uncertain. When the forecast of the future becomes more difficult, as in the

case of excessive exchange rate volatility, firms will restrict their investment because the decision is irreversible. Consequently, production and trade are expected to drop.

Some theoretical studies support the positive impact of exchange rate volatility, but generally, the direction of the effect depends on the assumptions. For example, De Grauwe (1988) modelled a competitive firm selling to both domestic and foreign markets with profits that depend on its total sales denominated in local currency. In such a situation, the firm's export performance depends on the degree of risk aversion. Very risk-averse firms will export more to avoid the worst scenario, a drastic drop in their revenue, when exchange rate risks increase, while less risk-averse firms will choose an opposite approach by exporting less. A better way to understand this is to recognize both an income and a substitution effect generated by an increase of risk. When risks are higher, the expected export revenue will decline (income), and the foreign market becomes less attractive (substitution). The fall of export revenue can be offset by expanding the export sector. When the income effects dominate the substitution effects, firms will increase their exports following a surge of exchange rate volatility.

### 1.2.3. Inspiration from finance literature

Franke (1991) investigated the export strategy of a monopolistic firm in an intertemporal and infinite setting when facing exchange rate volatility. In his model, firms will export as soon as the exchange rate permits profitable exports, and vice versa. To firms,

exporting is like a stock option, allowing the firm to profit from price differences between domestic and foreign markets, and the value of the option goes up following increased volatility (risk). Thus, when the exchange rate volatilities increase, some firms grow their exports because the cash flow from exporting is higher than the firms' entry and exit costs. Overall, it depends on the calculation of an optimal export volume after considering exchange rate risks, entry costs, and exit costs. A study by Dixit (1989) implies that higher exchange rate volatility encourages firms towards inertia in entry and exit given the role of "sunk costs" in exporting.

Different from Franke (1991), Sercu (1992) included trade friction terms such as tariffs and transport costs rather than lump-sum entry and exit costs in a small-country and short-term (market term) model. One of the innovations of the paper is that it considers all different market structures: competitive, partial monopoly, and total monopoly. The model predicts that increased exchange rate volatility may on average encourage trade in a competitive and monopolistic market. Rising exchange rate uncertainty increased the probability of a more competitive price, ex post deviations from Commodity Price Parity, that generates benefits above the transaction cost of trade. However, in a duopoly or potential monopoly market, the effect of volatility on trade is ambiguous.

Broll and Eckwert (1999) also found a positive link between exchange rate volatility and trade for firms able to adjust their sales between domestic and foreign markets in response to changes in exchange rates. In their theoretical paper, the authors also treated

exporting like an option and the price of such an option rises when exchange rate uncertainty increases. The economic intuition of the model is that higher volatility increases both potential gain and risks from international trade. These two effects work in opposite directions. Therefore, the net effect on trade rests on the degree of relative risk aversion of the exporter.

Furthermore, employing a conventional asset portfolio model, Dellas and Zilberfarb (1993) proved that the positive effect of exchange rate volatility on trade has a theoretical foundation. In the model, trade decisions are similar to the portfolio-savings decisions and the decisions are made ex ante without knowledge about the future return. Thus, exporting is like a normal risky asset that can yield a higher or lower return. When exchange rate volatility surges, the risk of exporting also goes up. However, whether this increases exporting solely depends on an investor's (firm's) risk appetite. A risk taker (a less risk averse firm) with a belief in "high risk, high return" will invest in the asset (exporting) in the hopes of getting a better return when the exchange rate moves towards favourable territory (no one knows the direction of exchange rate movements).

The availability of financial hedging instruments helps reduce the exchange rate uncertainty. But the differences in access and hedging positions may lead firms to have different export behaviors. Viaene and de Vries (1992) explicitly solved for the forward rate and advanced the theoretical framework in understanding the relationship between exchange rate volatility and trade given a well-developed forward market. Without a

mature forward market enabling perfect hedging, increasing volatility will dampen both exports and imports. However, the effect will change (it can be positive or negative) depending on the aggregate net position of foreign currencies in the country. This is because exporters and importers are on the opposite side in forward markets.

### 1.2.4. Firm heterogeneity and general equilibrium models

The impact of exchange rate movements on trade is heterogeneous among different firms. The IMF (1984) argues that small firms are more sensitive to exchange rate risks than large firms. This is simply because large firms often have many resources such as better risk management and access to financial hedging products, have foreign inputs, and export to more destinations (the diversification effect). Following the "New" new trade theory, research on firm heterogeneity such as productivity became a new trend. Though not directly linked with exchange rate volatility, Berman et al. (2012) examined how different exporters react to exchange rate changes. In their paper, the authors showed that high-performance firms react to depreciation by increasing their mark up much more than their export volume due to a decreasing demand elasticity with firm performance. The fact that a country's exports rest disproportionally on large and highly productive firms implies that exchange rate volatility should not have a major impact on export volume in aggregate trade data.

While most theoretical papers are of partial equilibrium, a few scholars have taken a

step further to build a general equilibrium model. For instance, Kumar (1992) included exchange rate risk in a two-country, two-goods general equilibrium model with scale economies and product differentiation. Based on each one's comparative advantage, the home country exports manufacturing goods while the foreign country exports agricultural goods. An increase in exchange rate volatility resembles that of negative technological change and shifts the supply curve to left. As a result, the comparative advantage in the respective industry is damaged in both countries and intercountry trade volume drops. Another interesting finding is that intra-industry trade may increase. In indirectly related research, Bacchetta and Van Wincoop (2000) developed a two-country, general equilibrium model to compare the level of trade and welfare between fixed and floating exchange rate regimes. In their model, uncertainty arises from monetary, fiscal, and technology shocks. They concluded that the exchange rate arrangements (fixed or floating) do not affect trade.

In short, theories do not offer a conclusive view on the impact of exchange rate movements on trade. The direction can vary depending on the assumptions built into the model. Hence, studying the relationship between exchange rates and trade should be an empirical exercise.

## 1.2 Structure of the dissertation

The main part of the dissertation consists of three empirical studies that examine the

relationship between exchange rates and international trade from three different angles: firms, products, and value-added trade. This study contributes to several spectrums of trade literature by providing a comprehensive review of the relationship between exchange rate movement and trade in the Asia Pacific Region using disaggregated firm-level and HS 10-digit product-level data and novel Trade in Value-added data. The results also have several policy implications especially at this time when trade tension is high.

In **Chapter 2**, entitled *"Exchange Rates and Firm Heterogeneity in Exporting: An Empirical Evidence from the ASEAN"*, I examine firms' heterogeneous responses to local currency appreciation in four ASEAN countries. Many firms in South East Asia see the rising labor costs in China as an opportunity for them to increase their exports. However, the appreciation of local currencies is not in their favour. Nevertheless, the aggregated trade data shows that the region's exports have steady growth despite unfavourable exchange rates. This macro-picture contrasts with what theories predict and might confuse local governments in designing export policies. So, what really happened? Is there a disconnection between currency movements and exports? How do different firms respond to the currency appreciation? To answer these questions, I constructed a firm-level panel data from four ASEAN countries based on the World Bank IFC Enterprise Survey in selected years from 2009 to 2016 and ran a series of econometric regressions. My robust results suggest that overall, firms in the sample were actually discouraged from exporting and they respond differently depending on the size, ownership structure, and export status.

**Chapter 3** "*Exchange Rate, Chinese Exports, and Competition in Asia: Empirical Evidence Using Product-level Data*" studies the relationship between the USD/RMB exchange rates and Chinese exports to the US as well as the dynamics of Chinese exports. The value of RMB is often believed to be instrumental in China's trade relationship with the United States, and the rise of China in global trade has raised many fears in the region and beyond. The worry is valid as China not only expanded its export volume (intensive export margin) but also greatly increased its product variety from 5, 676 in 1989 to 13, 793 different products in 2015 in the US market (extensive export margin). I use a highly disaggregated HS 10-digit product-level data compiled by the US Bureau of the Census to re-examine the issue over 27 years since 1989, which covers most of the period of the Chinese export boom. The results of employing a Fixed Effects model with clustering effects suggest that USD/RMB appreciation negatively affects Chinese exports to the US but the effect varies by sector, product category, and time period. In addition, though some countries may cooperate with China in certain sectors through the global production network, China now is competing with almost all major Asian countries in the US market. Last but not least, the effect of exchange rates on Chinese exports is statistically and economically significant, yet incomparable to the effect of US demand for Chinese exports, especially during the financial crisis.

Last but not least, **Chapter 4** on "*Exchange Rate Volatility, Value-added Trade, and Intra-regional trade in East Asia*" attempts to be the first study, to the best of my knowledge,

to investigate the impact of exchange rate volatility on value-added trade in comparison with gross trade. Increasing numbers of publications suggest that the traditional approach of using gross trade data to measure and study trade may not be accurate due to the "double counting" problem and multi-country production chains. Some findings also indicate that Global Value Chains (GVCs) and Global Production Networks (GPNs) weakened the link between exchange rate volatility and trade. But what is the impact of exchange rate volatility on value-added trade? The impact should be larger because value-added trade directly measures a country's real input and comparative advantage. Using a value-added bilateral trade dataset of 41 countries during 1995~2013, I employ the classic Gravity Model to test the hypothesis. My findings suggest exchange rate volatility discourages trade in general, but more significantly for value-added trade. Value-added trade data also reduced the importance of geographical distance, common language, and border effects. Lastly, developed countries and intra-regional trade are less responsive to exchange rate volatility.

The **Chapter 5** summarizes the findings and concludes the dissertation.

## Chapter 2. Exchange Rates and Firm Heterogeneity in Exporting: Empirical Evidence from the ASEAN

Abstract

This chapter examines currency appreciation and exporter heterogeneity in ASEAN, which is on track to replicate China's export-driven economic miracle amidst rising Chinese labor costs. This study fills a gap in the literature on exchange rate movements and firm heterogeneity in South East Asia and solves the zero-trade problem often found in trade studies. The results suggest that first, contrary to the macro-picture, exchange rate appreciation does discourage ASEAN companies' exports. Second, firms' responses to currency appreciation varies; while SMEs and new exporters are more vulnerable to exchange rate movements, exporters can mitigate exchange rate risks through foreign and domestic affiliations, but foreign owners are much more helpful. Third, firms whose exports consist of foreign inputs are less affected by the rise of local currency. Lastly, firms in the service sector are more sensitive to currency appreciation than manufacturers.

*Keywords: exchange rates, firm heterogeneity, export participation, ASEAN, international trade*
*JEL classification: F14 F31 F40 F10 F15*

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## 2.1 Introduction

The ASEAN (Association of South East Asian Nations) is now in the spotlight at a time when Chinese labor cost is escalating and China's economic growth rate is slowing. The ASEAN consists of ten countries[1] in South East Asia with a total population of 625 million (estimated in 2013), making it the fourth most populous economy with a total nominal GDP of 2.8 trillion USD in 2015, representing the sixth largest economy in the world. In terms of international trade, it is the fourth largest exporting region after the European Union, North America, and China/HK (HV et al., 2014). Moreover, it plays a central role in Asian economic regional integration and regional FTA such as the Trans-Pacific Partnership (TPP), the Regional Comprehensive Economic Partnership (RCEP), and ASEAN+1.

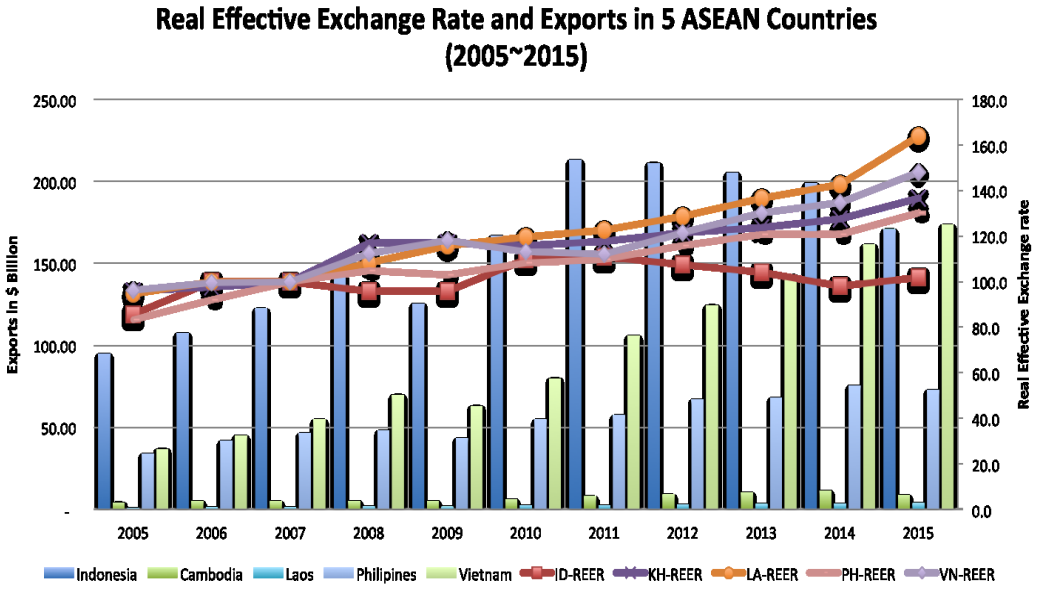
The exchange rate, which measures the relative price competitiveness of a country's exports, has become extremely important at a time when the ASEAN leaders seek to replicate China's economic miracle through export-driven growth. The devaluation of the Chinese RMB is generously believed to be a key reason for the success of Chinese exports (Ahmed, 2009; Aziz and Li, 2007; Cheung et al., 2015). The Chinese evidence is consistent with the conventional view that depreciation or devaluation of a local currency will lead to more exports by making exports more competitive in the international market. Another

[1] The ten ASEAN countries are Indonesia, Malaysia, Singapore, Thailand, Vietnam, Cambodia, Lao, Myanmar, Philippines, and Brunei.

example of this phenomenon is the quick recovery of Europe and Japan after the Second World War which was also largely attributed to the devaluation of their currency (Eichengreen, 2005, 2006). Currency deprecation also hastened economic recovery from the Great Depression of the 1930s (Eichengreen and Sachs, 1985). In fact, exchange rate devaluation is often seen as a tool to boost exports.

Surprisingly, many ASEAN countries seem to defy the common perception as they increased total exports despite a steady appreciation of the Real Effective Exchange Rate (REER) in recent years. As shown in Figure 2.1, five selected ASEAN countries (Indonesia, Philippines, Vietnam, Laos, and Cambodia) saw an upward trend between 2005 and 2015 in their REERs, which indicates that those economies are losing price competitiveness in their exports or increasing export price ceteris paribus assuming a certain level of exchange rate pass-through. Nevertheless, their aggregated exports also expanded during most periods from 2005 to 2015 except in Indonesia, which had some fluctuations.

Figure 2. 1 Real effective exchange rate and total exports in five ASEAN countries (2005-2015)




*Source:* World Bank and think-tank Bruegel

The seemingly true phenomenon and puzzle in exchange rates and trade nexus observed using aggregated data in ASEAN countries can have several implications for policymakers and researchers in the region and beyond. If the observation is true, it means that the link between trade and exchange rates that is taken for granted is no longer the case, at least in the emerging ASEAN region. In other words, the devaluation or depreciation of a local currency cannot be seen as a policy tool or a windfall to exporters and economies that bet on export-driven strategies for economic development.

Therefore, it is meaningful, natural, and timely to ask whether, on a micro-level, ASEAN firms are immune to exchange rate appreciation in export performance and if they are not, what kind of firms are more sensitive to exchange rate movement. Surprisingly, to

the best knowledge of the author, no published paper has addressed this particular phenomenon to date, especially using firm-level data. Previous work on the exchange rate and trade in ASEAN has either focused on exchange rate volatility (Poon, Choong, and Habibullah, 2005; Chit, Rizov, and Willenbockel, 2010), the whole East Asia region (Thorbecke, 2011b), or a single country (Abeysinghe and Yeok, 2010; Siregar and Rajan, 2004). Those who consider the exchange rate level directly often use aggregated country-level data (Liew, Lim, and Hussain,2003; Thorbecke and Smith, 2010).

This study attempts to fill the gap by using firm-level panel data of four ASEAN countries from the World Bank IFC Enterprise Survey in selective years from 2009 – 2016. The presence of the 'zero trade' problem in my dataset, which consists of data for four ASEAN countries (Indonesia, Vietnam, Philippines, and Laos) from the World Bank IFC Enterprise Survey in selective years between 2009 and 2016, prompted me to follow the common practice and choose Poisson-Pseudo-Maximum Likelihood (PPML) as the main estimation method along with the Tobit, the Ad Hoc solution, and the Heckman Two-stage Model in this empirical exercise.

For the baseline econometric analysis, a change of a firm's real export is considered to be a function of the Real Effective Exchange Rate level and volatility in addition to firm characteristics (firm size and labor productivity), controlling for unobserved time-invariant effects of year, country, and sector. Next, I extended the equation by including other firm heterogeneities in the explanatory variable: foreign ownership, internationally recognized

quality certificate, and financial obstacles. Alternative measurements of exchange rates, the Nominal Effective Exchange Rate, the USD-Local currency exchange rate, and data decomposition methods are employed for robustness check. Finally, interaction terms between exchange rate and firm heterogeneities (SMEs, prior export experience, foreign and domestic affiliation, foreign contents in exports) are constructed to analyze how firms with different characteristics respond to exchange rate appreciation.

The findings suggest that first, contrary to the macro-picture, exchange rate appreciation does discourage ASEAN companies' exports, and second, firms' responses to currency appreciation varies. While SMEs and new exporters are more vulnerable to exchange rate movements, exporters can reduce exchange rate risks through a foreign or domestic affiliation (though foreign owners are more helpful). Third, firms whose exports consist of foreign inputs are less affected by the rise of local currency, and lastly, firms in the service sector are more responsive to currency appreciation than manufacturers.

Besides the studies mentioned above that focus on the region, the results presented here are also related to literature in several spectrums. First, this study relates to the literature on firm heterogeneity in export decisions (Melitz, 2003; Bernard and Jensen, 1999 and 2004). Second, the present work is also associated with the literature on exchange rate, sunk cost, and hysteresis in trade (Baldwin and Krugman, 1989; Dixit, 1989; Campa, 2004). Lastly, this study is linked with studies on the exchange rate and trade connection (Leigh et al., 2015; Amiti, Itskhoki and Konings, 2014; Bernini and Tomasi, 2015).

Chapter 2 is structured as follows. The next section introduces the data. Section 3 explains the empirical framework and methodology and Section 4 presents the empirical results. Limitations of the research are acknowledged in Section 5 and the last part discusses the findings and concludes.

## 2.2 Data

The data consist of two parts: the exchange rate and the firm-level trade data in four[2] ASEAN countries. All data sources are familiar to researchers.

To measure each country's exchange rate, I use the Annual Consumer Price Index (CPI)-based Real Effective Exchange Rates (REER) for 178 countries plus the Euro Area Database of Bruegel, an economic think tank in Brussels. The real and nominal effective exchange rates are calculated to measure the real value of a country's currency against a basket of trading partners of the country. The base year is 2007. The dataset[3] has two sub-sets: the broad index considers 172 trading partners and is available from 1995 and the narrow index considers 67 trading partners and is available from 1960. I rely on the monthly CPI REERs database for 165 countries plus the euro area of the Bruegel to calculate exchange rate volatility. Although the World Bank, the Organization for

[2] Four ASEAN countries are Indonesia, Philippines, Vietnam and Lao. The reason to choose these four particular countries in ASEAN is due to data availability.

[3] Bruegel. (2012). Real effective exchange rates for 178 countries: a new database. Retrieved from http://bruegel.org/publications/datasets/real-effective-exchange-rates-for-178-countries-a-new-database/

Economic Co-operation and Development (OECD), and the Bank of International Settlement (BIS) all publish effective exchange rate data, the Bruegel database is the most comprehensive and complete and the only one that contains all four ASEAN countries in the research scope. The rise of REER and NEER means the appreciation of location currency. The local currency to USD currency used for robustness check is downloaded from the website of the International Monetary Fund (IMF).

The firm-level export data is from the well-known World Bank IFC Enterprise Survey database. Every year, the World Bank and its private contractors use stratified random sample methodology to conduct a number of firm-level surveys in selected countries. The database is compiled based on the survey results of numerous face-to-face interviews with business owners, top management, and department managers, mainly in the manufacturing and services sectors. Although many questions may overlap, the surveys use two separate questionnaires for the manufacturing and services industries. The GDP deflator published by the World Bank is used to calculate a firm's real exports.

The main firm-level data are unbalanced panel data. This data set contains four countries (Indonesia, Vietnam, Philippines, and Laos) for selected years between 2009 and 2016. In total, the data set has 5, 032 observations after dropping missing values in key explanatory variables as shown in Table 2.1

Table 2. 1 Observations tabulated by country and year

| Survey Year | Indonesia | Laos | Philippines | Vietnam | Total |
|---|---|---|---|---|---|
| **2009** | 412 | 95 | 319 | 273 | 1, 099 |
| **2012** | 0 | 113 | 0 | 0 | 113 |
| **2015** | 1,312 | 0 | 1, 184 | 965 | 3, 461 |
| **2016** | 0 | 359 | 0 | 0 | 359 |
| **Total** | 1, 724 | 567 | 1, 503 | 1, 238 | 5, 032 |

The survey does not include unit price and quantity of a firm's main products. Though not ideal, the free firm-level data of the World Bank is publicly available and reveals crucial information on firm characteristics and export behavior. Based on the dataset, I can calculate firms' extensive (export participation ratio) and intensive exports (export volume) and obtain information on firm heterogeneity including firm size, labor productivity, and whether the firm has a foreign affiliation, an internationally recognized quality certificate, or obstacles to accessing finance.

As reported in Table 2.2, the descriptive analysis shows that on average, exporters are larger in size measured by the number of employees hired; are more productive; and are more likely to be affiliated with foreign owners, have more internationally recognized quality certificates, and face fewer financial obstacles[4]. In addition, the descriptive analysis also suggests that only a small portion (24.2%) of companies actually engage in exporting, a finding which is consistent with the literature.

[4] The explanatory variable of financial obstacles has less observation because those negative and non-applicable values are excluded.

Table 2. 2 Summary statistics

| Variables | Obs. | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| **Whole** | | | | | |
| Real Export | 5,032 | 9.35E+12 | 1.17E+14 | 0 | 5.12E+15 |
| REER | 5,032 | 116.8197 | 19.08106 | 95.5 | 163.7 |
| REER Vol | 5,032 | 1.825957 | 0.9447247 | 1.021272 | 4.298595 |
| NEER | 5,032 | 91.76524 | 15.70303 | 76.5 | 129.7 |
| NEER Vol | 5,032 | 1.46811 | 0.8955019 | 0.8305811 | 4.053859 |
| USD ER | 5,032 | 9760.7 | 7539.846 | 44.32329 | 21148 |
| Firm Size | 5,032 | 138.4607 | 553.3707 | 1 | 17000 |
| Labor Productivity | 5,032 | 1.68E+09 | 2.68E+10 | 2222.222 | 1.72E+12 |
| Foreign Ownership | 5,032 | 0.1474563 | 0.3545954 | 0 | 1 |
| Quality Certificate | 5,032 | 0.1899841 | 0.3923273 | 0 | 1 |
| Financial Obstacles | 4,877 | 0.9885175 | 1.131559 | 0 | 4 |
| **Exporters** | | | | | |
| Real Export | 1,219 | 3.86E+13 | 2.34E+14 | 7268851 | 5.12E+15 |
| REER | 1,219 | 117.4189 | 16.78604 | 95.5 | 163.7 |
| REER Vol | 1,219 | 1.768429 | 0.9352878 | 1.021272 | 4.298595 |
| NEER | 1,219 | 91.55792 | 14.22824 | 76.5 | 129.7 |
| NEER Vol | 1,219 | 1.427388 | 0.8745037 | 0.8305811 | 4.053859 |
| USD ER | 1,219 | 9796.63 | 8218.27 | 44.32329 | 21148 |
| Firm Size | 1,219 | 322.0541 | 756.2823 | 1 | 9000 |
| Labor Productivity | 1,219 | 2.00E+09 | 9.39E+09 | 3785.714 | 1.27E+11 |
| Foreign Ownership | 1,219 | 0.3798195 | 0.485541 | 0 | 1 |
| Quality Certificate | 1,219 | 0.4019688 | 0.4904969 | 0 | 1 |
| Financial Obstacles | 1,187 | 0.8803707 | 1.086097 | 0 | 4 |
| **Non-exporters** | | | | | |
| Real Export | 3,813 | 0 | 0 | 0 | 0 |
| REER | 3,813 | 116.6281 | 19.75683 | 95.5 | 163.7 |
| REER Vol | 3,813 | 1.844348 | 0.9471066 | 1.021272 | 4.298595 |
| NEER | 3,813 | 91.83152 | 16.14731 | 76.5 | 129.7 |
| NEER Vol | 3,813 | 1.481128 | 0.9018369 | 0.8305811 | 4.053859 |
| USD ER | 3,813 | 9749.213 | 7310.799 | 44.32329 | 21148 |
| Firm Size | 3,813 | 79.76659 | 455.154 | 1 | 17000 |
| Labor Productivity | 3,813 | 1.58E+09 | 3.03E+10 | 2222.222 | 1.72E+12 |
| Foreign Ownership | 3,813 | 0.0731707 | 0.2604507 | 0 | 1 |
| Quality Certificate | 3,813 | 0.1222135 | 0.3275752 | 0 | 1 |
| Financial Obstacles | 3,690 | 1.023306 | 1.143771 | 0 | 4 |

*Note:* firms' exports and labor productivity measured in unit value in local currency; firm size: unit number of employees.

As shown in Tables 2.3-2.5, the export participation rate[5] varies greatly between time periods, among countries, and between industries. This means that, at least to some extent, unobserved factors in a period of time, country, and industry affect a firm's export decision. Theoretically and conceptually, different economic development strategies, export promotion policies, and geographic locations among countries depend partly on the intrinsic industry characteristics (such as the export-oriented electronics and textile industries vs. the home focused telecommunication industry), and certain historical events like the Global Financial Crisis will lead to heterogeneity of firms' exports. My data offer some evidence. For instance, 27.7% of firms participated in exports in the year 2009[6], but the figure dropped to 13.6% in 2016 in my dataset. In the survey, almost a third of Vietnamese firms benefited from the natural endowment of a 3,260-kilometer-long coastline while 83% of companies in Laos, a land-locked nation, do not have any sales from abroad. The same variation is true by industry as presented in Table 2.5.

[5] Export participation rate is calculated as the number of exporters over the total number of firms. It can be divided by year, country, and industry. For example, the export participation rate by sector is the number of exporters in an industry divided by the total number of firms in the same industry.

[6] It seems the negative impact of the 2008 Global Financial Crisis has a lag-effect on firms' exit from export markets.

Table 2. 3 Export participation rate by year

| Year | 2009 | 2012 | 2015 | 2016 |
|---|---|---|---|---|
| **Number of Exporter** | 304 | 32 | 834 | 49 |
| **Number of Non-exporter** | 795 | 81 | 2,627 | 310 |
| **Export Participation Rate** | 0.276615105 | 0.283185841 | 0.240970818 | 0.136490251 |

Table 2. 4 Export participation rate by country

| Country | Indonesia | Laos | Philippines | Vietnam |
|---|---|---|---|---|
| **Number of Exporter** | 317 | 96 | 426 | 380 |
| **Number of Non-exporter** | 1,407 | 471 | 1,077 | 858 |
| **Export Participation Rate** | 0.18387471 | 0.169312169 | 0.283433134 | 0.306946688 |

Table 2. 5 Export participation rate by sector

| Sector | Industry | ISIC Code | Non-exporter # | Exporter # | Total # | Export Participation Rate |
|---|---|---|---|---|---|---|
| Manufacturing | Electronics (31&32) | 32 | | 1 | 1 | 100.00% |
| Manufacturing | Precision instruments | 33 | 2 | 2 | 4 | 50.00% |
| Manufacturing | Electronics (31&32) | 31 | 82 | 68 | 150 | 45.33% |
| Manufacturing | Germents | 18 | 281 | 189 | 470 | 40.21% |
| Manufacturing | Transport machines (34 &35) | 35 | 6 | 4 | 10 | 40.00% |
| Manufacturing | Wood | 20 | 31 | 19 | 50 | 38.00% |
| Manufacturing | Leather | 19 | 22 | 9 | 31 | 29.03% |
| Manufacturing | Tobacco | 16 | 13 | 5 | 18 | 27.78% |
| Manufacturing | Machinery and equipment (29&30) | 29 | 37 | 14 | 51 | 27.45% |
| Manufacturing | Forestry and logging | 2 | 35 | 13 | 48 | 27.08% |
| Manufacturing | Chemicals | 24 | 256 | 88 | 344 | 25.58% |
| Manufacturing | Food | 15 | 440 | 151 | 591 | 25.55% |
| Manufacturing | Furniture | 36 | 43 | 14 | 57 | 24.56% |
| Manufacturing | Plastics & rubber | 25 | 268 | 87 | 355 | 24.51% |
| Manufacturing | Textiles | 17 | 176 | 54 | 230 | 23.48% |
| Manufacturing | Paper | 21 | 14 | 4 | 18 | 22.22% |
| Manufacturing | Fabricated metal products | 28 | 230 | 64 | 294 | 21.77% |
| Manufacturing | Transport machines (34 &35) | 34 | 11 | 3 | 14 | 21.43% |
| Manufacturing | Non metallic mineral products | 26 | 283 | 74 | 357 | 20.73% |
| Manufacturing | Publishing, pringting, and Recorded media | 22 | 39 | 7 | 46 | 15.22% |
| Manufacturing | Basic metals | 27 | 24 | 3 | 27 | 11.11% |
| Manufacturing | Fishing and aquaculture | 3 | 32 | 3 | 35 | 8.57% |
| Manufacturing | Refined petroleum product | 23 | 11 | 1 | 12 | 8.33% |
| Manufacturing | Machinery and equipment (29&30) | 30 | 1 | 0 | 1 | 0.00% |
| Manufacturing | Recycling | 37 | 6 | 0 | 6 | 0.00% |
| Service | Transport section I: (60-64) | 61 | 1 | 1 | 2 | 50.00% |
| Service | Transport section I: (60-64) | 63 | 12 | 3 | 15 | 20.00% |
| Service | IT | 72 | 10 | 2 | 12 | 16.67% |
| Service | Wholesales | 51 | 102 | 16 | 118 | 13.56% |
| Service | Hotel and restaurants: section H | 55 | 126 | 18 | 144 | 12.50% |
| Service | Transport section I: (60-64) | 64 | 7 | 1 | 8 | 12.50% |
| Service | Services of motor vehicles | 50 | 35 | 3 | 38 | 7.89% |
| Service | Retail | 52 | 461 | 39 | 500 | 7.80% |
| Service | Transport section I: (60-64) | 60 | 52 | 3 | 55 | 5.45% |
| Service | Construction Selection F: | 45 | 115 | 4 | 119 | 3.36% |
| Service | Transport section I: (60-64) | 62 | 1 | 0 | 1 | 0.00% |
| | | Total | 3,265 | 967 | 4,232 | 22.85% |

## 2.3 Empirical framework and methodology

Following literature on firm heterogeneity and export behavior (Melitz, 2013; Bernard and Jensen, 1999 and 2004), I included exchange rate movement variables, exchange rate level, and exchange rate volatility in the model. The model specification is as below:

$$Y_{i,t,s,c} = \beta_0 + \beta_1 REER_t + \beta_2 ER\ \ Volatility_t + \beta_3 Industry + \beta_4 Country + \beta_5 Year + X'_{i,t,s,c}\beta + \ \ \varepsilon$$

Where *i, t, s, c*, stands for firm *i,* survey year[7] *t*, industry[8] *s*, country *c*, respectively. Dependent variable *Y* denotes the real exports[9] of a firm *i*, in year *t,* industry *s*, country *c*. Depending on the fixed export costs (sunk costs) and the firm's heterogeneity (such as productivity), firms make decisions on whether to export, and, if they export, which exporting method (indirect or direct) to choose. Indirect exporting occurs when firms decide to export through an intermediary firm such as a specialized trading company rather than exporting directly through their own distribution channels. This is usually caused by higher market-specific fixed costs and higher risks than firms are willing to bear (Bernard et al., 2012). Due to the nature of exporting, firms that export through an indirect channel

[7] Survey year is the following year after conducting interviews. For example, the 2015 survey data is collected based on the survey results of 2014.
[8] Industry is the establishment's actual industry classification based on the main activity at the time of the survey
[9] Export value is the sum of indirect and direct overseas sales. Indirect overseas sales are recorded in the World Bank IFC Enterprise Survey because firms know that their products are sold overseas. A GDP deflator is used to obtain the real term.

are considered exporters in several empirical studies (Jinjarak et al., 2014; Fakih and Ghazalian, 2014; Tian, 2016). In this study, I also consider both indirect and direct exporting.

REER, the variable of interest, and ER Volatilities are the Real Effective Exchange Rate and its volatility in year *t.* The exchange rate volatility[10] is measured as the standard deviation of the first difference of the logarithm of the monthly exchange rate in current year *t*. *X* is the matrix of vectors of firm characteristics that are usually used in previous studies and include firm size and firm productivity measured by labor productivity rather than by Total Factor Productivity (TFP)[11] due to data limitations. In extension, firm heterogeneity also includes dummy variables of foreign ownership and internationally recognized quality certificates[12] as well as the self-reported obstacles in accessing financing[13]. As mentioned above, because of the unobserved factors that affect a firm's export performance, I control the fixed effects of time, country, and industry. I also controlled the lagged dependent variable due to the dynamic nature of exports, but the analysis suggests the lagged real export has no effect (no statistically significant effect) on

[10] Exchange rate volatility is not a key interest variable but a control variable in this chapter. The choice of the short-term volatility (t) is for simplicity. An alternative measurement of exchange rate volatility, long-term volatility (t and t-1) which is used in the baseline analysis of Chapter 4, has been used to run the regression and the results did not change.

[11] Ideally, TFP should be used to measure firm's productivity. Author has tried to calculate TFP as the residual term of the Cobb-Douglas production function after removing capital (purchase of new machinery, vehicles and equipment), labor (cost of labor including wages, salaries, bonuses, social security payments), and intermediate goods (cost of raw materials and intermediate materials) from output (total sales); however, due to the large number of missing values, it will reduce the number of observations by 67.2% (3,386 out of 5,032). Thus, the author has decided to use labor productivity as a proxy for firm productivity like in previous studies since the focus of this research is on the exchange rate movements rather the productivity.

[12] For example: ISO 9000 or 14000, or HACCP.

[13] Financial obstacles based on self-evaluation are not optimal yet it presents useful information on the financial condition of firms.

a firm's present export performance. The low frequency of the data (6-year gap between two time periods except for Laos) is believed to contribute to the econometric result. The descriptions of the dependent and independent variables are explained in Table 2.6.

Table 2. 6 Description of dependent and independent variables

| | Variable | Description |
|---|---|---|
| Y | Real Export | Firm's export deflated by GDP change of deflator |
| X1 | REER | Interest variable: Real Effective Exchange Rate |
| X2 | ER Vol | Control Variable: The standard deviation of the first difference of logorithm of monthly exchange rate in year t |
| X3 | Firm Size | Control firm's characteristics: Number of total employees |
| X4 | Labor Productivity | Control firm's characteristics:Firm's total sales divided by number of employees |
| X5 | Quality Certificate | Control firm's characteristics:Dummy variable (1 for a firm which has an internationally-recognized quality certification, 0 otherwise) |
| X6 | Foreign Ownership | Control firm's characteristics:Dummy variable (1 for a firm which has foreign shareholders , 0 otherwise) |
| X7 | Financial Obstacles | Control firm's characteristics: Self evaluated obstacles in access to finance (5 degrees 0-4,0 means no obstacles, 4 means very severe obstacle) |
| X8 | FE Year | Fixed Effects, Dummy variable: survey year |
| X9 | FE Country | Fixed Effects, Dummy variable: country in where the firm belongs to |
| X10 | FE Industry | Fixed Effects, Dummy variable: industry that a firm belongs to at the survey year (completed before the interview) |

A usual challenge in studying firms' export behavior is that many companies actually do not export, a situation that represents the zero-trade problem. As presented in Table 2.7,

3, 813 out of 5, 032 or 75.8% of companies report no overseas sales and that indicates a serious but common 'zero-trade' problem in trade research. Ignoring this problem will lead to biased estimation results and deleting all 0 values of the dependent variable will cause a significant loss of information hidden in these values.

Table 2. 7 Number of exporters and non-exporters

| Status | Real Export | # of firms | Per cent |
|---|---|---|---|
| **Exporter** | $Y > 0$ | 1,219 | 24.22 |
| **Non-exporter** | $Y = 0$ | 3,813 | 75.78 |
| | Total | 5,032 | 100 |

There is no consensus on the best way to handle this, albeit four methods are often used to address this 'zero-trade' issue in empirical literature. They are the Tobit[14] model, the Ad hoc solution[15], the Heckman[16] two-step sample selection model, and PPML[17] (Poisson Pseudo Maximum Likelihood). Each method has its own advantages and disadvantages as explained in the footnote.

[14] Using the censoring method, Tobit can effectively solve the 'zero trade' problem. Though it is simple, the major criticism is lacking of theoretical foundation.

[15] Ad Hoc solution attempts to solve the 'zero trade' problem by adding a very small number such as 0.0001 in the dependent variable or trade flow simply because log (0) is undefined but log (0+0.0001) is not. The advantage of this method is simple (that is probably why it is often used in policy research), however, it does not have theoretical basis and is biased.

[16] Heckman sample selection model consider firm's export decision as two-stage process or two equations (first to decide whether to export; second to decide how much to export) into consideration. Its merits rest in the rational of export decision and theoretical support, nevertheless, it faces criticism for a potentially generating a biased coefficient and exclusion restriction.

[17] Rather than taking a log form of the dependent variable which cannot be zero, PPML assumes the dependent variable as a Poisson distribution and count the data, and then takes a maximum likelihood estimation method to get the coefficient. It solves the problem, gives the lowest bias, takes into consideration of heterogeneity, but it is criticized for producing a potential bias if the presence of over-dispersion in dependent variable. Santo Silva and Tenreyro (2011) defended their model with new evidence.

I chose PPML as the main estimation method because it is arguably the most popular tool used to tackle this problem. In addition, I conducted a basic analysis applying the other alternative methods to be safe as suggested by literature (Herrera, 2013; Kareem et al., 2016).

## 2.4 Estimation results

### 2.4.1. Baseline analysis

The baseline results using pooled OLS, the Tobit model, the Ad hoc solution (OLS), the Heckman Sample Selection Model, and PPML are presented in Table 2.8. Despite the difference among estimation methods[18], the results are consistent and expected. The coefficient of REER is negative and statistically significance at a p-value of less than 0.01 in all estimations except the Heckman Sample Selection Model in which the direction is negative but not significant. Even though OLS, the Tobit model, and the Ad-hoc solution (OLS) report a good result, caution is needed in interpreting the results. The much lower number of observations in using OLS compared to using other methods (967 vs. 4, 232) raises a red flag of significant loss of information and estimation bias. The Tobit model shows a magnitude of the coefficient which is economically suspicious because an increase in REER of one point will lower firms' real exports by 257%. The ad hoc solution (OLS) displays an economically reasonable and statistically significant sign, yet the method lacks theoretical backing and reports a biased result. Based on the main estimation method PPML, which is believed to have the lowest bias and also deal with heterogeneity, one unite increase of REER (currency appreciation) will lower the real exports of a firm by 4.2% on

[18] Author also performed Fixed Effects, but the results are not significant. The low frequency of the data (6-year gap between two time periods except Laos) means many firm-specific variables probably have changed dramatically over six years.

average. Consistent with the literature, all other explanatory variables report statistically significant results. Whereas exchange rate volatility discourages firm exports, firm size and labor productivity[19] are associated with higher value of exports.

[19] Using labor productivity rather than TFP is a limitation of this study. The reasons are explained in footnotes above.

Table 2. 8 Baseline analysis results using five different models

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | OLS | Tobit | Ad Hoc: OLS | Heckman Sample Selection Model | | PPML |
| VARIABLES | Y=Log Real Export | Y= Export Participation Ratio:0-100 | Y=Log Real Export (+0.0001) | Y=Log Real Export Outcome Eq. | Y= Dummy Export Selection Eq. | Y=Real Export |
| REER | -0.0330*** | -2.571*** | -0.286*** | -0.00882 | -0.00328 | -0.0421*** |
| | (0.00866) | (0.562) | (0.0616) | (0.00992) | (0.00507) | (0.00907) |
| ER Volatility | -0.688** | -144.5*** | -14.26*** | 0.469 | -0.593*** | -0.728*** |
| | (0.302) | (18.52) | (1.848) | (0.353) | (0.164) | (0.182) |
| Firm Size | 0.00119*** | 0.0315*** | 0.00514*** | 0.00101*** | 0.000206*** | 0.000410*** |
| | (0.000141) | (0.00377) | (0.00168) | (7.06e-05) | (3.50e-05) | (7.57e-05) |
| Log Labor Productivity | 1.082*** | 13.21*** | 1.738*** | 0.973*** | 0.0868*** | 0.780*** |
| | (0.0233) | (1.526) | (0.165) | (0.0293) | (0.0134) | (0.0615) |
| Foreign Ownership | | | | | 1.122*** | |
| | | | | | (0.0649) | |
| Constant | 12.84*** | 558.9*** | 55.00*** | 8.805*** | 0.605 | 19.12*** |
| | (1.846) | (112.9) | (11.76) | (2.010) | (1.019) | (2.265) |
| Sigma | | 124.7*** | | | | |
| | | (4.318) | | | | |
| Lambda | | | | | -1.159*** | |
| | | | | | (0.150) | |
| Observations | 967 | 4,232 | 4,232 | 4,232 | 4,232 | 4,224 |
| R-squared | 0.861 | | 0.144 | | | 0.209 |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |

*Note:* Export participation is measured as the overseas sales ratio and its value is between 0 and 100. For Tobit, left-censoring point is Export Participation = 0 and right-censoring point is Export Participation = 100. In the Ad Hoc method, every value of Y is added 0.0001 to avoid the undefined value of log zero and then pooled OLS is used for regression. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

Table 2.9 reports the results of extending the baseline analysis to include more firm-specific variables including foreign ownership, internationally recognized quality certificates, and financial obstacles. It is not surprising that the magnitude of the coefficient of REER and exchange rate volatility decreases as more explanatory variables are controlled while maintaining the same statistically significant and negative direction. As expected, foreign ownership and internationally recognized quality certificates are positively associated with real exports at the firm level. However, financial obstacles are negatively associated (low readings indicate fewer constraints in accessing financing) with real exports.

Table 2. 9 Analysis results of extending the baseline analysis to include more firm-specific variables

| VARIABLES | (1) PPML | (2) PPML | (3) PPML | (4) PPML |
|---|---|---|---|---|
| REER | -0.0421*** | -0.0400*** | -0.0294*** | -0.0252*** |
| | (0.00907) | (0.00924) | (0.00967) | (0.00903) |
| ER Volatility | -0.728*** | -0.573*** | -0.533*** | -0.477** |
| | (0.182) | (0.203) | (0.192) | (0.189) |
| Firm Size | 0.000410*** | 0.000350*** | 0.000402*** | 0.000405*** |
| | (7.57e-05) | (7.11e-05) | (6.84e-05) | (6.23e-05) |
| Log Labor Productivity | 0.780*** | 0.737*** | 0.713*** | 0.732*** |
| | (0.0615) | (0.0643) | (0.0606) | (0.0567) |
| Foreign Ownership | | 0.988*** | 0.523* | 0.517* |
| | | (0.368) | (0.289) | (0.287) |
| Quality Certificate | | | 1.681*** | 1.434** |
| | | | (0.586) | (0.583) |
| Financial Obstacles | | | | -0.432*** |
| | | | | (0.164) |
| Constant | 19.12*** | 18.61*** | 16.78*** | 16.17*** |
| | (2.265) | (2.383) | (2.489) | (2.314) |
| Observations | 4,224 | 4,224 | 4,224 | 4,093 |
| R-squared | 0.209 | 0.307 | 0.479 | 0.547 |
| Year FE | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

### 2.4.2. Robustness check

To verify estimation results, I run three robust regressions and the results successfully pass the sensitivity test. First, I replace REER with two alternative measurements of the exchange rate, NEER and USD[20], and the results are shown in Tables 2.10 and 2.11. Next, I decompose the dataset into two sub-samples or two sectors (the manufacturing and the

[20] The exchange rate is local currency unit per USD and lower value means the appreciation of local currency. Consistent with REER, all four ASEAN countries saw a clear and steady appreciation measured by USD except Indonesia whose currency is more volatile from 2005 to 2015.

service sectors) as presented in Table 2.12. All results are as expected and consistent with the literature. An interesting finding is that the service sector is more sensitive to exchange rate appreciation and volatility. Services exports are associated with lower fixed costs of entry and fewer imported inputs, and the sector has a higher supply and demand elasticity and is more price sensitive than the manufacturing industry. Thus, exports of services are more responsive to exchange rate movements (Eichengreen and Gupta, 2013).

Table 2. 10 Robustness check replacing REER with NEER

| VARIABLES | (1)<br>PPML | (2)<br>PPML | (3)<br>PPML | (4)<br>PPML |
|---|---|---|---|---|
| NEER | -0.0434*** | -0.0422*** | -0.0300*** | -0.0256*** |
| | (0.00985) | (0.00996) | (0.0105) | (0.00982) |
| NEER Vol | -0.343** | -0.220 | -0.262* | -0.242* |
| | (0.134) | (0.151) | (0.139) | (0.142) |
| Firm Size | 0.000410*** | 0.000350*** | 0.000402*** | 0.000405*** |
| | (7.57e-05) | (7.11e-05) | (6.84e-05) | (6.23e-05) |
| Log Labor Productivity | 0.780*** | 0.737*** | 0.713*** | 0.732*** |
| | (0.0615) | (0.0643) | (0.0606) | (0.0567) |
| Foreign Ownership | | 0.988*** | 0.523* | 0.517* |
| | | (0.368) | (0.289) | (0.287) |
| Quality Certificate | | | 1.681*** | 1.434** |
| | | | (0.586) | (0.583) |
| Financial Obstacle | | | | -0.432*** |
| | | | | (0.164) |
| Constant | 17.30*** | 17.06*** | 15.48*** | 15.02*** |
| | (1.957) | (2.038) | (2.136) | (1.986) |
| Observations | 4,224 | 4,224 | 4,224 | 4,093 |
| R-squared | 0.209 | 0.307 | 0.479 | 0.547 |
| Year FE | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

Table 2. 11 Robustness check replacing REER with USD

| VARIABLES | (1)<br>PPML | (2)<br>PPML | (3)<br>PPML | (4)<br>PPML |
|---|---|---|---|---|
| USD | 0.000132** | 0.000144*** | 0.000133*** | 0.000132*** |
| | (5.25e-05) | (5.02e-05) | (5.10e-05) | (4.93e-05) |
| Firm Size | 0.000410*** | 0.000350*** | 0.000402*** | 0.000405*** |
| | (7.57e-05) | (7.11e-05) | (6.84e-05) | (6.23e-05) |
| Log Labor Productivity | 0.780*** | 0.737*** | 0.713*** | 0.732*** |
| | (0.0615) | (0.0643) | (0.0606) | (0.0567) |
| Foreign Ownership | | 0.988*** | 0.523* | 0.517* |
| | | (0.368) | (0.289) | (0.287) |
| Quality Certificate | | | 1.681*** | 1.434** |
| | | | (0.586) | (0.583) |
| Financial Obstacles | | | | -0.432*** |
| | | | | (0.164) |
| Constant | 10.68*** | 10.94*** | 10.40*** | 10.43*** |
| | (1.060) | (1.009) | (1.035) | (1.001) |
| Observations | 4,224 | 4,224 | 4,224 | 4,093 |
| R-squared | 0.209 | 0.307 | 0.479 | 0.547 |
| Year FE | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |

*Note:* USD stands for the local currency unit per dollar which means a smaller value means the appreciation of local currency. Because of the data availability of monthly exchange rates in the four ASEAN countries, exchange rate volatility is not included as a control variable. Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

Table 2. 12 Robustness check by decomposing the data to manufacturing and service sectors

| VARIABLES | (1) Manufacturing | (2) Manufacturing | (3) Manufacturing | (4) Service | (5) Service | (6) Service |
|---|---|---|---|---|---|---|
| REER | -0.0351*** | -0.0219** | -0.0182** | -0.0975*** | -0.0967*** | -0.0583*** |
| | (0.00952) | (0.00978) | (0.00919) | (0.0150) | (0.0152) | (0.0200) |
| REER Volatility | -0.521*** | -0.479** | -0.429** | -2.225*** | -2.195*** | -1.559** |
| | (0.202) | (0.189) | (0.184) | (0.527) | (0.523) | (0.679) |
| Firm Size | 0.000349*** | 0.000402*** | 0.000405*** | 0.00253 | 0.00254 | 0.00123*** |
| | (7.17e-05) | (7.02e-05) | (6.43e-05) | (0.00555) | (0.00595) | (0.000282) |
| Log Labor Productivity | 0.773*** | 0.745*** | 0.762*** | 0.416*** | 0.418*** | 0.959*** |
| | (0.0655) | (0.0630) | (0.0595) | (0.0969) | (0.0944) | (0.115) |
| Foreign Ownership | 0.975*** | 0.509* | 0.505* | -1.453 | -1.517 | -2.080 |
| | (0.375) | (0.289) | (0.286) | (5.533) | (5.449) | (1.646) |
| Quality Certificate | | 1.734*** | 1.538** | | 0.347 | -1.651*** |
| | | (0.671) | (0.662) | | (0.811) | (0.336) |
| Financial Obstacles | | | -0.382** | | | -3.189*** |
| | | | (0.155) | | | (0.694) |
| Constant | 19.27*** | 15.39*** | 14.77*** | 34.74*** | 34.53*** | 15.65*** |
| | (2.697) | (2.437) | (2.192) | (3.588) | (3.429) | (4.736) |
| Observations | 3,155 | 3,155 | 3,055 | 986 | 986 | 957 |
| R-squared | 0.307 | 0.483 | 0.554 | 0.245 | 0.258 | 0.980 |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

### 2.4.3. Expanding the analysis by including interaction terms

Interaction terms are employed to examine firm heterogeneity in response to the appreciation of local currency. I am interested in whether SMEs (Small and Medium-sized Enterprises)[21] and firms with prior export experience are more sensitive to exchange rate movements, whether having foreign and conglomerate (domestic business group)[22] affiliation through ownership has an impact on firms' export performance, and whether foreign contents[23] or imports lower firms' exchange rate risks as suggested in previous studies. The results of five regressions with interaction terms are presented in Tables 2.13, 2.14, 2.15, 2.16, and 2.17, respectively.

The results present several findings. First, Table 2.13 suggests that SMEs, which have fewer economic resources, are more sensitive to currency appreciation. Second, real exports of firms with prior export experience are more stable compared to first-entry exporters when the local currency becomes less competitive, as shown in Table 2.14. This is likely to be caused by the sunk-cost in trade and presents another example of trade hysteresis (Baldwin and Krugman, 1989; Dixit, 1989). Third, it is interesting to note both foreign and conglomerate (domestic business group) affiliation will help mitigate firms' exchange rate risks, but foreign owners are more helpful as indicated in Tables 2.15 and 2.16. This implies that the domestic parent company offers many resources and benefits such as capital and management expertise to a child company. Nonetheless, these parent companies are not commensurate with foreign owners who, in addition, have foreign

[21] SMEs are defined as companies with a number of employees below 100.
[22] The survey question is whether the firm is a part of a larger firm. If the answer is yes, I consider it as a conglomerate or domestic affiliation.
[23] A portion of material inputs or supplies are of foreign origin.

knowledge and networks. The results in Table 8 also imply that a firm with foreign affiliation is likely to take advantage of the resources they possess to expand their exports amidst a currency appreciation, at least in the case of the four ASEAN countries. Last, Table 2.17 indicates that firms with imported or foreign inputs are less responsive to exchange rate movements. This result reconfirms the conceptual framework and theoretical literature that global production network has lowered the effect of exchange rate movements on trade because the negative impact of currency appreciation will be offset by the gains of foreign imports and companies with higher foreign imports have a lower exchange rate pass-through and lower exchange rate and trade link (Amiti, Itskhoki, and Konings, 2014).

Table 2. 13 Analysis results by adding an interaction term between SME Dummy and REER

| VARIABLES | (1) PPML | (2) PPML | (3) PPML | (4) PPML |
|---|---|---|---|---|
| REER | -0.0250*** | -0.0245*** | -0.0222** | -0.0177** |
| | (0.00879) | (0.00888) | (0.00885) | (0.00799) |
| SME*REER | -0.694*** | -0.664*** | -0.589*** | -0.575*** |
| | (0.0945) | (0.100) | (0.111) | (0.0942) |
| REER Volatility | -0.695*** | -0.644*** | -0.597*** | -0.526*** |
| | (0.233) | (0.236) | (0.199) | (0.190) |
| Firm Size | 0.000334*** | 0.000322*** | 0.000346*** | 0.000349*** |
| | (6.73e-05) | (6.49e-05) | (6.53e-05) | (5.91e-05) |
| Log Labor Productivity | 0.862*** | 0.842*** | 0.808*** | 0.828*** |
| | (0.0639) | (0.0693) | (0.0725) | (0.0645) |
| Foreign Ownership | | 0.245 | 0.0897 | 0.0882 |
| | | (0.299) | (0.281) | (0.272) |
| Quality Certificate | | | 0.824 | 0.685 |
| | | | (0.519) | (0.480) |
| Financial Obstacles | | | | -0.408*** |
| | | | | (0.145) |
| Constant | 16.29*** | 16.28*** | 15.88*** | 15.04*** |
| | (2.530) | (2.572) | (2.478) | (2.213) |
| Observations | 4,224 | 4,224 | 4,224 | 4,093 |
| R-squared | 0.482 | 0.485 | 0.533 | 0.629 |
| Year FE | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

*Source*: author's calculations.

Table 2. 14 Analysis results by adding an interaction term between Export-before Dummy and REER

| VARIABLES | (1) PPML | (2) PPML | (3) PPML | (4) PPML |
|---|---|---|---|---|
| REER | -0.0319*** | -0.0312*** | -0.0333*** | -0.0320*** |
| | (0.00610) | (0.00617) | (0.00681) | (0.00678) |
| Export Before*REER | | 1.049*** | 1.106*** | 1.064*** |
| | | (0.292) | (0.304) | (0.310) |
| ER Volatility | -0.620*** | -0.573*** | -0.597*** | -0.568*** |
| | (0.122) | (0.127) | (0.150) | (0.138) |
| Firm Size | 0.000577*** | 0.000570*** | 0.000583*** | 0.000572*** |
| | (7.35e-05) | (7.63e-05) | (7.89e-05) | (7.79e-05) |
| Log Labor Productivity | 0.831*** | 0.819*** | 0.839*** | 0.832*** |
| | (0.0463) | (0.0500) | (0.0522) | (0.0549) |
| Foreign Ownership | | 0.200 | 0.270 | 0.269 |
| | | (0.194) | (0.191) | (0.196) |
| Quality Certificate | | | -0.319 | -0.311 |
| | | | (0.254) | (0.251) |
| Financial Obstacle | | | | -0.126 |
| | | | | (0.0947) |
| Constant | 12.20*** | 12.02*** | 11.88*** | 12.02*** |
| | (2.517) | (2.573) | (2.676) | (2.701) |
| Observations | 4,224 | 4,224 | 4,224 | 4,093 |
| R-squared | 0.789 | 0.784 | 0.794 | 0.793 |
| Year FE | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

Table 2. 15 Analysis results by adding an interaction term between Foreign Ownership Dummy and REER

| VARIABLES | (1)<br>PPML | (2)<br>PPML | (3)<br>PPML |
|---|---|---|---|
| REER | -0.0405*** | -0.0296*** | -0.0255*** |
| | (0.00926) | (0.00965) | (0.00900) |
| Foreign*REER | 0.211*** | 0.110* | 0.109* |
| | (0.0793) | (0.0620) | (0.0620) |
| ER Volatility | -0.576*** | -0.536*** | -0.480** |
| | (0.203) | (0.191) | (0.188) |
| Firm Size | 0.000347*** | 0.000401*** | 0.000404*** |
| | (7.15e-05) | (6.87e-05) | (6.25e-05) |
| Log Labor Productivity | 0.738*** | 0.713*** | 0.733*** |
| | (0.0643) | (0.0606) | (0.0566) |
| Quality Certificate | | 1.685*** | 1.437** |
| | | (0.587) | (0.584) |
| Financial Obstacle | | | -0.432*** |
| | | | (0.164) |
| Constant | 18.68*** | 16.82*** | 16.21*** |
| | (2.385) | (2.479) | (2.305) |
| Observations | 4,224 | 4,224 | 4,093 |
| R-squared | 0.305 | 0.478 | 0.546 |
| Year FE | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

Table 2. 16 Analysis results by adding an interaction term between Conglomerate Dummy and REER

| VARIABLES | (1)<br>PPML | (2)<br>PPML | (3)<br>PPML | (4)<br>PPML |
|---|---|---|---|---|
| REER | -0.0421*** | -0.0397*** | -0.0321*** | -0.0282*** |
| | (0.00832) | (0.00851) | (0.00922) | (0.00876) |
| Conglomerate*REER | 0.0141*** | 0.0127*** | 0.0101*** | 0.00967*** |
| | (0.00243) | (0.00292) | (0.00303) | (0.00274) |
| ER Volatility | -0.520*** | -0.452** | -0.403** | -0.354* |
| | (0.187) | (0.191) | (0.186) | (0.183) |
| Size | 0.000419*** | 0.000389*** | 0.000416*** | 0.000417*** |
| | (6.57e-05) | (6.42e-05) | (6.20e-05) | (5.72e-05) |
| Log Labor Productivity | 0.765*** | 0.743*** | 0.709*** | 0.721*** |
| | (0.0544) | (0.0590) | (0.0599) | (0.0574) |
| Foreign Ownership | | 0.484 | 0.294 | 0.286 |
| | | (0.324) | (0.271) | (0.272) |
| Quality Certificate | | | 1.354** | 1.168** |
| | | | (0.634) | (0.588) |
| Financial Obstacle | | | | -0.400*** |
| | | | | (0.132) |
| Constant | 18.17*** | 17.91*** | 16.75*** | 16.36*** |
| | (2.196) | (2.269) | (2.383) | (2.351) |
| Observations | 4,224 | 4,224 | 4,224 | 4,093 |
| R-squared | 0.517 | 0.501 | 0.569 | 0.607 |
| Year FE | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

Table 2. 17 Analysis results by adding an interaction term between Foreign Contents Dummy and REER

| VARIABLES | (1)<br>PPML | (2)<br>PPML | (3)<br>PPML | (4)<br>PPML |
|---|---|---|---|---|
| REER | -0.0660*** | -0.0625*** | -0.0501*** | -0.0438*** |
| | (0.0114) | (0.0115) | (0.0148) | (0.0133) |
| Foreign Contents*REER | 0.0179*** | 0.0163*** | 0.0117** | 0.0107** |
| | (0.00499) | (0.00495) | (0.00589) | (0.00541) |
| ER Volatility | -0.777*** | -0.701*** | -0.668*** | -0.595*** |
| | (0.172) | (0.192) | (0.197) | (0.189) |
| Firm Size | 0.000489*** | 0.000453*** | 0.000443*** | 0.000440*** |
| | (6.12e-05) | (6.00e-05) | (5.66e-05) | (5.27e-05) |
| Log Labor Productivity | 0.714*** | 0.696*** | 0.673*** | 0.699*** |
| | (0.0590) | (0.0626) | (0.0628) | (0.0575) |
| Foreign Ownership | | 0.461 | 0.331 | 0.328 |
| | | (0.293) | (0.283) | (0.279) |
| Quality Certificate | | | 1.072 | 0.916 |
| | | | (0.690) | (0.646) |
| Financial Obstacle | | | | -0.392*** |
| | | | | (0.151) |
| Constant | 21.47*** | 21.06*** | 19.78*** | 18.75*** |
| | (2.397) | (2.501) | (2.785) | (2.508) |
| Observations | 4,224 | 4,224 | 4,224 | 4,093 |
| R-squared | 0.534 | 0.532 | 0.550 | 0.615 |
| Year FE | Yes | Yes | Yes | Yes |
| Country FE | Yes | Yes | Yes | Yes |
| Industry FE | Yes | Yes | Yes | Yes |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1.
*Source*: author's calculations.

## 2.5 Limitations

The study has several limitations, mostly due to data availability. First is the potential endogeneity problem. As documented in the literature on learning by exporting and firm growth, the reverse causality problem can exist between firm size, productivity, and firms' exports. The same is true for financial obstacles. I was not able to find a good instrument to solve this issue[24]. However, I am not interested in the causality relationship between these variables and exports. Fixed effects were not feasible to control the unobserved time-invariant variable hidden in the error term owing to a low frequency and short time dimension in the panel data. The second problem is the lack of data to construct firm-specific REER. Although REER has some degree of signaling power and is a proxy for a country's export competitiveness (and the sampling is random), using the effective exchange rate to examine firm export performance unrealistically assumes that all firms have the same export structure and weights of export destinations as the nation as a whole. This assumption can hardly be true especially for SMEs who often trade with a limited number of countries. Finally, the data needed to calculate exchange rate pass-through and export price elasticity, two factors critical in determining export value, are lacking. These factors must be known in order to decompose export value and thereby understand how exchange rate movements affect firm's pricing and export decisions.

[24] Author replaced firm size, labor productivity and financial obstacles with their lag terms and run several regressions. Results show that lag labor productivity has a positive and significant sign while firm size and financial obstacles are not significant.

## 2.6 Conclusion

I conclude that the observed macro-picture that exports of ASEAN countries are immune to currency appreciation is incorrect. Using firm-level data from four ASEAN countries in selected years between 2009 and 2016, I find that, different from what is seen in aggregated data, ASEAN countries are not indifferent to exchange rate movement. The findings are summarized as follows. First, the appreciation of local currency discourages companies' exports on a micro-level. Second, firms' responses to exchange rate appreciation are heterogeneous due to firm-specific characters. SMEs and first-entry exporters are more sensitive to exchange rate movements. Having both foreign and domestic business group affiliations will help firms alleviate the exchange rate risk but foreign ownership, which not only brings capital but also an international network and know-how, is more helpful than having a domestic shareholder. Third, firms with imports are less affected by the rise of local currency value as the gains from importing offsets the loss from exporting. This finding provides a micro-foundation that explains why the spread of global production networks weakens the link between exchange rates and trade. Lastly, firms in the service sector are more sensitive to currency appreciation than manufacturers, probably due to the nature of service exports.

Two factors are believed to contribute to the difference between the macro-picture (country-level exports) and the micro-picture (firm-level exports) in my analysis. The first is the data aggregation problem, which is often found in trade literature. While my analysis

using micro-data shows that on average, firms in selected ASEAN countries are negatively affected by local currency appreciation, the total exports by country I presented in the introduction are from aggregated data, which is a summation of exports by all firms in different sectors of that country. That is to say, if one or a few firms or sectors dominate a country's exports, the country's exports are largely determined by the performance of those firms or sectors. For instance, around 60% of Indonesia's exports are in the commodity sector, which is less sensitive to exchange rates moments, and thus the local currency appreciation would not have as much effect on the country's exports. Second, the survey data may not be very representative. The World Bank- IFC Enterprise Survey is said to be a firm-level survey of a representative sample of an economy's private sector but it may not be very representative of that country's exports sector.

Despite limitations, this empirical exercise suggests that policy-makers and researchers should be cautious in interpreting the relationship between exchange rate movement and export performance solely based on the aggregated data or perceived big picture. In addition, governments should have an SME support policy and encourage foreign investment and global production networks.

## Chapter 3. Exchange Rate, Chinese Exports, and Competition in Asia: Empirical Evidence Using Product-level Data


Abstract

This study examines the impact of the USD/RMB exchange rate on Chinese exports to the US and China's relationship with its neighbors from 1989 to 2015 using HS 10-digit commodity data. This study tackles the aggregation problem and contributes to the literature by providing a comprehensive analysis of whether China's rise is a threat or a windfall to the region. Major findings are as follows. First, USD/RMB appreciation discourages Chinese exports to the US. The effect is more pronounced at a product level than at an aggregated level. Second, the impact is heterogeneous by sector, time period, and product category. Capital-intensive industries and differentiated goods are more sensitive to changes of exchange rate and exchange rate effects increased after China's WTO accession and during the 2008 Global Financial Crisis. Third, overall, China is competing with almost all Asian countries for the US market, but it may cooperate with some Asian countries in certain sectors through the global production network. Fourth, although exchange rates affect Chinese exports, US demand is by far the most important determinant.



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*Key words:* Exchange Rate, International Trade, Products, Competition, China, RCEP
*JEL Code:* F14, F10, F15, F31

## 3.1. Introduction

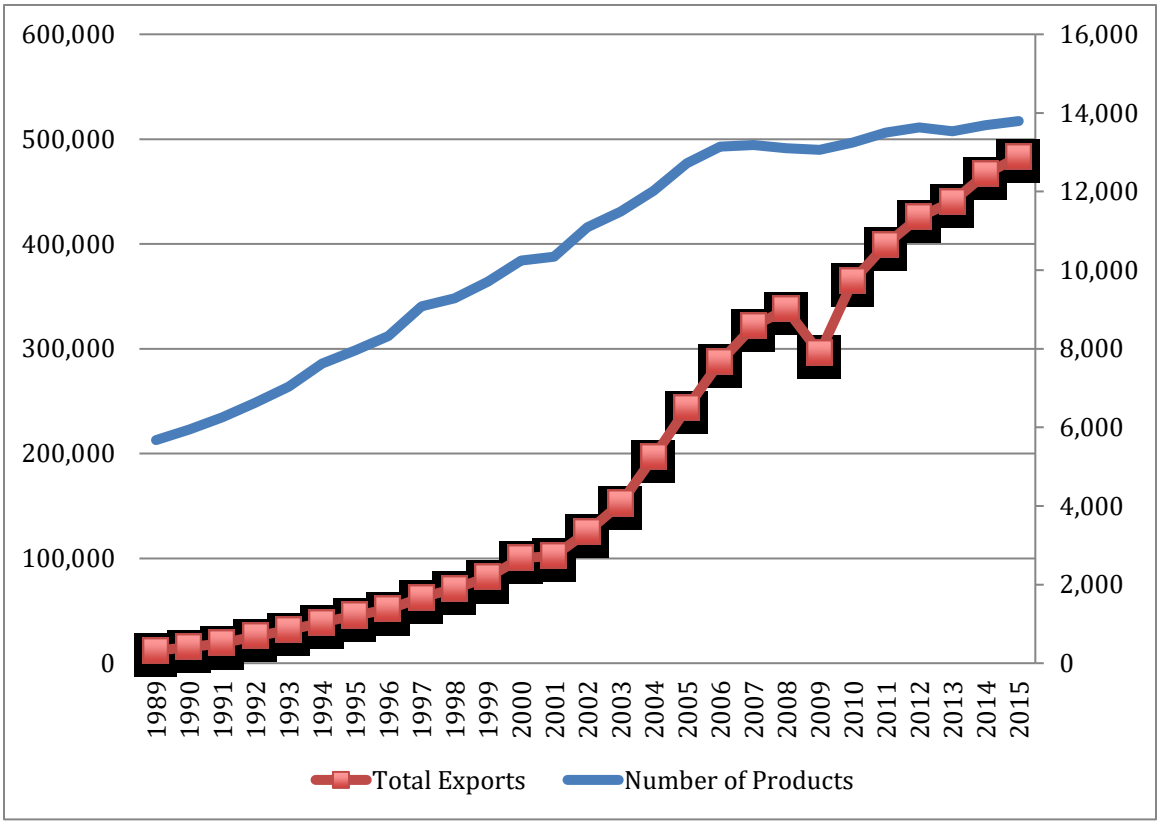
China's economic miracle is primarily driven by its success in exports. In the late 1970s, as part of the Opening Up Reform, China opened its door and embraced the international market. Many foreign investors were invited to participate in China's economic development. With the help of the FDI (Foreign Direct Investment), China capitalized on its abundance in labor and exported labor-intensive goods based on this comparative advantage (Zhang and Song, 2011; Yao, 2006). Since its accession to the WTO in 2001, China has taken advantage of the regional Production Network (PNs) established mostly by MNCs from its advanced neighbors like Japan and South Korea and emerged as the factory of the world. As the final stage of the Global Value Chains (GVCs), it imports raw materials and intermediates from the rest of Asia, processes and assembles them, and then exports the final goods to rich nations, especially in Europe and North America. This structure of trade is called a "Triangle Trade" (Baldwin, 2008).

The most remarkable fact of Chinese international trade is with the United States. In 1978, China was running a trade deficit against the US (exports of $270.7 million vs. imports of $721.1 million). However, China was able to reverse its bilateral trade balance in 1993 with a trade surplus of $ 6.3 billion. In 2015, China's annual trade surplus reached an unprecedented level at $ 266 billion[25]. In fact, Chinese exports to the US increased by 1, 517 times between 1978 and 2015, compared to 360 times for Chinese exports to the

[25] The data is obtained via CEIC which compiles data from various official sources.

rest of the world during the same period. In addition to the intensive margin, the new product varieties (extensive margin) of Chinese exports also contributed to the exceptional success of Chinese goods in the US (Feenstra and Wei, 2010). For instance, China increased its product offerings from 5, 676 varieties in 1989 to 13, 793 different products in 2015 as illustrated in Figure 3.1.

Figure 3. 1 Chinese exports in value ($ million) and product varieties




*Source:* U.S. Bureau of the Census

China's rise in international trade triggered the "fear of China" debate. Initially, China's concentration in exporting labor-intensive goods like apparel and textiles

competed with many developing countries, especially in developing Asia due to similar factor endowment and geographical proximity. As China upgrades its industry structure and expands its product mix, its export structure increasingly overlaps with that of developed or high-income countries (Schott, 2008). However, the well-established regional production networks complicate China's relationship with its Asian neighbors. Whether this represents cooperation or competition depends on the product and its position in the GVCs (Athukorala, 2009). Pontines and Siregar (2012) studied trade competition with China in four East Asian economies (Indonesia, South Korea, Philippines, and Thailand) and found an increased the fear of their currency appreciation against the RMB. Greenaway et al. (2008) suggest that China has displaced other Asian countries' exports (which are relatively minor), especially to more industrialized countries, but China's export expansion also increased other Asian countries' exports to China. China's emergence also led to many debates in Latin America over the role of China in trade and economic growth (Moreira, 2007; Jenkins and Barbosa, 2012).

China's exchange rate policy is often believed, especially by the American government, to be responsible for China's tremendous success in exports. The policy and academic debates over the value of the RMB in international trade have produced voluminous literature on this topic. Most studies conclude that the appreciation of the RMB reduces Chinese exports, especially in ordinary (non-processing) exports (Marquez and Schinder 2007; Ahmed, 2009; Garcia-Herrero and Koivu, 2009; Thorbecke and Smith, 2010;

Thorbecke, 2011a; Xing, 2012). However, an opposite sign was found by Cheung, Chinn, and Fujii (2010). Surprisingly, only a few studies have specifically investigated the impact of the USD/RMB exchange rate on US-China bilateral trade (Thorbecke, 2006; Baak, 2008; Cheung, Chinn, and Qian, 2015; Thorbecke, 2015). All these empirical studies employed only time-series techniques in their analysis. Because of the rapidly changing nature of Chinese export structure recently, caution needs to be taken in using historical data to interpret the results (Aziz and Li, 2007). Furthermore, except Bahmani-Oskooee and Wang (2007) who used HS 2-digit and HS 3-digit industry level data, previous studies focused mainly on aggregate trade data[26], which causes concern about aggregation bias. With the availability of more detailed data, the trend is to use more disaggregated data[27]. Finally, the literature is outdated in terms of the period of the coverage. With an exception of Thorbecke (2015) who used a gravity model to analyze panel data for 31 countries over 1988-2012, all other studies only covered up to 2008.

This chapter revisits the role of the USD/RMB in Chinese exports to the US using the most detailed or disaggregated HS 10-digit[28] product-level data of nearly 290,000 observations from 1989 to 2015. In addition, this study uses local exchange rates of other countries against the USD Dollar as proxies to assess China's competition with its most

[26] Thorbecke and Smith (2010), Thorbecke (2011a), and Xing (2012) also separated Chinese exports into ordinary trade (non-processing) and processing trade, and it is called disaggregate export in their paper on comparing the aggregated export. Tang and Zhang (2012) and Li, Ma, and Xu (2015) used firm-level data to analyse the connection between exchange rates movement and Chinese exports.
[27] There are three stages in trade studies in terms of data usage. First stage: aggregate data (aggregation bias); second stage: bilateral data (aggregation bias); third stage: product and industry level data (Baek and Koo, 2011)
[28] Li and Zhao (2016) also used the same dataset merged with Chinese customs transaction-level database to study forward exchange rate pass-through on Chinese export price at a firm-level between 2000 and 2008.

important Asian neighbors. This study contributes to the literature on two fronts. First, it solves the aggregation problem by being the first to use a highly detailed product-level data set, to the best knowledge of the author, to investigate the impact of the value of the RMB on Chinese exports to the US. The existence of the aggregation problem is also demonstrated. Second, the research is the most comprehensive and thorough study on this topic. The period of study covers all major events of Chinese USD/RMB movements and export performance such as four RMB reforms, the Asian Financial Crisis, and the Global financial crisis. Furthermore, all major Asian economies are included in the analysis. Finally, the study considers product and industry categorization and GVCs in Asia.

I provide several interesting findings. First, USD/RMB appreciation, both in the nominal and the real term, discourages Chinese exports to the US. Due to an aggregation problem, the exchange rate effect is more noticeable at a product-level than at an aggregated total export level. Second, the impact of exchange rate movements on exports is heterogeneous by sector, time period, and product classification. The effect is more pronounced for capital-intensive industries and differentiated goods, and the coefficient grew after China joined the WTO in 2001 and during the 2008 Global Financial Crisis. This is probably due to the difference of exchange rate pass-through, price elasticity of exports, and exchange rate elasticity of exports among sectors and between two time periods. Third, overall, China is competing with almost all Asian countries for the US market. However, China's relationship may be complementary with certain countries in

specific sectors such as electronics through the regional production networks. Lastly, although exchange rates affect Chinese exports, US demand is by far the most important determinant.

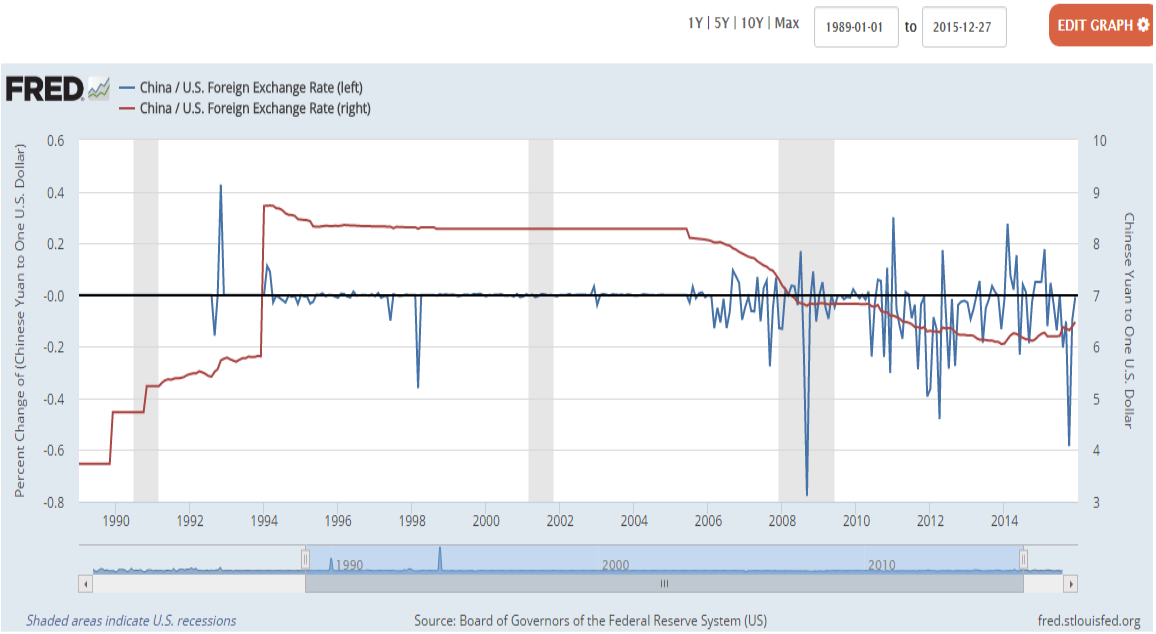
Chapter 3 is structured as follows. The next section discusses Chinese RMB currency reforms. In Section III, I introduce the data and empirical framework. Section IV presents the results and Section V concludes.

## 3.2. RMB currency reforms

China's foreign exchange rate policy has gone through several major reforms. From 1949 to the late 1970s, as part of its import substitution strategy, the government fixed its exchange rate at a level widely perceived to be overvalued. Following a series of economic reforms in the 1980s and early 1990s, the state gradually allowed the market to play a role in determining exchange rates at a platform called Swap Centres while continuing to maintain an official exchange rate. In 1994, the authority decided to unify its dual exchange rates by aligning official and Swap Centre rates and devalued the RMB by 33% overnight. Under heavy external pressure and urgency for furthering economic reforms, China moved to a managed floating exchange rate based on market supply and demand with reference to a basket of currencies in 2005. However, in the middle of the Global Financial Crisis, the currency was effectively pegged against the USD again in curbing the negative impacts of the crisis in 2008. In 2010, the government declared it had resumed its currency reform to

allow the RMB to move freely. Based on the timeline of the four major currency reforms, I divide the reform into five major phases (phase 1:1989-93; phase 2: 1994-2004; phase 3: 2005-07; phase 4: 2008-10; and phase 5: 2011-15) and the USD/RMB exchange rate and volatility are shown in Figure 3.2.

Figure 3. 2 USD/RMB exchange rate movement and volatility between 1989 and 2015




*Source:* Federal Reserve Bank of St. Louis

## 3.3. Data and empirical framework

### 3.3.1. Data

The data are obtained from several public sources. The data on Chinese exports to the

US or US imports from China between 1989 and 2015 is one of, if not the, most disaggregated product-level (HS 10-digit) data among world's major economies compiled by the Foreign Trade Division of the U.S. Bureau of the Census[29]. China exported 13, 793 varieties of products in 2015 from 18, 600 product categories included in the data. I note there are four rounds of revisions in product classifications during my scope of study, in 1996, 2002, 2007 and 2012 (major revisions in 1996 and 2002), but the changes (many are not products China exports to the US) are minimal compared to the large number of products China exports. To further reduce the concern over reclassification, I run several robustness checks for different time periods (before and after revisions).

Except the RMB/TWD (New Taiwan Dollar) downloaded from the website of the Federal Reserve in St. Louis, the rest of the exchange rate data is obtained from the IMF. GDP and CPI are sourced from the World Bank. As described in Table 3.1, the dataset, with nearly 290,000 observations, is probably the largest used in the study of the impact of bilateral exchange rate movement on US-China trade. As opposed to our general perception, the range of the USD-RMB exchange rate is relatively large due to the 1994 foreign exchange reform.

[29] Many thanks to Professor Peter K. Schott at Yale University for making the data available.

Table 3. 1 Summary statistics

| Variable | Obs | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| Real Export | 285,292 | 1.76e+07 | 2.68e+08 | 0 | 4.12e+10 |
| ER: USD/RMB | 285,292 | 7.400795 | 1.223043 | 3.939021 | 10.20243 |
| Real ER: USD/RMB | 285,292 | 7.594935 | 1.283118 | 3.762922 | 9.190557 |
| Export Quantity | 285,292 | 9686404 | 4.40e+08 | 0 | 9.67e+10 |
| Export Price | 250,690 | 1893.352 | 89038.11 | .0009259 | 3.56e+07 |
| US GDP | 285,292 | 1.33e+07 | 2239220 | 8786400 | 1.64e+07 |
| China GDP | 285,292 | 3886585 | 3518636 | 347767.2 | 1.11e+07 |
| China GFCF | 285,292 | 1.67e+12 | 1.62e+12 | 8.86e+10 | 4.84e+12 |

### 3.3.2. Empirical framework

Following a common approach in the literature (Bayoumi, 1999; Ahmed, 2009; Aziz and Li, 2007; Bahmani-Oskoosee and Wang, 2007; Chen et al., 2012), I consider Chinese export to the US as a function of the USD/RMB exchange rate[30], US domestic demand, Chinese capability to produce, time-invariant characteristics of different products, and economic shocks and events that may affect the value of the RMB and Chinese exports such as financial crises, China's accession to the WTO, and currency reforms. The basic model used to investigate the relationship between the USD/RMB exchange rate and Chinese exports is presented as below:

[30] There are two methods of quoting foreign exchange rate (direct quotes and indirect quotes). Direct quotes refer to the price of one unit of foreign currency expressed in terms of domestic currency while indirect quotes report the price of one unit of domestic currency expressed in terms of foreign currency. Two quotes are exactly the opposite. This study follows the direct quotation method: a higher value of USD/RMB means the depreciation of Chinese Renminbi against American dollar.

$$EX_{i,t} = \alpha + \beta \cdot ER_t + \gamma \cdot GDP_t^{US} + \delta \cdot GDP_t^{CN} + \partial \cdot Events + F_i + \varepsilon_{i,t}$$

$EX_{i,t}$ stands for real export product $i$ of China to the US in year $t$. $ER_t$, $GDP_t^{US}$, and $GDP_t^{CN}$ are the USD/RMB exchange rate, US domestic demand for Chinese goods proxied by US GDP, and Chinese production capability proxied by Chinese GDP and Gross Fixed Capital Formation, respectively. I also control $Events$ or economic shocks (dummy variables) that disrupt Chinese exports and/or dramatically change the value of the RMB against the US dollar. These include four major currency reforms which divide the period into five phases[31]: a sudden devaluation of the RMB in the 1994 reform, China's accession to the WTO in 2001, the 1997-98 Asian Financial Crisis, the 2001 Dotcom crisis, and the 2008 Global Financial Crisis. The $Events$ variable captures many unobserved variables including Chinese government support policies, company restructuring, product churning, and credit crunches that occurred during these times. These time dummy variables are equal to 1 if these events happen and 0 otherwise.

$F_i$ is the fixed effect of product $i$ to control time-invariant variables. One major advantage of using panel data is the ability to employ a fixed effects model. The fixed effects are essential to capture many unobserved product-specific characteristics, such as product marginal costs, import market structure, demand elasticity, and substitution elasticity, which are more stable over time. Certainly, this assumption is strong, and the

[31] Phase 1:1989-93; phase 2: 1994-2004; phase 3: 2005-07; phase 4: 2008-10; phase 5: 2011-15. In all the regression phase 5 is omitted.

fixed effects are not able to perfectly control all omitted variables that are simultaneously affecting the RMB/USD and Chinese exports, nevertheless, it allows for the best use of this large-panel data by looking into the impact of exchange rate on export within the same product group. $\varepsilon_{i,t}$ is the error term.

In the second part of my analysis, I added $ER_t^{Other}$ to the basic equation above, which is the exchange rate among nine major Asian economies against the USD, to measure China's relationship (competitive or complementary) with its neighbors in the US market. The direction of the effects of the USD/RMB and other exchange rates (for example, the USD/JPY) on a certain exported product should be the same when China and another economy have a complementary relationship. This often signals that these two economies are linked through their participation in the Regional Production Networks or Global Value Chains (GVCs) in producing and exporting the final goods for the US market. In such a trade structure, China needs to purchase foreign inputs (raw materials and intermediates) from other economies to produce exports (backward participation to the GVCs). Thus, the depreciation of a foreign currency is beneficial for Chinese exports, just as the depreciation of the Chinese RMB is. On the contrary, if the depreciation of a foreign currency lowers Chinese exports to the US, it hints that China and this country are competing for exports to the US market.

The nine Asian economies are carefully chosen to reflect their economic significance to China in reference to the RMB CFETS Index, BIS Index, and SDR Currency Basket

Index as well as the regional production networks. This group of economies consists of Japan, South Korea, Taiwan, and Australia in Advanced/Developed Asia; Malaysia, Thailand, Indonesia, Vietnam in ASEAN; and India which is included in the regional mega-FTA RCEP. These nine economies are no doubt the most important neighbors for China. Hong Kong and Singapore are excluded because of their role as trading hubs rather than production bases.

## 3.4. Empirical Results

### 3.4.1. Baseline analysis

A higher value of the USD/RMB (direct quote) means cheaper Chinese Renminbi against the US dollar. That is good news for Chinese exporters simply because it increases the price competitiveness of Chinese goods and services. Thus, I expect the sign of the coefficient of the USD/RMB to be positive. The HS 10-digit products can be grouped by industry (HS-2, HS-4, or HS-6) and some factors do not affect each product individually but affect all products within that industry. Therefore, I cluster the data by HS-4 industries[32] to capture those unobserved variables in addition to controlling Fixed Effects in the analysis. Although the F-test and the Hausman test suggest that Fixed Effects should be used, I also present the results of Pooled Ordinary Least Squares (OLS) and Random

[32] Clustering by HS-2 and HS-6 and without clustering did not change the regression results expect a slight change of standard error.

Effects (RE) in Columns (4) and (5) along with the Fixed Effects (Colum 1, 2, and 3) in the baseline regression shown in Table 3.2. As expected, the results suggest that the USD/RMB exchange rate is positively associated with Chinese export to the US at a significance level of 0.01, and the findings are robust and consistent across different models and different cluster categories.

Among all control variables, the time dummies deal with the unobserved or mitted variables associated with these specific time periods which might bias the results. A generally positive and statistically significant correlation is observed between Chinese export growth at a very detailed product-level and most of these time periods are separated by China's currency reforms and WTO membership. This probably reflects an upward trend of Chinese exports to the US during this period from 1989 to 2015. It is worth noting that, while China's capacity to produce and the value of the RMB all matter, the US demand is by the far the most important factor in determining Chinese exports.

Table 3. 2 Baseline analysis results of Fixed Effects, Pooled OLS and Random Effects

| VARIABLES | (1) Fixed Effects | (2) Fixed Effects | (3) Fixed Effects | (4) OLS | (5) Random Effects |
|---|---|---|---|---|---|
| ln_er | 0.857*** | 0.838*** | 0.620*** | 0.418*** | 0.592*** |
| | (0.0751) | (0.0752) | (0.0799) | (0.0677) | (0.0794) |
| ln_gdp | 4.147*** | 3.971*** | 3.572*** | 1.738*** | 3.477*** |
| | (0.209) | (0.181) | (0.233) | (0.249) | (0.230) |
| ln_gdpcn | 0.499*** | 0.505*** | 0.430*** | 0.339*** | 0.419*** |
| | (0.0310) | (0.0308) | (0.0447) | (0.0478) | (0.0440) |
| Phase 1 | | | 0.154** | - | 0.140** |
| | | | (0.0645) | - | (0.0641) |
| Phase 2 | | | -0.210*** | -0.261*** | -0.216*** |
| | | | (0.0491) | (0.0429) | (0.0482) |
| Phase 3 | | | 0.0944** | -0.0927* | 0.0879** |
| | | | (0.0394) | (0.0554) | (0.0385) |
| Phase 4 | | | 0.0545*** | -0.145** | 0.0497** |
| | | | (0.0202) | (0.0656) | (0.0199) |
| Phase 5 | | | - | -0.123* | - |
| | | | - | (0.0731) | - |
| WTO | | 0.0476** | 0.0455** | -0.0521** | 0.0478** |
| | | (0.0229) | (0.0227) | (0.0256) | (0.0227) |
| 1994 Reform | -0.639*** | -0.608*** | | | |
| | (0.0527) | (0.0499) | | | |
| Constant | -63.30*** | -60.53*** | -52.96*** | -20.99*** | -51.79*** |
| | (3.186) | (2.729) | (3.394) | (3.609) | (3.342) |
| Observations | 284,692 | 284,692 | 284,692 | 284,692 | 284,692 |
| R-squared | 0.329 | 0.329 | 0.331 | 0.051 | |

*Note*: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Clustering effects by industry (HS-4) in these regressions. "-" means variables are omitted in the regression

Are the results different from using aggregated data? If yes, how different are they? To answer these questions, I run a series of regressions using aggregated data of total Chinese exports to the US in the same period. Due to a small number of observations in the aggregated dataset, I chose the OLS method to run the regression. In addition to the nominal USD/RMB, the real exchange rates (Column 4) and interaction terms with the WTO and the Global Financial Crisis (Columns 5 and 6), which will be discussed in detail later in the chapter, are used to test the results, as shown in Table 3.3. The results confirm the sign of the USD/RMB exchange rate effect on Chinese exports to the US. However, the magnitude seems to be smaller than that obtained when using disaggregated product-level data. This is not surprising because the exchange rate effect on one product can be offset by another product, which the aggregated data cannot distinguish. That is why I employ such highly disaggregated data to solve the aggregation problem.

Table 3. 3 Regression results using aggregated data of Chinese exports to the US.

| VARIABLES | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| DV: Total EX | NER | NER | NER | Real ER | WTO | GFC |
| ln_er | 0.415*** | 0.448*** | 0.418*** | | 0.446*** | 0.418*** |
| | (0.127) | (0.140) | (0.129) | | (0.139) | (0.129) |
| ln_rer | | | | 0.390*** | | |
| | | | | (0.124) | | |
| ln_er*WTO | | | | | 0.0309 | |
| | | | | | (0.0297) | |
| ln_er*GFC | | | | | | 0.0372** |
| | | | | | | (0.0157) |
| wto | | 0.0673 | | | | |
| | | (0.0661) | | | | |
| gfc | | | 0.0738** | | | |
| | | | (0.0310) | | | |
| ln_gdp | 3.947*** | 3.707*** | 3.956*** | 3.853*** | 3.686*** | 3.956*** |
| | (0.326) | (0.377) | (0.337) | (0.327) | (0.379) | (0.337) |
| ln_gdpcn | 0.323*** | 0.339*** | 0.317*** | 0.332*** | 0.346*** | 0.317*** |
| | (0.0571) | (0.0562) | (0.0584) | (0.0606) | (0.0560) | (0.0584) |
| Constant | -58.34*** | -54.75*** | -58.42*** | -56.89*** | -54.49*** | -58.41*** |
| | (4.423) | (5.303) | (4.579) | (4.390) | (5.325) | (4.579) |
| Observations | 27 | 27 | 27 | 27 | 27 | 27 |
| R-squared | 0.995 | 0.995 | 0.995 | 0.994 | 0.995 | 0.995 |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

### 3.4.2. Robustness check

The results survived several robustness checks as illustrated in Tables 3.4-3.6. First, I replace the nominal exchange rate with the real exchange rate because of concerns over the measurement error. Consistent with previous studies, the choice between real or nominal exchange rate does not make much difference in the analysis (Table 3.4). Second, because GDP contains both investment and consumption along with government spending and net exports, it may not be very accurate for capturing a country's capability to produce. Thus, as an alternative to measuring a country's production capability, I replace Chinese GDP with the Gross Fixed Capital Formation (GFCF), a component of GDP in the expenditure approach, in the analysis (Table 3.5). Third, economic shocks and crises including the 1994 currency reform, China's accession to the WTO, the 1997-98 Asian Financial Crisis, the 2011 Dotcom Crisis, and the 2008 Global Financial Crisis are considered in the analysis (Table 3.6). As expected, all economic crises had a negative effect on Chinese exports while China's joining the WTO helped Chinese exports. All results are robust and consistent with the baseline findings.

Table 3. 4 Robustness check by replacing ER with Real ER

| VARIABLES | (1)<br>ln_rexport | (2)<br>ln_rexport | (3)<br>ln_rexport | (4)<br>ln_rexport |
|---|---|---|---|---|
| ln_rer | 0.647*** | 0.656*** | 0.637*** | 0.656*** |
| | (0.0568) | (0.0568) | (0.0582) | (0.0581) |
| ln_gdp | 4.091*** | 3.739*** | 3.517*** | 3.289*** |
| | (0.104) | (0.102) | (0.124) | (0.125) |
| ln_gdpcn | 0.477*** | 0.497*** | 0.445*** | 0.434*** |
| | (0.0193) | (0.0191) | (0.0276) | (0.0277) |
| Phase 1 | | | 0.174*** | 0.0984** |
| | | | (0.0439) | (0.0434) |
| Phase 2 | | | -0.225*** | -0.270*** |
| | | | (0.0307) | (0.0307) |
| Phase 3 | | | 0.110*** | 0.0763*** |
| | | | (0.0251) | (0.0249) |
| Phase 4 | | | 0.0671*** | 0.0440*** |
| | | | (0.0128) | (0.0127) |
| 1994 Reform | -0.540*** | -0.508*** | | |
| | (0.0348) | (0.0346) | | |
| wto | | 0.0891*** | | 0.0794*** |
| | | (0.0138) | | (0.0139) |
| Constant | -61.75*** | -56.39*** | -52.30*** | -48.45*** |
| | (1.445) | (1.419) | (1.676) | (1.701) |
| Observations | 284,692 | 284,692 | 284,692 | 284,692 |
| R-squared | 0.328 | 0.328 | 0.330 | 0.330 |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10

Table 3. 5 Robustness check by replacing Chinese GDP with GFCF

| VARIABLES | (1)<br>ln_rexport | (2)<br>ln_rexport | (3)<br>ln_rexport | (4)<br>ln_rexport |
|---|---|---|---|---|
| ln_er | 0.580*** | 0.567*** | 0.424*** | 0.419*** |
| | (0.0412) | (0.0415) | (0.0442) | (0.0443) |
| ln_gdp | 4.255*** | 4.168*** | 3.853*** | 3.781*** |
| | (0.0925) | (0.0894) | (0.110) | (0.111) |
| ln_gfcf | 0.396*** | 0.397*** | 0.322*** | 0.312*** |
| | (0.0136) | (0.0136) | (0.0206) | (0.0206) |
| Phase 1 | | | 0.0241 | -0.0193 |
| | | | (0.0389) | (0.0376) |
| Phase 2 | | | -0.247*** | -0.270*** |
| | | | (0.0292) | (0.0289) |
| Phase 3 | | | 0.0736*** | 0.0565** |
| | | | (0.0239) | (0.0234) |
| Phase 4 | | | 0.0439*** | 0.0336*** |
| | | | (0.0122) | (0.0119) |
| 1994 Reform | -0.496*** | -0.478*** | | |
| | (0.0300) | (0.0292) | | |
| wto | | 0.0248* | | 0.0327** |
| | | (0.0139) | | (0.0140) |
| Constant | -68.23*** | -66.85*** | -59.67*** | -58.20*** |
| | (1.254) | (1.216) | (1.410) | (1.440) |
| Observations | 284,692 | 284,692 | 284,692 | 284,692 |
| R-squared | 0.328 | 0.328 | 0.331 | 0.331 |

*Note*: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10.

Table 3. 6 Robustness check by considering economic shocks

| VARIABLES | (1)<br>ln_rexport | (2)<br>ln_rexport | (3)<br>ln_rexport | (4)<br>ln_rexport |
|---|---|---|---|---|
| ln_er | 0.838*** | 0.830*** | 0.757*** | 0.756*** |
| | (0.0457) | (0.0465) | (0.0467) | (0.0468) |
| ln_gdp | 3.971*** | 3.998*** | 3.855*** | 3.813*** |
| | (0.0941) | (0.0941) | (0.0951) | (0.117) |
| ln_gdpcn | 0.505*** | 0.501*** | 0.480*** | 0.491*** |
| | (0.0170) | (0.0172) | (0.0172) | (0.0230) |
| 1994 Reform | -0.608*** | -0.603*** | -0.525*** | -0.526*** |
| | (0.0311) | (0.0314) | (0.0312) | (0.0312) |
| wto | 0.0476*** | 0.0411*** | 0.115*** | 0.116*** |
| | (0.0139) | (0.0141) | (0.0167) | (0.0166) |
| afc | | -0.0117 | -0.00344 | -0.00250 |
| | | (0.0113) | (0.0113) | (0.0112) |
| dotcom | | | -0.196*** | -0.195*** |
| | | | (0.0153) | (0.0153) |
| gfc | | | | -0.0111 |
| | | | | (0.0150) |
| Constant | -60.53*** | -60.90*** | -58.21*** | -57.68*** |
| | (1.346) | (1.340) | (1.361) | (1.624) |
| Observations | 284,692 | 284,692 | 284,692 | 284,692 |
| R-squared | 0.329 | 0.329 | 0.329 | 0.329 |
| Number of commodity | 23,894 | 23,894 | 23,894 | 23,894 |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10.

3.4.3. Extension of the analysis by industry, time period, and product category

The existence of potential heterogeneous effects of exchange rates by industry, time period, and product category motives me to extend the analysis and find explanations for these heterogeneities. First, as China shifts towards a more capital-intensive economy, it is interesting to investigate whether the impact of the USD/RMB on Chinese exports to the US is different between labor-intensive industries and capital intensive industries. Depending on the share of inputs (labor or capital) in the production process, industries can be categorized into two types: capital-intensive industries and labor-intensive industries. The different nature of production between these two industries (for example, capital-intensive sectors usually have higher fixed cost and require a longer term investment) suggests that they may respond differently to exchange rate movements. Based on HS 2-digit industry categorization, industries belonging to HS-2 digit 8533 such as electrical machinery and equipment can be considered capital-intensive while HS-2 digit 60-67[34] such as footwear, clothing, and apparel are labor-intensive industries. As shown in Table 3.7, the coefficients of exchange rate and industry interaction terms indicate their correspondent effects in comparison to all samples (Columns 1 and 3) and to subsamples,

[33] HS2 85 Electrical machinery and equipment and parts thereof; sound recorders and reproducers, television image and sound recorders and reproducers, and parts and accessories of such articles,

[34] HS-2 60-67: 60 Knitted or crocheted fabrics. 61 Articles of apparel and clothing accessories, knitted or crocheted. 62 Articles of apparel and clothing accessories, not knitted or crocheted. 63 Other made up textile articles; sets; worn clothing and worn textile articles; rags. 64 Footwear, gaiters and the like; parts of such articles, 65 Headgear and parts thereof. 66 Umbrellas, sun umbrellas, walking-sticks, seat-sticks, whips, riding-crops and parts thereof. 67 Prepared feathers and down and articles made of feathers or of down; artificial flowers; articles of human hair.

capital intensive sectors and labor-intensive sectors (Columns 2 and 4). The results suggest that exports in capital-intensive sectors are more responsive to USD/RMB exchange rate movements than labor-intensive sectors. Details will be discussed later in this section.

Table 3. 7 Regression results by industry

| VARIABLES<br>DV: Export Value | (1)<br>All<br>Industries | (2)<br>Subsample:<br>Labor & Elec | (3)<br>All<br>Industries | (4)<br>Subsample:<br>Labor & Elec |
|---|---|---|---|---|
| ln_er | 0.736*** | 1.277*** | 0.562*** | 0.393*** |
| | (0.0494) | (0.123) | (0.0469) | (0.0822) |
| ln_er*Labor | -0.409*** | -0.884*** | | |
| | (0.0653) | (0.121) | | |
| ln_er*Elec | | | 0.667*** | 0.884*** |
| | | | (0.109) | (0.121) |
| ln_gdp | 3.588*** | 2.066*** | 3.587*** | 2.066*** |
| | (0.121) | (0.224) | (0.121) | (0.224) |
| ln_gdpcn | 0.428*** | 0.520*** | 0.427*** | 0.520*** |
| | (0.0273) | (0.0496) | (0.0273) | (0.0496) |
| Phase 1 | 0.155*** | 0.222*** | 0.151*** | 0.222*** |
| | (0.0427) | (0.0765) | (0.0427) | (0.0765) |
| Phase 2 | -0.212*** | -0.178*** | -0.208*** | -0.178*** |
| | (0.0302) | (0.0556) | (0.0302) | (0.0556) |
| Phase 3 | 0.0925*** | 0.231*** | 0.0960*** | 0.231*** |
| | (0.0245) | (0.0445) | (0.0245) | (0.0445) |
| Phase 4 | 0.0539*** | 0.0741*** | 0.0552*** | 0.0741*** |
| | (0.0125) | (0.0224) | (0.0125) | (0.0224) |
| wto | 0.0447*** | 0.0347 | 0.0459*** | 0.0347 |
| | (0.0140) | (0.0249) | (0.0140) | (0.0249) |
| Constant | -53.20*** | -29.56*** | -53.15*** | -29.56*** |
| | (1.666) | (3.073) | (1.667) | (3.073) |
| Observations | 284,692 | 96,114 | 284,692 | 96,114 |
| R-squared | 0.331 | 0.240 | 0.331 | 0.240 |

*Note*: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 and clustered with product id.

I also run several regressions considering economic shocks such as the Asian Financial Crisis, the Doc Com Crisis, the Global Financial Crisis, and the results are robust and consistent. Labor, electronics, and phase 5 variables are omitted because of collinearity.

In the second part, I examine whether the bilateral exchange rate affects Chinese exports differently. Two historical events that had major impacts on Chinese exports, China's accession to the World Trade Organization (WTO) and the 2008 Global Financial Crisis (GFC), are employed to analyze this issue. As indicated in Table 3.8, the effects of the USD/RMB exchange rate increased after China became a member of the WTO in 2001 and during the 2008 Global Financial Crisis. One surprise is seen in Column 2, which shows that the control variable wto was negatively correlated with Chinese exports, which is different from other regression results. This is probably due to an estimation bias caused by the interaction term (ln_er*wto) that is strongly correlated with dummy variable wto (correlation coefficient of 0.9944). The economic intuition behind this finding is straightforward. China's membership in the WTO was a positive economic shock to Chinese exporters whereas the 2008 GFC crashed US-China bilateral trade. Both events increased the variability of the dependent variable (export), thus a small movement of the USD/RMB exchange (independent variable) rate would appear to affect Chinese exports more, all else being equal (or ceteris paribus).

Table 3. 8 Regression results by time period: WTO and the Global Financial Crisis

| VARIABLES | (1)<br>WTO | (2)<br>WTO | (3)<br>GFC | (4)<br>GFC |
|---|---|---|---|---|
| ln_er | 0.617*** | 0.552*** | 0.570*** | 0.570*** |
| | (0.0462) | (0.0505) | (0.0495) | (0.0495) |
| ln_er*wto | 0.0229*** | 0.599*** | | |
| | (0.00658) | (0.101) | | |
| ln_er*GFC | | | 0.676*** | 0.676*** |
| | | | (0.104) | (0.104) |
| ln_gdp | 3.555*** | 3.371*** | 3.494*** | 3.494*** |
| | (0.122) | (0.127) | (0.123) | (0.123) |
| ln_gdpcn | 0.432*** | 0.495*** | 0.504*** | 0.504*** |
| | (0.0272) | (0.0296) | (0.0290) | (0.0290) |
| Phase 1 | 0.147*** | 0.0695 | 1.539*** | 1.539*** |
| | (0.0430) | (0.0462) | (0.207) | (0.207) |
| Phase 2 | -0.214*** | -0.276*** | 1.161*** | 1.161*** |
| | (0.0303) | (0.0310) | (0.213) | (0.213) |
| Phase 3 | 0.0908*** | 0.0293 | 1.438*** | 1.438*** |
| | (0.0245) | (0.0248) | (0.210) | (0.210) |
| Phase 4 | 0.0523*** | 0.0205* | 0.0227* | 0.0227* |
| | (0.0125) | (0.0123) | (0.0122) | (0.0122) |
| wto | | -1.230*** | | |
| | | (0.215) | | |
| gfc | | | | - |
| Constant | -52.70*** | -50.38*** | -53.97*** | -53.97*** |
| | (1.675) | (1.741) | (1.652) | (1.652) |
| Observations | 284,692 | 284,692 | 284,692 | 284,692 |

| | | | | |
|---|---|---|---|---|
| R-squared | 0.331 | 0.331 | 0.331 | 0.331 |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1 and clustered with product id. Reform variables are omitted in the regression results. The author also ran several regressions considering economic shocks such as the Asian Financial Crisis, the Dot Com Crisis, and the Global Financial Crisis, and the results are robust and consistent but the magnitude is larger for the exchange rate interaction terms with WTO and GFC. Dummy variable phase 5, and GFC "-" in column 4 are omitted because of collinearity.

Last, I run the analysis using two product categories. Products can be categorized into three categories: homogeneous, heterogeneous/differentiated, and reference-priced goods based on where these goods are sold (Rauch, 1999). Homogeneous products like oil are traded on organized exchanges with a quoted price; reference-priced goods are those which are not traded in organized exchange but the of which price can be found without knowing the brand or the manufacturer, such as some chemical products polymerization and copolymerization products; and differentiated goods are those whose price is associated with a particular producer and it is harder to quote the price, for example TVs and mobile phones. Since Rauch (1999)'s influential paper on network vs. market international trade, many trade economists have looked into the difference between heterogeneous products and reference-priced products in international trade. For instance, Besedeš and Prusa (2006) found that compared to homogeneous goods, trade in differentiated goods starts with a low volume but the relationship lasts longer. Li and Zhao (2016) showed heterogeneous goods have a higher exchange rate pass-through than homogeneous goods. Following previous studies, I run regressions by two types of products (differentiated/heterogeneous and homogeneous, which includes reference-priced goods) using both the real exchange rate (Columns 1 and 2) and the normal exchange rate (Columns 3 and 4) shown in Table 3.9. The results suggest that differentiated goods are more sensitive to fluctuations in exchange rate.

Table 3. 9 Regression results by product categories

| VARIABLES | (1)<br>ln_rexport | (2)<br>ln_rexport | (3)<br>ln_rexport | (4)<br>ln_rexport |
|---|---|---|---|---|
| ln_rer | 0.276* | 0.280* | | |
| | (0.164) | (0.164) | | |
| ln_rer*diff_product | 0.229* | 0.232* | | |
| | (0.123) | (0.123) | | |
| ln_er | | | 0.807*** | 0.776*** |
| | | | (0.150) | (0.150) |
| ln_er*diff_product | | | 0.0761 | 0.0772 |
| | | | (0.129) | (0.129) |
| ln_gdp | 4.931*** | 4.501*** | 4.846*** | 4.599*** |
| | (0.163) | (0.204) | (0.145) | (0.185) |
| ln_gdpcn | 0.494*** | 0.518*** | 0.560*** | 0.568*** |
| | (0.0351) | (0.0358) | (0.0283) | (0.0285) |
| wto | | 0.109*** | | 0.0668** |
| | | (0.0308) | | (0.0311) |
| aftreform | -0.443*** | -0.402*** | -0.649*** | -0.605*** |
| | (0.0788) | (0.0797) | (0.0625) | (0.0657) |
| Constant | -75.44*** | -68.87*** | -75.60*** | -71.70*** |
| | (2.140) | (2.837) | (1.996) | (2.700) |
| Observations | 47,342 | 47,342 | 47,342 | 47,342 |
| R-squared | 0.401 | 0.401 | 0.402 | 0.402 |
| Number of commodity | 3,824 | 3,824 | 3,824 | 3,824 |
| Fixed Effect | YES | YES | YES | YES |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10. prod_diff omitted because of collinearity

### 3.4.4. Underlying mechanism of exchange rate effects on exports

Thus far, my results show that depreciation or appreciation of the RMB against the USD encourages or discourages, respectively, Chinese exports to the US at a product-level and it affects exports differently by industry, time period, and product category. The exchange rate effect on trade is more significant or stronger for capital-intensive industries vs. labor-intensive industries, stronger after China joined the WTO and during the 2008 Global Financial Crisis, and more significant for heterogeneous or differentiated products than for homogenous or reference-priced products.

But what is the underlying mechanism behind the impact of exchange rate movements on trade and these differences? Exploiting this rich dataset permits me to give an answer. Exchange rates can affect exports both directly and indirectly. In a direct channel, exchange rate appreciation or depreciation will be reflected in export prices at different degrees depending on exchange rate pass-through. Changes of export prices do affect the demand for such goods, depending on price elasticity of export or import demand. Therefore, exchange rate affects export value. Sometimes, exporters absorb all the positive or negative effect of exchange rate shocks (zero exchange rate pass-through). In this case, though the export price remains the same, firms' overseas sales and profits measured by a local currency are affected. Thus, exchange rate fluctuations indirectly affect firms' behavior in exporting. The exchange rate elasticity of exports captures some of these indirect effects.

I consider the differences among industries, time periods, and product categories, and run three

separate regressions: exchange rate pass-through, price elasticity of export demand, and exchange rate elasticity of exports. Table 3.10 summarizes the results and the detailed regression results can be found in Appendices A and B. The results show that USD/RMB depreciation will lead to lower Chinese export prices (incomplete exchange rate pass-through), which generates more demand for Chinese goods and increases China's export quantity and total value exported to the United States. Exchange rate movements affect capital-intensive exports more than labor-intensive exports probably because capital-intensive exports have a higher exchange rate pass-through (due to a lower price elasticity of demand) and higher exchange rate export elasticity as shown in Column 4. The same is true for differentiated goods which have a higher exchange rate pass-through than homogeneous goods (Li and Zhao, 2016). My results are similar to Li and Zhao (2016)'s finding, though slightly smaller[35]. The economic reason behind this is that by nature, differentiated goods, the category to which the majority of capital-intensive goods belong, have a greater scope of quality differentiation while homogenous goods often have a universal market price and less flexibility to change prices (Fan, Li and Yeaple 2015; Fan, Lai and Li, 2015), in addition to lower price sensitivity or price elasticity of demand. I also investigate how China's joining of the WTO and the 2008 Global Financial Crisis shape the exchange rate effects on Chinese exports to the US in terms of exchange rate pass-through, export demand elasticity, and exchange rate elasticity.

[35] Two factors may contribute to this difference. First, model specification. Li and Zhao (2016) used forward exchange rates in the analysis while my research looks at the contemporary exchange rate. Second, different time periods. I cover a much longer period of time between 1989 to 2015 while were focused the period of 2000-08.

Table 3. 10 Summary of regression results of ERPT, export demand elasticity, and ER export elasticity

| | Dependent (1) | Predictor (2) | Total (3) | Cap ids. (4) | WTO (5) | GFC (6) | Diff_prod (7) |
|---|---|---|---|---|---|---|---|
| Overall effect | Export Value | USD/RMB | Positive | Larger | Larger | Larger | Larger |
| ER Pass-through | Export price | USD/RMB | Negative (Incomplete) | Higher | Higher | Higher | Higher |
| Export Demand Elasticity | Export Quantity | Export Price | Negative | Lower | Insignificant | Lower | Lower |
| ER Export Elasticity | Export Quantity | USD/RMB | Positive | Lower | Higher | Lower | insignificant |

## 3.5. China: competition or cooperation

As shown in Table 3.11, the emergence of China in trade implies the country competes with all its important neighbors in the US market, but to different degrees. This empirical result aligns with the general perception about China in recent years, that China is growing fast and starting to compete with everyone. The competition pressure is most important for economies with similar economic structures and levels of economic development such as Malaysia, Taiwan, and Thailand.

Table 3. 11 Regression results by including other foreign currencies in the region

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Var. | JPY | KRW | TWD | AUD | MYR | THB | IDR | VND | INR |
| ln_er | 0.345*** | 0.409*** | 0.347*** | 0.422*** | 0.317*** | 0.355*** | 0.373*** | 0.401*** | 0.510*** |
| | (0.0481) | (0.0447) | (0.0484) | (0.0443) | (0.0464) | (0.0467) | (0.0460) | (0.0552) | (0.0432) |
| ln_jpy | -0.126*** | | | | | | | | |
| | (0.0268) | | | | | | | | |
| ln_krw | | -0.0942*** | | | | | | | |
| | | (0.0278) | | | | | | | |
| ln_twd | | | -0.346*** | | | | | | |
| | | | (0.0781) | | | | | | |
| ln_aud | | | | -0.283*** | | | | | |
| | | | | (0.0265) | | | | | |
| ln_myr | | | | | -0.377*** | | | | |
| | | | | | (0.0358) | | | | |
| ln_thb | | | | | | -0.239*** | | | |
| | | | | | | (0.0396) | | | |
| ln_idr | | | | | | | -0.0762*** | | |
| | | | | | | | (0.0133) | | |
| ln_vnd | | | | | | | | 0.0154 | |
| | | | | | | | | (0.0365) | |
| ln_inr | | | | | | | | | -0.207*** |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | (0.0318) |
| ln_gdp | 3.921*** | 3.953*** | 4.063*** | 4.346*** | 4.760*** | 4.440*** | 4.351*** | 3.759*** | 4.075*** |
| | (0.120) | (0.109) | (0.117) | (0.120) | (0.134) | (0.136) | (0.129) | (0.111) | (0.115) |
| ln_gfcf | 0.291*** | 0.299*** | 0.296*** | 0.221*** | 0.207*** | 0.231*** | 0.266*** | 0.310*** | 0.342*** |
| | (0.0216) | (0.0205) | (0.0206) | (0.0220) | (0.0221) | (0.0235) | (0.0210) | (0.0219) | (0.0212) |
| Phase 1 | 0.00285 | -0.0136 | 0.0264 | 0.0239 | 0.0132 | -0.00997 | -0.0220 | -0.0266 | 0.0514 |
| | (0.0377) | (0.0375) | (0.0385) | (0.0377) | (0.0375) | (0.0375) | (0.0376) | (0.0404) | (0.0379) |
| Phase 2 | -0.239*** | -0.254*** | -0.190*** | -0.229*** | -0.221*** | -0.229*** | -0.259*** | -0.268*** | -0.224*** |
| | (0.0297) | (0.0290) | (0.0338) | (0.0293) | (0.0294) | (0.0293) | (0.0290) | (0.0290) | (0.0295) |
| Phase 3 | 0.0806*** | 0.0416* | 0.0992*** | 0.0254 | 0.0503** | 0.0509** | 0.0376 | 0.0605** | 0.0419* |
| | (0.0240) | (0.0234) | (0.0261) | (0.0231) | (0.0233) | (0.0233) | (0.0231) | (0.0236) | (0.0232) |
| Phase 4 | 0.0372*** | 0.0439*** | 0.0709*** | 0.0421*** | 0.0525*** | 0.0429*** | 0.0403*** | 0.0358*** | 0.0187 |
| | (0.0120) | (0.0122) | (0.0144) | (0.0121) | (0.0122) | (0.0120) | (0.0120) | (0.0125) | (0.0117) |
| wto | 0.0283** | 0.0310** | 0.0432*** | 0.0341** | 0.0119 | 0.0415*** | 0.0247* | 0.0339** | 0.0101 |
| | (0.0139) | (0.0139) | (0.0147) | (0.0141) | (0.0140) | (0.0144) | (0.0138) | (0.0137) | (0.0136) |
| Constant | -59.20*** | -60.00*** | -61.11*** | -64.92*** | -70.71*** | -65.82*** | -65.51*** | -57.90*** | -63.28*** |
| | (1.490) | (1.376) | (1.455) | (1.525) | (1.727) | (1.642) | (1.652) | (1.426) | (1.529) |
| Obs | 284,692 | 284,692 | 284,692 | 284,692 | 284,692 | 284,692 | 284,692 | 284,692 | 284,692 |
| R-sqd | 0.331 | 0.331 | 0.331 | 0.331 | 0.331 | 0.331 | 0.331 | 0.331 | 0.331 |
| ID | 23,894 | 23,894 | 23,894 | 23,894 | 23,894 | 23,894 | 23,894 | 23,894 | 23,894 |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10 and clustered with product id

However, the picture can be very different when products are divided into labor-intensive industries and capital-intensive industries. For instance, with the exception of Japan, China is competing with all major Asian economies in labor-intensive industries, especially Taiwan, Thailand, and Korea (Table 3.12). However, in capital-intensive industries, Taiwan, Korea, and Vietnam now have a complementary relationship probably due to a regional Production Network with China while Malaysia, which is at a similar economic development stage, and Japan seem to be challenged by China in the GVCs as illustrated in Table 3.13.

The complementary relationship in international trade exists between two countries when an increase in export of one country to a third country benefits the export of the other country. In other words, the exports of these two economies have a positive correlation. Often such a relationship can be found among countries within the same regional Production Network or GVC. A classic example is China's export of mobile phones. To make a mobile phone, China needs to import a production line (high-tech machines) and many inputs or intermediate goods, which cannot be sourced domestically with a reasonable price and quality, such as batteries, optics, displays, memory chips, and semiconductors which are sourced from Japan, Korea, and Taiwan. For instance, depreciation of the Japanese Yen means the price of all Japanese products including those used to produce Chinese exports decreases. This lowers Chinese production costs and ultimately benefits Chinese exports to different degrees depending on the share of Japanese inputs in the final exports. In this section, I examine the overall effect of Japanese depreciation on Chinese exports at a product-level, rather than how Chinese products compete with Japanese products within the

same category in the US.

Table 3. 12 Regression results by including foreign currencies in the region in labor-intensive industries

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Var. | JPY | KRW | TWD | AUD | MYR | THB | IDR | VND | INR |
| ln_er | 0.263*** | 0.161* | 0.0514 | 0.184** | 0.120 | 0.0997 | 0.0963 | 0.337*** | 0.228*** |
| | (0.0911) | (0.0843) | (0.0912) | (0.0837) | (0.0876) | (0.0879) | (0.0868) | (0.111) | (0.0837) |
| ln_jpy | 0.142** | | | | | | | | |
| | (0.0556) | | | | | | | | |
| ln_krw | | -0.268*** | | | | | | | |
| | | (0.0573) | | | | | | | |
| ln_twd | | | -0.651*** | | | | | | |
| | | | (0.163) | | | | | | |
| ln_aud | | | | -0.114** | | | | | |
| | | | | (0.0552) | | | | | |
| ln_myr | | | | | -0.231*** | | | | |
| | | | | | (0.0749) | | | | |
| ln_thb | | | | | | -0.323*** | | | |
| | | | | | | (0.0818) | | | |
| ln_idr | | | | | | | -0.150*** | | |
| | | | | | | | (0.0287) | | |
| ln_vnd | | | | | | | | -0.132* | |
| | | | | | | | | (0.0712) | |
| ln_inr | | | | | | | | | -0.0992 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | (0.0649) |
| ln_gdp | 1.035*** | 1.685*** | 1.731*** | 1.426*** | 1.796*** | 2.087*** | 2.311*** | 1.387*** | 1.340*** |
| | (0.255) | (0.231) | (0.253) | (0.254) | (0.287) | (0.290) | (0.281) | (0.233) | (0.243) |
| ln_gfcf | 0.436*** | 0.377*** | 0.382*** | 0.378*** | 0.349*** | 0.304*** | 0.324*** | 0.432*** | 0.428*** |
| | (0.0454) | (0.0429) | (0.0433) | (0.0457) | (0.0464) | (0.0486) | (0.0440) | (0.0456) | (0.0444) |
| Phase 1 | -0.131* | -0.0853 | -0.0171 | -0.0833 | -0.0835 | -0.0889 | -0.106 | -0.0393 | -0.0677 |
| | (0.0789) | (0.0784) | (0.0810) | (0.0791) | (0.0783) | (0.0783) | (0.0783) | (0.0861) | (0.0807) |
| Phase 2 | -0.351*** | -0.272*** | -0.169** | -0.298*** | -0.286*** | -0.261*** | -0.294*** | -0.331*** | -0.294*** |
| | (0.0632) | (0.0622) | (0.0718) | (0.0629) | (0.0628) | (0.0629) | (0.0621) | (0.0618) | (0.0634) |
| Phase 3 | 0.187*** | 0.171*** | 0.293*** | 0.203*** | 0.211*** | 0.207*** | 0.178*** | 0.179*** | 0.208*** |
| | (0.0491) | (0.0484) | (0.0532) | (0.0478) | (0.0482) | (0.0482) | (0.0477) | (0.0489) | (0.0480) |
| Phase 4 | 0.00237 | 0.0352 | 0.0761*** | 0.0105 | 0.0182 | 0.0190 | 0.0200 | -0.0124 | -0.000515 |
| | (0.0243) | (0.0247) | (0.0294) | (0.0245) | (0.0248) | (0.0244) | (0.0244) | (0.0253) | (0.0239) |
| wto | 0.0156 | 0.00550 | 0.0300 | 0.00978 | -0.00267 | 0.0220 | -0.00597 | -0.000648 | -0.00130 |
| | (0.0292) | (0.0292) | (0.0305) | (0.0293) | (0.0294) | (0.0300) | (0.0290) | (0.0291) | (0.0287) |
| Constant | -17.36*** | -23.66*** | -24.08*** | -21.32*** | -26.23*** | -28.87*** | -32.88*** | -21.22*** | -21.05*** |
| | (3.130) | (2.908) | (3.114) | (3.224) | (3.685) | (3.528) | (3.607) | (3.011) | (3.245) |
| Obs | 74,337 | 74,337 | 74,337 | 74,337 | 74,337 | 74,337 | 74,337 | 74,337 | 74,337 |
| R-sqd | 0.195 | 0.195 | 0.195 | 0.195 | 0.195 | 0.195 | 0.195 | 0.195 | 0.195 |
| ID | 5,738 | 5,738 | 5,738 | 5,738 | 5,738 | 5,738 | 5,738 | 5,738 | 5,738 |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10 and clustered with product id

Table 3. 13 Regression results by including foreign currencies in the region in capital-intensive industries

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| Var. | JPY | KRW | TWD | AUD | MYR | THB | IDR | VND | INR |
| ln_er | 0.741*** | 0.932*** | 1.010*** | 0.928*** | 0.818*** | 0.922*** | 0.938*** | 0.397** | 0.909*** |
| | (0.166) | (0.155) | (0.165) | (0.152) | (0.161) | (0.161) | (0.158) | (0.197) | (0.151) |
| ln_jpy | -0.311*** | | | | | | | | |
| | (0.0917) | | | | | | | | |
| ln_krw | | 0.204** | | | | | | | |
| | | (0.0936) | | | | | | | |
| ln_twd | | | 0.470* | | | | | | |
| | | | (0.254) | | | | | | |
| ln_aud | | | | -0.154* | | | | | |
| | | | | (0.0907) | | | | | |
| ln_myr | | | | | -0.409*** | | | | |
| | | | | | (0.120) | | | | |
| ln_thb | | | | | | 0.0262 | | | |
| | | | | | | (0.135) | | | |
| ln_idr | | | | | | | 0.0436 | | |
| | | | | | | | (0.0419) | | |
| ln_vnd | | | | | | | | 0.437*** | |
| | | | | | | | | (0.124) | |
| ln_inr | | | | | | | | | 0.0128 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | (0.110) |
| ln_gdp | 5.407*** | 4.711*** | 4.720*** | 5.440*** | 6.220*** | 5.046*** | 4.776*** | 4.428*** | 5.102*** |
| | (0.423) | (0.374) | (0.397) | (0.422) | (0.454) | (0.446) | (0.424) | (0.384) | (0.402) |
| ln_gfcf | 0.450*** | 0.531*** | 0.524*** | 0.445*** | 0.376*** | 0.508*** | 0.528*** | 0.450*** | 0.497*** |
| | (0.0735) | (0.0697) | (0.0699) | (0.0749) | (0.0728) | (0.0777) | (0.0699) | (0.0751) | (0.0738) |
| Phase 1 | 0.447*** | 0.387*** | 0.342*** | 0.421*** | 0.431*** | 0.402*** | 0.406*** | 0.202 | 0.399*** |
| | (0.128) | (0.126) | (0.131) | (0.127) | (0.127) | (0.127) | (0.127) | (0.137) | (0.127) |
| Phase 2 | 0.206** | 0.105 | 0.0327 | 0.150 | 0.175* | 0.133 | 0.135 | 0.204** | 0.134 |
| | (0.0986) | (0.0954) | (0.112) | (0.0959) | (0.0971) | (0.0962) | (0.0954) | (0.0959) | (0.0963) |
| Phase 3 | 0.283*** | 0.262*** | 0.171* | 0.201** | 0.208*** | 0.227*** | 0.240*** | 0.358*** | 0.227*** |
| | (0.0834) | (0.0803) | (0.0904) | (0.0785) | (0.0796) | (0.0801) | (0.0784) | (0.0802) | (0.0797) |
| Phase 4 | 0.282*** | 0.255*** | 0.227*** | 0.278*** | 0.293*** | 0.275*** | 0.274*** | 0.344*** | 0.277*** |
| | (0.0429) | (0.0436) | (0.0505) | (0.0429) | (0.0440) | (0.0433) | (0.0430) | (0.0444) | (0.0415) |
| wto | -0.0397 | -0.0302 | -0.0503 | -0.0332 | -0.0586 | -0.0372 | -0.0317 | -0.000325 | -0.0351 |
| | (0.0468) | (0.0461) | (0.0493) | (0.0474) | (0.0469) | (0.0481) | (0.0461) | (0.0454) | (0.0454) |
| Constant | -86.51*** | -80.54*** | -80.76*** | -88.64*** | -98.87*** | -84.04*** | -80.52*** | -75.45*** | -84.59*** |
| | (5.324) | (4.766) | (5.014) | (5.381) | (5.862) | (5.395) | (5.442) | (4.942) | (5.287) |
| Obs | 21,777 | 21,777 | 21,777 | 21,777 | 21,777 | 21,777 | 21,777 | 21,777 | 21,777 |
| R-sqd | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 | 0.449 |
| ID | 1,957 | 1,957 | 1,957 | 1,957 | 1,957 | 1,957 | 1,957 | 1,957 | 1,957 |

*Note:* Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10 and clustered with product id

Some caveats should be noted in interpreting the results. I do not consider the potential impact of Chinese export performance on the exchange rate movement of its neighbors and the existence of hard currencies, such as AUD and JPY. For example, the performance of the Australian Dollar (AUD) is strongly correlated with Chinese exports, to the US because the country depends on the Chinese market for its commodity exports as demonstrated in Appendix C. Japan is no longer competing with China if we consider the interaction term between the JPY and the GFC perhaps because of the JPY's safe haven currency status during the Global Financial Crisis (Appendix C).

## 3.6. Conclusion

This chapter revisits the role of the USD/RMB in Chinese exports to the US using the most detailed or disaggregated HS 10-digit[36] product-level data from 1989 to 2015. In addition, the chapter uses the local exchange rate as a proxy to assess China's competition with its most important Asian neighbors. I present several interesting findings. First, USD/RMB appreciation both in nominal and real terms discourages Chinese exports to the US. It is also noted that the exchange rate effect on trade is larger at a product-level than at a country-level, likely due to an aggregation problem. This justifies my use of highly disaggregated data.

Second, exchange rate movements affect exports differently by sector, time period, and product category. Capital-intensive industries and differentiated goods are more sensitive to changes in exchange rates, and the effect of exchange rate movements

[36] Li and Zhao (2016) also used the same dataset merged with Chinese customs transaction-level database to study forward exchange rate pass-through on Chinese export price at a firm-level between 2000 and 2008.

increased after China's WTO accession in 2001 and during the 2008 Global Financial Crisis. Differences in exchange rate pass-through, price elasticity of export demand, and exchange rate elasticity of exports across industries, time periods, and product categories are likely the reasons behind these results. Third, overall, China is competing with almost all Asian countries for the US market. However, China may cooperate with some Asian countries in certain sectors such as electronics through the global production network. Finally, although exchange rates affect Chinese exports, US demand is by far the most important determinant.

## Chapter 4. Exchange Rate Volatility, Value-added Trade, and Intra-regional trade in East Asia

Abstract

Value-added export is what really matters to an economy in terms of job creation and value generation. Traditional approaches using gross trade data to measure and study trade faces more challenges and criticisms due to "double counting" and multi-country production chains (Johnson, 2014) and some evidence indicates that the rise of Global Value Chains (GVCs) and Global Production Networks (GPNs) has weakened the link (IMF, 2015). The literature presents no consensus on the relationship between exchange rate volatility and gross trade, and it also lacks empirical studies on the impact on value-added trade. To fill the gap, this study empirically re-examines the relationship between exchange rate volatility and trade using new value-added bilateral trade data for 41 countries during 1995~2013 in comparison with the gross trade. The results of using the Poisson Pseudo-Maximum-Likelihood (PPML) method provide several findings. First, exchange rate volatility discourages trade in general, but more significantly for value-added trade. Second, trade costs resulting from geographical distance and common language and border effects between two countries has become less important in value-added trade. Third, results confirm that, as in gross trade, the empirical results of real or nominal exchange on trade are similar in value-added trade and companies do respond to the volatility of the previous year in making export decisions for the current year. Fourth, developed countries face lower exchange rate risks. Last but not least, intra-regional trade is less responsive to exchange rate volatility in East Asia and NAFTA, especially in NAFTA.

*Keywords*: value-added trade, exchange rate volatility, international trade, intra-regional trade, East Asia, NAFTA
*JEL Classification*: F31 F14 F40

## 4.1. Introduction

Since the collapse of the Bretton Woods system, the debate on the impact of exchange rate volatility on international trade has never stopped among academics and policymakers. In times of financial crisis, many governments seek to intervene in foreign exchange markets by arguing that volatile exchange rates will hurt their exports and harm their economy. The most recent high-profile case, which was well covered in the G20 and G7 meetings, was Japan's intervention in the so-called "excessive volatility and disorder movements" of the foreign exchange early in 2016.

But how does exchange rate volatility affect trade? There is no consensus on this topic either theoretically or empirically. In early theoretical studies, exchange rate volatility was often seen as an additional commercial risk and a transaction cost associated with international trade. Thus, greater volatility means more uncertainty of expected profits and consequently, firms will reduce their outputs and exports (Clark, 1973). Exchange rate volatility also can be a sunk cost or fixed entry cost that discourages firms from exporting (Hayakawa and Kimura, 2009). Many empirical studies have proven this negative relationship (Hooper and Kohlhagen, 1978; Baron, 1976; Cushman 1983; IMF, 1984; Feenstra and Kendall, 1991; Arize et al., 2000; Willem Thorbecke, 2008; Ozturk and Kalyoncu, 2009; Hayakawa and Fimura, 2009; Chit et al., 2010). However, these conclusions rely on many theoretical assumptions such as perfect competition, the absence of imported inputs, high aversion to risk, and the absence of hedging financial instruments (Auboin and Ruta, 2011). Once those assumptions are relaxed, the relationship between exchange rate volatility and trade becomes more complicated and ambiguous.

Alternatively, some studies suggest a positive relationship. Depending on the level of

risk aversion, greater exchange rate volatility may lead highest risk-averse firms to increase their overseas sales (the income effect is larger than the substitution effect) owing to an expected revenue cut per export unit (De Grauwe, 1998). Broll and Eckwert (1999) reconfirmed the positive relationship by studying heterogeneous firms' responses to exchange rate volatility. Some researchers reported the same findings using different datasets and estimation techniques (Mckenzie and Brooks, 1997; Brada and Mendez, 1998; Klein and Shambaugh, 2006; Rahman and Serletis, 2009). At the same time, many other researchers did not find a significant association between exchange rate volatility and trade (Hondroyiannis et al., 2008; Boug and Fagereng, 2010; Tenreyro, 2007). The ambiguity suggests the well-accepted view that the study of exchange rate volatility on trade is an empirical issue (Chit et al., 2010) given that econometric results rely heavily on the model specification, samples, time periods, and estimation methods.

Almost all exchange rate and trade literature relies on gross trade data which may no longer be accurate in measuring "real" bilateral trade positions given the rise of production networks, due to "double counting" and multi-country production chains (Johnson, 2014). As Johnson (2014) pointed out, the gross trade data overestimate or underestimate bilateral trade relations and foreign exposure when intermediate trade dominates two-thirds of world trade. For instance, China only created a value of $6.5 to the I-phone's total manufacturing cost of $179 but the gross trade data reports China's I-phone export to the US as $179 per unit, which dramatically inflated Chinese exports to the US because the outdated gross trade statistics do not reveal trade based on supply chains (Xing and Detert, 2010; Xing, 2012). Thus, the USD-RMB movements are likely to have a limited impact on the US-China bilateral gross trade given China's "final assembly" status in the supply chain. Nicita (2013) and IMF (2015) noted that the impact

of exchange rate on trade has decreased following the rise of production networks together with the availability of hedging products.

As demonstrated in the case of the I-phone (Xing and Detert, 2010), exchange rate movements are likely to have a different impact on trade, particularly in magnitude, between gross trade data and trade in value-added. Moreover, it is the value-added of final exports that really matters to job creation, value generation, and wealth accumulation. Therefore, it is necessary and critical to re-examine the impact of exchange rate on trade using value-added trade data and compare it with the results using gross trade data. As value-added trade directly measures the price level of a country's real labor and capital inputs (Johnson, 2014), it is expected that exchange rate volatility will have a negative and more sensitive relationship than that measured in gross trade.

This study is, to the best knowledge of the author, the first to examine the impact of exchange rate volatility on value-added trade using comprehensive bilateral value-added trade data. The exercise will contribute to the empirical literature of exchange rate and trade by providing several novel findings in connection with value-added trade. Multiple analyzes were conducted in comparison with gross trade: the impact of exchange rate volatility on value-added trade; trade costs or trade frictions in value-added trade; the effects of nominal exchange rate volatility and short-term volatility on trade; the impact of exchange rate volatility on intra-regional trade which is relevant to Thorbecke's (2008) and Hayakawa and Kimura's (2009) work on East Asia; and the impact of value-added trade in different stages of economic development.

Chapter 4 is constructed as follow. Section 2 discusses the data and methodology. Section 3 reports the results. Section 4 concludes.

## 4.2. Data and methodology

### 4.2.1. Data

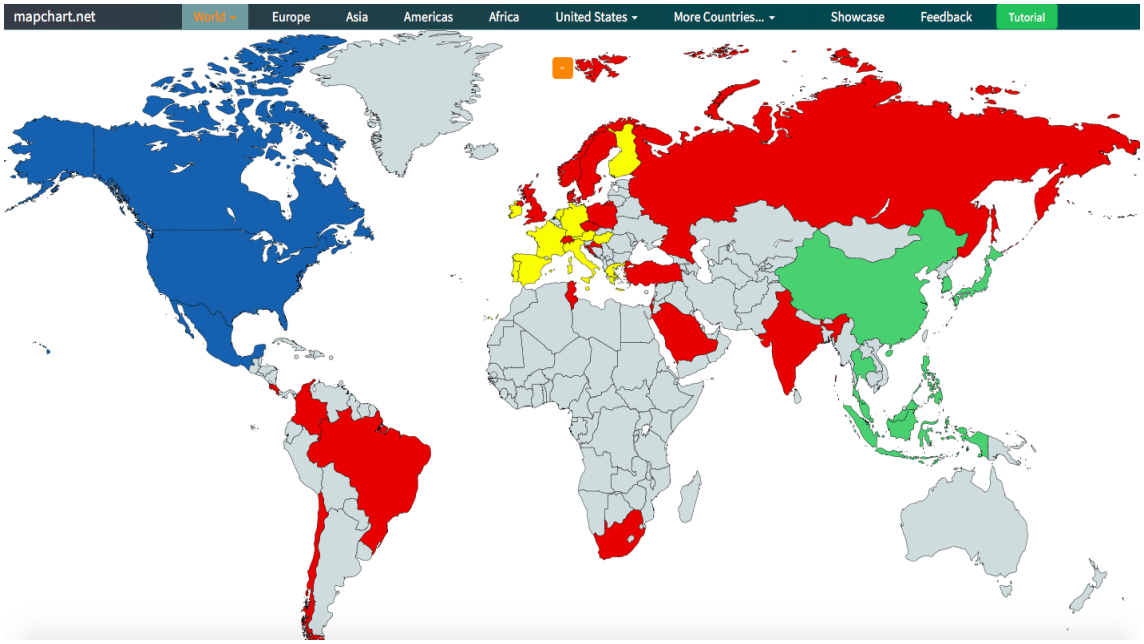
The sample includes annual bilateral trade among 41 countries[37] (see the Figure 4.1 below) from 1995 to 2013. While the gross trade data is World Trade Flows (WTF) bilateral data[38], the value-added trade data[39] is made available by Duval, Li, Saraf, and Seneviratne who constructed the data set based on the OECD-WTO Trade in Value Added (TiVA) dataset and published their work in the *Journal of International Economics* (Duval, et al., 2016). Countries can participate in Global Value Chains (GVCs) through a forward participation (the seller's perspective, the export of goods and services that will be used by other countries to export) and backward participation (the buyer's perspective, purchasing foreign inputs or intermediaries to export). The Value-added exports in this dataset are recorded as a forward participation to GVCs from an exporter or seller's perspective. Both gross export data and Value-added exports (TiVA) are in millions of US dollars. The GDP and GDP deflator are from the World Development Indicators at the World Bank. The GDP deflator data is used to generate the real GDP, real gross, and value-added exports.

[37] The availability of data on monthly exchange rate and monthly CPI from 1995~2013 limits the number of sample countries. Belgium and Luxembourg were dropped as the two countries were treated as one combined entity in trade statistics until 1999.

[38] World Trade Flows (WTF) bilateral data is constructed based on UN COMTRADE database by Robert C. Feenstra and Robert Lipsey and is available at http://cid.econ.ucdavis.edu/Html/WTF_bilateral.html

[39] The original OECD-WTO Trade is only available for selected years and the authors used methods of interpolation and extrapolation to generate annual value-added trade data. They have proved their data is reliable and details of their work can be found at their paper "*Value-added trade and business cycle synchronization*" on Journal of International Economics, 2016.

Figure 4. 1 Sample countries




*Source*: graphed by the author based on the dataset

The nominal monthly exchange rate is derived from the International Financial Statistics (IFS) of the IMF and the real term is obtained by deflating the monthly consumer price index[40] at IFS. Control variables related to the gravity model such as distance, common language, adjacency (contiguous), Regional Trade Agreements, population, and colony are downloaded from the Gravity Dataset from the website of the Centre d'Études Prospectives et d'Informations Internationales (CEPII). The correlation of the exchange rate volatility and trade (gross and value added) without controlling other factors are illustrated in Appendix D. The summary statistics of the main variables are shown in Table 4.1.

[40] Chinese monthly CPI was found at the Federal Reserve Bank of St. Louis https://fred.stlouisfed.org/tags/series?t=china%3Bcpi

Table 4. 1 Summary Statistics

| Variable | Obs | Mean | Std. Dev | Min | Max |
|---|---|---|---|---|---|
| Real TiVA | 31,160 | 3775291 | 1.29E+07 | 0 | 3.46E+08 |
| Real Gross Export | 31,160 | 4627523 | 1.65E+07 | 0 | 4.50E+08 |
| Log_TiVA | 31,158 | 13.22346 | 2.150619 | 4.43741 | 19.66168 |
| Log_Gross Export | 29,516 | 11.88141 | 2.6102 | -2.318883 | 21.65787 |
| Real ER Vol | 31,160 | 0.7827764 | 0.6656752 | 0.0021269 | 2.980767 |
| Nominal ER Vol | 31,160 | 0.7574027 | 0.6429797 | 0 | 3.612946 |
| RER Vol (T) | 31,160 | 0.7948418 | 0.6786822 | 0.0016942 | 3.142886 |
| Log GDPi | 28,400 | 25.40791 | 1.94102 | 20.08501 | 31.56992 |
| Log GDPj | 28,400 | 25.40791 | 1.94102 | 20.08501 | 31.56992 |
| Log Distance | 31,160 | 8.538924 | 0.9279997 | 5.6215 | 9.871479 |
| Adjacency | 31,160 | 0.0414634 | 0.1993627 | 0 | 1 |
| Common Language | 31,160 | 0.0890244 | 0.2847835 | 0 | 1 |
| Colony | 31,160 | 0.0353659 | 0.1847057 | 0 | 1 |
| Log Population i | 31,160 | 3.421076 | 1.46629 | 1.437331 | 7.179154 |
| Log Popolation j | 31,160 | 3.421076 | 1.46629 | 1.437331 | 7.179154 |
| RTA | 31,160 | 0.3560976 | 0.4788522 | 0 | 1 |

4.2.2. Methodology

The gravity model is often used to examine bilateral trade flows and is one of the most successful empirical models in economics (Anderson, 2010). Following recent literature (Tenreyro, 2004; Clark, Tamirisa, and Wei, 2004; Hayakawa and Kimura, 2009), this study also uses the gravity model in exploring the impact of exchange rate volatility on trade in value-added and gross trade.

The gravity model usually suffers from the "zero trade flow" problem, which causes information loss and potentially biased results. The Poisson Pseudo Maximum Likelihood (PPML) estimation method is often used and is arguably the best tool for addressing the "zero trade" issue in the gravity model (Santos,Siliva and Tenreyro, 2006, 2011). This study employs the PPML method for the baseline analysis while OLS and panel fixed effect are also used for robustness check.

The baseline equation is as below:

$$Export_{ij,t} = \beta_0 + \beta_1 ln\ GDP_{i,t} + \beta_2 ln\ GDP_{j,t} + \beta_3 ln\ distance_{ij} + \beta_4 Vol_{ij,t} + \delta_k Control_{ij,t} + \varepsilon_{ij,t}$$

$Export_{ij,t}$ represents real export values of country *i* to country *j* at time *t* in either gross trade or in TiVA (trade in value-added). $ln\ GDP_{i,t}$ and $ln\ GDP_{j,t}$ are the log of the real GDP of country *i* and the log of real GDP of country *j* respectively at time *t*. $ln\ distance_{ij,t}$ is the log of geographical distance between country *i* and country *j*. $Control_{ij,t}$ stands for several control variables that are often used in gravity models. In this study, $Control_{ij,t}$ includes dummy variables and takes a value of 1 if two countries

share a common language, common border, are former colonies one of the other, or have a regional trade agreement; it is 0 otherwise. The control variables also include the log of population of country $i$ and country $j$.

$Vol_{ij,t}$ is the volatility of real or nominal exchange rate. Lacking consensus on the best measurement of exchange rate volatility, this study employs the widely used first-difference approach; the first-difference of the monthly natural logarithm of bilateral exchange rate (real and nominal) in the current and previous years (IMF, 2004). This method captures both the lag and anticipated effect of volatility on firms' export decisions (Thorbeck, 2008). Contemporaneous volatility or short-term volatility, which is the first-difference of the monthly natural logarithm of bilateral exchange rate in the current year, is also used for robustness check.

## 4.3. Estimation results

This section reports the econometric results, which include baseline results; extension of the baseline equation by controlling more variables; robustness checks; and adding interaction variables with East Asia, NAFTA, and high-income countries.

### 4.3.1. Baseline analysis

Table 4.2 reports the baseline results and suggests a significant negative relationship between real exchange rate volatility and export value in both value-added exports and gross exports regardless of the estimation methods, including PPML, OLS,

and Fixed Effects[41]. The rest of the gravity variables are as expected.

[41] Hausman Test was performed and it suggests applying Fixed Effects rather than Random Effects.

Table 4. 2 Baseline results of three different estimation methods

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | PPML | OLS | Fixed Effects | PPML | OLS | Fixed Effects |
| VARIABLES | TiVA | TiVA | TiVA | Gross Export | Gross Export | Gross Export |
| Log_Real $GDP_i$ | 0.367*** | 0.461*** | 0.0505*** | 0.386*** | 0.821*** | 0.745*** |
| | (0.00955) | (0.00519) | (0.00493) | (0.0100) | (0.00446) | (0.00955) |
| Log_Real $GDP_j$ | 0.372*** | 0.404*** | -0.00434 | 0.424*** | 0.520*** | 0.190*** |
| | (0.0104) | (0.00533) | (0.00510) | (0.0119) | (0.00463) | (0.00723) |
| Log_Distance | -0.0410 | -0.547*** | | -0.0603** | -0.632*** | |
| | (0.0263) | (0.0109) | | (0.0277) | (0.00943) | |
| *Real ER Volatility* | -0.155*** | -0.0792*** | -0.203* | -0.0462* | 0.000491 | -1.093*** |
| | (0.0263) | (0.0150) | (0.109) | (0.0266) | (0.0128) | (0.179) |
| *Adjacency* | 1.190*** | 1.004*** | | 1.330*** | 0.840*** | |
| | (0.0784) | (0.0465) | | (0.0769) | (0.0385) | |
| *Common Language* | 0.391*** | 0.558*** | | 0.475*** | 0.716*** | |
| | (0.0600) | (0.0332) | | (0.0636) | (0.0313) | |
| *Colony* | 0.0802 | 0.478*** | | -0.299*** | 0.140*** | |
| | (0.0608) | (0.0423) | | (0.0555) | (0.0387) | |
| *Constant* | -4.083*** | -4.221*** | 12.14*** | -5.749*** | -17.06*** | -11.18*** |
| | (0.438) | (0.216) | (0.169) | (0.520) | (0.191) | (0.319) |
| *Observations* | 25,894 | 25,892 | 25,892 | 25,894 | 25,855 | 25,855 |
| *R-squared* | 0.262 | 0.503 | 0.006 | 0.274 | 0.738 | 0.717 |
| *Number of id* | | | 1,638 | | | 1,638 |

*Note:* Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

### 4.3.2. Extension of more control variables

Following previous studies, this study extended the baseline equation by controlling more variables, namely population and the dummy variable regional trade agreement (RTA) while controlling country-year pair dummy variables as shown in Table 4.3. Intuitively, the growth of population (a proxy for domestic production and demand) and having an RTA help increase trade flows. The major results are consistent, and all expected except an unusual, but understandable, negative relationship with colony[42] in gross exports. The PPML results suggest that the negative impact of real exchange rate volatility on exports is greater in TiVA than in gross exports. One explanation may be that value-added exports measure the value-added as an output of labor and capital within a national boundary in final exports, thus the real exchange rate volatility changes the price competitiveness of local labor and capital and leads to a direct impact on the value-added exports to the final market.

Furthermore, the table shows that values of geographic distance, adjacency, and common language are smaller in TiVA. This empirical finding echoes the argument that GVCs reduce the sensitivity of exports to bilateral geographic distance as value-added export can involve third countries (Johnson, 2014). For the same reason, trade friction or trade costs caused by common borders and language barriers also become weaker.

[42] Some literatures suggest colony and trade can have a negative relationship as many former colonies got independence by opposing former colonizers. As a result, the bilateral trade between two countries saw a decline after independence.

Table 4. 3 Estimation results by controlling more variables using PPML method

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| VARIABLES | TiVA | TiVA | TiVA | Gross Export | Gross Export | Gross Export |
| $Log\_Real\ GDP_i$ | 0.377*** | 0.287*** | 0.281*** | 0.398*** | 0.311*** | 0.309*** |
| | (0.00883) | (0.00839) | (0.00825) | (0.00928) | (0.00791) | (0.00776) |
| $Log\_Real\ GDP_j$ | 0.380*** | 0.292*** | 0.286*** | 0.431*** | 0.357*** | 0.355*** |
| | (0.00927) | (0.00866) | (0.00845) | (0.0104) | (0.00923) | (0.00892) |
| *Log_Distance* | -0.129*** | -0.653*** | -0.555*** | -0.170*** | -0.664*** | -0.636*** |
| | (0.0236) | (0.0190) | (0.0258) | (0.0255) | (0.0177) | (0.0258) |
| *Real ER Volatility* | -0.0998*** | -0.220*** | -0.211*** | 0.0162 | -0.0862*** | -0.0828*** |
| | (0.0264) | (0.0264) | (0.0265) | (0.0269) | (0.0250) | (0.0256) |
| *Adjacency* | 1.207*** | 0.537*** | 0.500*** | 1.337*** | 0.704*** | 0.693*** |
| | (0.0707) | (0.0537) | (0.0486) | (0.0653) | (0.0465) | (0.0467) |
| *Common Language* | 0.471*** | 0.638*** | 0.631*** | 0.564*** | 0.736*** | 0.735*** |
| | (0.0550) | (0.0479) | (0.0456) | (0.0565) | (0.0493) | (0.0494) |
| *Colony* | -0.0190 | 0.0127 | 0.0612 | -0.409*** | -0.382*** | -0.367*** |
| | (0.0590) | (0.0489) | (0.0469) | (0.0524) | (0.0413) | (0.0431) |
| $Log\_Population_i$ | | 0.416*** | 0.442*** | | 0.405*** | 0.412*** |
| | | (0.0129) | (0.0137) | | (0.0151) | (0.0156) |
| $Log\_Population_j$ | | 0.413*** | 0.438*** | | 0.362*** | 0.369*** |
| | | (0.0116) | (0.0119) | | (0.0133) | (0.0139) |
| *RTA* | | | 0.371*** | | | 0.107 |
| | | | (0.0465) | | | (0.0665) |
| *Import-year dummy* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Export-year dummy* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Constant* | -4.526*** | 1.354*** | 0.517 | -6.119*** | -0.663* | -0.893** |
| | (0.399) | (0.332) | (0.368) | (0.462) | (0.368) | (0.442) |
| Observations | 25,894 | 25,894 | 25,894 | 25,894 | 25,894 | 25,894 |
| R-squared | 0.317 | 0.487 | 0.517 | 0.348 | 0.544 | 0.551 |

*Note:* Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.

### 4.3.3. Robustness check

Three methods are used in robustness checks for the interest variable: different estimation methods, nominal exchange rate volatility, and different measurement of real exchange volatility. The results reconfirm the significance and robustness of the previous estimation results.

Table 4.4 shows the results of the robustness check using OLS and Fixed Effects. Results of both OLS and Fixed Effects confirm the direction of exchange rate volatility using the PPML method. However, it is noted that Fixed Effects suggests a more sensitive relationship in gross trade while PPML reports a greater impact of volatility on TiVA. This difference is due to the choice of estimation method and is usually acceptable given it does not change the sign of the relationship.

Table 4. 4 Robustness check using OLS and Fixed Effects

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | PPML | OLS | Fixed Effects | PPML | OLS | Fixed Effects |
| VARIABLES | TivA | TiVA | TiVA | Gross Export | Gross Export | Gross Export |
| $Log\_Real\ GDP_i$ | 0.281*** | 0.377*** | 0.0489*** | 0.309*** | 0.804*** | 0.618*** |
| | (0.00825) | (0.00459) | (0.00558) | (0.00776) | (0.00442) | (0.00906) |
| $Log\_Real\ GDP_j$ | 0.286*** | 0.311*** | -0.00591 | 0.355*** | 0.460*** | 0.0629*** |
| | (0.00845) | (0.00465) | (0.00592) | (0.00892) | (0.00447) | (0.00724) |
| *Log_Distance* | -0.555*** | -0.849*** | | -0.636*** | -0.766*** | |
| | (0.0258) | (0.0135) | | (0.0258) | (0.0132) | |
| *Real ER Volatility* | -0.211*** | -0.126*** | -0.207* | -0.0828*** | 0.00151 | -1.409*** |
| | (0.0265) | (0.0134) | (0.110) | (0.0256) | (0.0123) | (0.203) |
| *Adjacency* | 0.500*** | 0.527*** | | 0.693*** | 0.646*** | |
| | (0.0486) | (0.0401) | | (0.0467) | (0.0346) | |
| *Common Language* | 0.631*** | 0.577*** | | 0.735*** | 0.736*** | |
| | (0.0456) | (0.0313) | | (0.0494) | (0.0305) | |
| *Colony* | 0.0612 | 0.408*** | | -0.367*** | 0.0918** | |
| | (0.0469) | (0.0385) | | (0.0431) | (0.0370) | |
| *RTA* | 0.371*** | 0.0652*** | | 0.107 | 0.0567** | |
| | (0.0465) | (0.0247) | | (0.0665) | (0.0251) | |
| $Log\_Population_i$ | 0.442*** | 0.365*** | | 0.412*** | 0.0727*** | |
| | (0.0137) | (0.00654) | | (0.0156) | (0.00574) | |
| $Log\_Population_j$ | 0.438*** | 0.420*** | | 0.369*** | 0.291*** | |
| | (0.0119) | (0.00707) | | (0.0139) | (0.00655) | |
| *Import-year dummy* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Export-year dummy* | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.517 | 0.0486 | 11.98*** | -0.893** | -15.49*** | -24.23*** |
| | (0.368) | (0.214) | (0.332) | (0.442) | (0.210) | (0.580) |
| Observations | 25,894 | 25,892 | 25,892 | 25,894 | 25,855 | 25,855 |
| R-squared | 0.517 | 0.613 | 0.006 | 0.551 | 0.766 | 0.748 |
| Number of id | | | 1,638 | | | 1,638 |

*Note:* Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<*0.*

As indicated in Table 4.5, the results are robust. In addition, the result reconfirms that the choice of real or nominal exchange rate makes no significant difference in empirical studies on trade flows (IMF, 2004). This empirical evidence is also true in value-added trade.

Table 4. 5 Robustness check using nominal exchange rate volatility

| VARIABLES | (1) PPML TivA | (2) OLS TiVA | (3) Fixed Effects TiVA | (4) PPML Gross Export | (5) OLS Gross Export | (6) Fixed Effects Gross Export |
|---|---|---|---|---|---|---|
| $Log\_Real\ GDP_i$ | 0.282*** | 0.377*** | 0.0481*** | 0.311*** | 0.804*** | 0.615*** |
| | (0.00823) | (0.00460) | (0.00557) | (0.00772) | (0.00443) | (0.00874) |
| $Log\_Real\ GDP_j$ | 0.287*** | 0.311*** | -0.00666 | 0.356*** | 0.460*** | 0.0598*** |
| | (0.00849) | (0.00466) | (0.00589) | (0.00892) | (0.00448) | (0.00686) |
| *Log_Distance* | -0.556*** | -0.849*** | | -0.639*** | -0.764*** | |
| | (0.0257) | (0.0135) | | (0.0257) | (0.0132) | |
| *Nominal ER Vol.* | -0.211*** | -0.129*** | -0.0965** | -0.0588** | -0.00612 | -0.511*** |
| | (0.0273) | (0.0139) | (0.0483) | (0.0257) | (0.0128) | (0.0775) |
| *Adjacency* | 0.497*** | 0.524*** | | 0.693*** | 0.646*** | |
| | (0.0486) | (0.0400) | | (0.0465) | (0.0346) | |
| *Common Language* | 0.633*** | 0.577*** | | 0.738*** | 0.734*** | |
| | (0.0458) | (0.0313) | | (0.0497) | (0.0305) | |
| *Colony* | 0.0597 | 0.406*** | | -0.366*** | 0.0932** | |
| | (0.0470) | (0.0385) | | (0.0432) | (0.0370) | |
| *RTA* | 0.372*** | 0.0685*** | | 0.110* | 0.0562** | |
| | (0.0464) | (0.0246) | | (0.0664) | (0.0251) | |
| $Log\_Population_i$ | 0.440*** | 0.366*** | | 0.411*** | 0.0729*** | |
| | (0.0137) | (0.00655) | | (0.0156) | (0.00574) | |
| $Log\_Population_j$ | 0.436*** | 0.421*** | | 0.368*** | 0.292*** | |
| | (0.0119) | (0.00708) | | (0.0140) | (0.00655) | |
| *Import-year dummy* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Export-year dummy* | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.482 | 0.0497 | 11.82*** | -0.960** | -15.47*** | -25.26*** |
| | (0.370) | (0.214) | (0.328) | (0.442) | (0.210) | (0.578) |
| Observations | 25,894 | 25,892 | 25,892 | 25,894 | 25,855 | 25,855 |
| R-squared | 0.515 | 0.613 | 0.006 | 0.549 | 0.766 | 0.747 |
| Number of id1 | | | 1,638 | | | 1,638 |

*Note:* Robust standard errors in parentheses and*** p<0.01, ** p<0.05, * p<0.1

As Table 4.6 presents, results are as expected and also robust using different measurements of real exchange volatility. The real exchange rate volatility in this regression is calculated as the first-difference of the monthly natural logarithm of bilateral real exchange rate in the current year. This measurement is contemporaneous and short-term, and it removes the partial effect of the volatility of the previous year. Consistent with my expectation, exports are slightly less sensitive to short-term volatility. In other words, companies do respond to the volatility observed in the previous year when making export decisions, though the effect may be very small.

Table 4. 6 Robustness check using different measurement of real exchange rate volatility

| | (1) PPML | (2) OLS | (3) Fixed Effects | (4) PPML | (5) OLS | (6) Fixed Effects |
|---|---|---|---|---|---|---|
| VARIABLES | TivA | TiVA | TiVA | Gross Export | Gross Export | Gross Export |
| $Log\_Real\ GDP_i$ | 0.282*** | 0.378*** | 0.0489*** | 0.309*** | 0.805*** | 0.617*** |
| | (0.00827) | (0.00460) | (0.00562) | (0.00776) | (0.00442) | (0.00917) |
| $Log\_Real\ GDP_j$ | 0.287*** | 0.312*** | -0.00590 | 0.355*** | 0.461*** | 0.0622*** |
| | (0.00844) | (0.00465) | (0.00594) | (0.00889) | (0.00447) | (0.00732) |
| *Log_Distance* | -0.556*** | -0.851*** | | -0.636*** | -0.767*** | |
| | (0.0258) | (0.0135) | | (0.0260) | (0.0132) | |
| RER Vol. *current* | -0.198*** | -0.109*** | -0.112 | -0.0797*** | 0.0104 | -0.896*** |
| | (0.0262) | (0.0131) | (0.0958) | (0.0253) | (0.0121) | (0.135) |
| *Adjacency* | 0.501*** | 0.526*** | | 0.694*** | 0.645*** | |
| | (0.0486) | (0.0401) | | (0.0467) | (0.0346) | |
| *Com. Language* | 0.631*** | 0.581*** | | 0.735*** | 0.738*** | |
| | (0.0457) | (0.0313) | | (0.0494) | (0.0305) | |
| *Colony* | 0.0622 | 0.405*** | | -0.367*** | 0.0900** | |
| | (0.0471) | (0.0386) | | (0.0431) | (0.0370) | |
| *RTA* | 0.373*** | 0.0671*** | | 0.108 | 0.0573** | |
| | (0.0465) | (0.0247) | | (0.0665) | (0.0251) | |
| $Log\_Population_i$ | 0.441*** | 0.365*** | | 0.412*** | 0.0725*** | |
| | (0.0137) | (0.00654) | | (0.0156) | (0.00574) | |
| $Log\_Population_j$ | 0.437*** | 0.420*** | | 0.369*** | 0.291*** | |
| | (0.0119) | (0.00707) | | (0.0139) | (0.00655) | |
| *Import-year* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Export-year* | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.511 | 0.0287 | 11.97*** | -0.890** | -15.50*** | -24.13*** |
| | (0.367) | (0.214) | (0.341) | (0.440) | (0.210) | (0.586) |
| *Observations* | 25,894 | 25,892 | 25,892 | 25,894 | 25,855 | 25,855 |
| *R-squared* | 0.517 | 0.612 | 0.005 | 0.551 | 0.766 | 0.746 |
| *Number of id1* | | | 1,638 | | | 1,638 |

*Note:* Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.

#### 4.3.4. Results of adding interaction variables of East Asia, NAFTA, and High-Income Economies

Following the re-opening of China and the enactment of the North American Free Trade Agreement in the 1990s, the share of intra-regional trade has increased dramatically in two regions thanks to regional production networks (Paprzycki and Ito, 2010). Exchange rate volatility can have a more serious negative impact on regional trade, particularly in the case of East Asia where a large amount of the trade is in intermediate goods (Thorbecke, 2008; Hayakawa and Kimura, 2009). To re-examine the effect of exchange rate volatility on intra-regional trade more generally, I include the interaction variables intra-Asia and intra-NAFTA trade with exchange rate volatility. Intra-regional trade is a dummy variable which equals to 1 if both exporters and importers are located within the same geographic region and 0 otherwise.

Different from previous studies by Thorbecke (2008) and Hayakawa and Kimura (2009), Table 7 suggests that intra-regional trade in East Asia[43] and NAFTA has a positive relationship with exchange rate volatility. East Asian companies whose trading partners are also in the region saw a decreased impact of exchange rate volatility on value-added export and a positive impact on gross trade. In addition, NAFTA countries all observe a positive relationship with exchange rate volatility. In another words, companies in a regional production network[44] generally export no less than otherwise when observing exchange rate volatility and being part of a global production network is advantageous for regional exporters. This advantage is greater in NAFTA than in East Asia. The different result may come from the model specification, estimation techniques, and, most importantly, different dataset[45].

Given these results, a natural question is why intra-regional trade is less sensitive to

[43] In this study, East Asia includes 9 economies: China, Japan, Korea, Hong Kong, Malaysia, Indonesia, Thailand, Philippines, and Vietnam.

[44] I acknowledge this statement is based on a strong, if not unrealistic, assumption because being part of the region does not necessarily mean companies or exporters are all involved in a regional production networks. Ideally, I should use a better indicator to capture the effect regional production network: such as an intra-industry share of total trade, vertical specialization proxy, and, intermediate goods share of total trade.

[45] Thorbecke (2008) used DOLS technique to examine electronics trade in East Asia. Hayakawa and Kimura (2009) employed OLS method to study manufacturing and machinery trade in East Asia.

exchange rate volatility in East Asia, particularly in NAFTA. Conceptually, these results may indicate that most of the intra-regional trade in the process of production network is done by large Multinational Corporations in the region with arm-length trade. Intra-firm trades for production purposes are less responsive to exchange rate volatility and other external disturbances. Many factors affect the difference in exchange rate effects on trade between East Asia and North America. For instance, both regions have vertical specialization and vertical intra-industry trade, but the structure of regional production networks[46] is very different. Another reason may be the difference of certain industry concentration in intraregional trade. For example, automotive components (SITC 78) and other transport equipment (SITC 79) accounted for over a third of components traded in NAFTA compared to less than 5% in East Asia in 2005-06 (Athukorala, 2010). NAFTA's concentration on the automobile with a few players (more intra-firm trade) and East Asia's focus on electronics (more inter-firm trade) with relatively more players (market competition structure) may be the reason. Future study of firms' export behaviors in intra-regional trade in response to exchange rate volatility will give a more detailed and comprehensive answer.

Table 4.7 also suggests that developed countries or high-income economies[47] face less exchange rate volatility risk probably due to the development of financial markets (more hedging financial instrument) and more export destinations (diversification effect). In general, exchange rate volatility discourages TiVA more than gross export.

[46] The structure of production networks in North America is more simplistic (for example: a US firm/HQs sends intermediate goods to its own factory in Mexico, and have its subsidiary firm export the final goods back to the US), while the East Asian Production Networks are open-ended and much more complicated, which involves a number of different companies in several countries trading with each other at an arm's length (inter-firm) or intra-firm (Kimura & Obashi, 2011).

[47] High-Income Economies are based on World Bank's clarification.

Table 4. 7 Results of adding interaction variables of East Asia, NAFTA and High-Income Economies

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| VARIABLES | TiVA | TiVA | TiVA | Gross Export | Gross Export | Gross Export |
| $Log\_Real\ GDP_i$ | 0.283*** | 0.280*** | 0.215*** | 0.311*** | 0.310*** | 0.267*** |
| | (0.00832) | (0.00795) | (0.0105) | (0.00784) | (0.00740) | (0.00972) |
| $Log\_Real\ GDP_j$ | 0.288*** | 0.284*** | 0.315*** | 0.358*** | 0.354*** | 0.373*** |
| | (0.00846) | (0.00823) | (0.00894) | (0.00899) | (0.00858) | (0.00920) |
| *Log_Distance* | -0.529*** | -0.602*** | -0.561*** | -0.574*** | -0.692*** | -0.642*** |
| | (0.0225) | (0.0274) | (0.0256) | (0.0234) | (0.0281) | (0.0255) |
| *Real ER Volatility* | -0.247*** | -0.253*** | -0.565*** | -0.167*** | -0.130*** | -0.292*** |
| | (0.0266) | (0.0267) | (0.0403) | (0.0252) | (0.0259) | (0.0368) |
| *Asia*RER Vol* | 0.193*** | | | 0.405*** | | |
| | (0.0589) | | | (0.0460) | | |
| *NAFTA*RER Vol* | | 1.226*** | | | 1.339*** | |
| | | (0.128) | | | (0.108) | |
| *HIC*RER Vol* | | | 0.595*** | | | 0.368*** |
| | | | (0.0488) | | | (0.0430) |
| *Adjacency* | 0.520*** | 0.341*** | 0.514*** | 0.738*** | 0.517*** | 0.701*** |
| | (0.0474) | (0.0509) | (0.0477) | (0.0465) | (0.0462) | (0.0463) |
| *Com.language* | 0.628*** | 0.688*** | 0.621*** | 0.727*** | 0.800*** | 0.730*** |
| | (0.0450) | (0.0459) | (0.0449) | (0.0482) | (0.0491) | (0.0488) |
| *Colony* | 0.0639 | 0.0733 | 0.0608 | -0.360*** | -0.359*** | -0.367*** |
| | (0.0466) | (0.0472) | (0.0460) | (0.0429) | (0.0447) | (0.0423) |
| $Log\_Population_i$ | 0.436*** | 0.425*** | 0.521*** | 0.399*** | 0.392*** | 0.462*** |
| | (0.0139) | (0.0139) | (0.0165) | (0.0160) | (0.0159) | (0.0184) |
| $Log\_Population_j$ | 0.432*** | 0.421*** | 0.421*** | 0.355*** | 0.349*** | 0.359*** |
| | (0.0116) | (0.0118) | (0.0116) | (0.0135) | (0.0136) | (0.0138) |
| *RTA* | 0.384*** | 0.205*** | 0.394*** | 0.139** | -0.0957 | 0.120* |
| | (0.0448) | (0.0504) | (0.0461) | (0.0641) | (0.0733) | (0.0661) |
| *Import-year* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Export-year* | Yes | Yes | Yes | Yes | Yes | Yes |
| *Constant* | 0.297 | 1.359*** | 1.334*** | -1.418*** | 0.0175 | -0.366 |
| | (0.355) | (0.397) | (0.365) | (0.441) | (0.477) | (0.449) |
| *Observations* | 25,894 | 25,894 | 25,894 | 25,894 | 25,894 | 25,894 |
| *R-squared* | 0.520 | 0.529 | 0.536 | 0.555 | 0.571 | 0.562 |

*Note:* Robust standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1

## 4.4. Conclusion

In the literature on the effect of exchange rate volatility on trade there is no consensus, though many findings show a negative relationship of exchange rate volatility on gross trade, however, there is no empirical study on its impact on value-added trade. This study took place at a time when the traditional approach to measuring and studying international trade has encountered an increasing amount of criticism due to "double counting" problems and multi-country production chains following the rise of GVCs and global production networks.

This study empirically investigated the relationship between exchange rate volatility and value-added trade in comparison with the gross trade. The summary of findings is as follows. First, exchange rate volatility has a significant negative relationship with exports, particularly in value-added exports. This provides evidence to support the hypothesis that value-added trade is more sensitive to exchange rate volatility than gross trade as it directly affects the price of labor and capital inputs by removing indirect foreign inputs. The results support Ito et al.'s (2017) finding that the Heckscher-Ohlin theory should be used to explain the flows of value-added trade and does a better job in predicting value-added trade than gross trade because countries export real "value" that is created or produced based on their abundant factors of production, such as skilled labor vs. unskilled labor, which can be captured by value-added trade data.

Second, trade frictions or costs caused by geographical distance, common language,

and border effects are smaller in value-added trade as firms can bypass these trade barriers by export via third countries. Third, exporters do respond to exchange rate volatility of the previous year and, consistent with the literature, nominal and real exchange rate makes no significant difference in this type of empirical exercise even in value-added trade. Fourth, high-income countries face less exchange rate risk likely due to the development of financial markets and the diversification effect of having multiple export destinations.

Last but not least, intra-regional trade is less responsive to exchange rate volatility in East Asia and NAFTA, especially in NAFTA, which is probably due to the market structure and concentration on automobile industries. This preliminary finding suggests that being part of a regional production network may help exporters cushion the blow of exchange rate volatility. The results are different from the findings of Thorbecke (2008) and Hayakawa and Kimura (2009) who argue that exchange rate volatility can be more damaging to East Asian intra-regional trade as the volatility increases fixed costs for trading and reduces locational benefits of overseas fragmentation. The author agrees with this argument. Nevertheless, the different results may be due to the choices of estimation method and difference in sampling and products. Another explanation may be the timing, that is, comparison before and after the set-up of a regional production networks can produce very different pictures. My findings indicate that many exporters rely on overseas sourcing, supplies, and other foreign inputs in the process of production, and change of suppliers is often costly and time-consuming once the fixed costs have been incurred or the

regional production network has already been established. Therefore, the impact of exchange rate volatility on trade is reduced in an intra-regional trade where the regional production network has already formed.

The findings have three policy implications. First, policymakers should pay more attention to exchange rate volatility as it affects value-added trade even more than gross trade, and government should encourage this vigilance. Second, governments should encourage global production networks because exports can be more stable once they are established, and in times of volatile exchange rates, global production networks can bypass bilateral trade barriers such as geographic distance with export via third countries. Third, countries should support the development of financial markets and hedging products.

## Chapter 5. Conclusion

In this exercise, I conducted a comprehensive study on the linkage between exchange rate movements and international trade from three different perspectives: firms, products, and value-added trade. I attempt to answer three main questions in Chapters 2-4. First, are firms in selected ASEAN countries immune to currency appreciation, and how do firms with different characteristics respond to a steady currency appreciation? I found that South East Asian firms are not special, and their exports were discouraged by local currency appreciation. Firms do respond differently to exchange rate movements depending on their respective firm size, ownership structure, experience in exporting, and foreign inputs in their exports. The difference of exchange rate effects between total export at a country level and export at a firm level is probably due to a data aggregation problem.

Second, how does the value of the Chinese Renminbi against the US Dollar affect Chinese exports at a highly disaggregated product level, and is China's rise a threat to the region? Results indicate that the increase of the USD/RMB exchange rate (depreciation) encourages Chinese exports. The exchange rate effect on trade is more pronounced at a highly disaggregated product level than at an aggregated country level, and it varies by industry, time period, and product category. Overall, Chinese exports seem to compete with all of its neighbors in Asia.

Third, how does the bilateral exchange rate volatility affect value-added trade in comparison with gross trade? Based on Ito et al.'s (2017) finding that the H-O theory

supports value-added trade even better. Value-added trade, which captures the real export "value" created based on factor abundance (skilled vs. unskilled labor) and removes foreign inputs from gross trade, is more vulnerable to exchange rate fluctuations.

Contrary to the growing perception that changes in exchange rates no longer matter to trade owing to the rise of Global Value Chains (GVCs) and availability of financial hedging instruments, my analysis suggests that a linkage between exchange rate movements and trade still exists. My results remain even using disaggregated firm-level and HS 10-digit product-level data as well as value-added trade data. In fact, the linkage is even stronger if I use an alternative measurement of trade (value-added trade) rather than the traditional gross trade.

Besides the academic contribution detailed in each of the main chapters, my research also relates to recent challenges of the world trade system and has several implications. First, my analysis of US-China trade relations using highly disaggregated data from 1989 to 2015 implies that in the event of a trade war, RMB devaluation/depreciation may help Chinese exports, but the effect is limited because the US domestic demand is by far the most important determinant of Chinese exports to the US. Thus, using a currency devaluation tool to boost Chinese exports may not be a good policy to use given the repercussions in the capital market.

Second, the rise of China in global trade means that China's economic miracle has provided tremendous opportunities for the Asia Pacific region. The rise of China in global

trade, an abrupt increase of Chinese exports both in volume and product offerings, has put a pressure on neighboring countries, including developed ones. Third, my analysis is relevant for designing trade policy. Governments should pay more attention to exchange rates movements because their impact on trade is even larger using value-added trade measurements. Policymakers who only consider the macro picture may be at risk of missing an underlying micro-mechanism because of the aggregation issue. Lastly, governments should have SMEs support policy and encourage foreign investment and production networks which will help lower the exchange rate risks and bypass bilateral trade barriers.

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## Appendix

Appendix A

Based on the literature on Exchange rate Pass-Through, I follow a standard model to estimate the USD/RMB exchange rate pass-through elasticity. The model specification is as follows:

$$\Delta p_{i,t} = \Delta ER_t + \ \Delta \pi_t + F_i + \epsilon_{i,t}$$

Where $i$, $t$ stand for product $i$ and year $t$. Dependent variable $\Delta p_{i,t}$ is the log export/import price difference of product $i$ in year $t$. $\Delta ER_t$ and $\Delta \pi_t$ are the log yearly exchange rate difference and the log inflation rate (Chinese CPI) difference. $F_i$ is the fixed effects of product $i$ and $\epsilon_{i,t}$ is the error term. The regression results are presented in Table 3.14.

Table 3. 14 Regression results of exchange rate pass through

| VARIABLES | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| DV: Export Price | Total | Labor & Elec | WTO | GFC | Diff prod |
| D.ln_er | -0.227*** | -0.368*** | -0.182*** | -0.151*** | -0.202*** |
| | (0.0276) | (0.116) | (0.0287) | (0.0290) | (0.0263) |
| D.ln_er*labor | | 0.266** | | | |
| | | (0.115) | | | |
| D.ln_er*wto | | | -0.580*** | | |
| | | | (0.0593) | | |
| D.ln_er*gfc | | | | -0.413*** | |
| | | | | (0.0742) | |
| D.ln_er*diff_prod | | | | | -0.107* |
| | | | | | (0.0594) |
| D.wto | | | 1.202*** | | |
| | | | (0.127) | | |
| D.gfc | | | | 0.912*** | |
| | | | | (0.148) | |
| D.cpiCN | 0.00437*** | 0.00427*** | 0.00696*** | 0.00527*** | 0.00423*** |
| | (0.000591) | (0.000804) | (0.000609) | (0.000643) | (0.000553) |
| Constant | 0.0123*** | 0.0115*** | 0.00552*** | 0.00453*** | 0.0118*** |
| | (0.000190) | (0.000317) | (0.000965) | (0.000755) | (0.00261) |
| Observations | 211,806 | 77,783 | 211,806 | 211,806 | 211,806 |
| R-squared | 0.000 | 0.001 | 0.001 | 0.001 | |
| Number of commodity | 18,543 | 6,415 | 18,543 | 18,543 | 18,543 |

*Note*: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Labor and differentiated products variables are omitted because of collinearity.

Appendix B

For price elasticity of export demand and exchange rate elasticity of exports, attention needs to be paid to the changes of dependent variables and independent variables while all other control variables are as the same as the baseline regression in Chapter 3. Price elasticity of export demand measures the change of export demand (quantity) over a unit change in export price, while exchange rate elasticity of exports is calculated using the change of export volume (quantity) in response to a change in exchange rate. The results are presented in Tables 3.15-16.

Table 3. 15 Price elasticity of export demand

| VARIABLES | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| DV: Export Quantity | Total | Labor & Elec | WTO | GFC | Diff prod |
| ln_price | -1.151*** | -0.951*** | -1.157*** | -1.156*** | -1.188*** |
| | (0.00752) | (0.0291) | (0.00843) | (0.00762) | (0.00807) |
| ln_price*labor | | -0.505*** | | | |
| | | (0.0338) | | | |
| ln_price*wto | | | 0.00951 | | |
| | | | (0.00699) | | |
| ln_price*gfc | | | | 0.0156*** | |
| | | | | (0.00589) | |
| ln_price*diff_prod | | | | | 0.186*** |
| | | | | | (0.0193) |
| ln_gdp | 3.361*** | 2.114*** | 3.363*** | 3.365*** | 3.363*** |
| | (0.125) | (0.220) | (0.125) | (0.125) | (0.125) |
| ln_gdpcn | 0.424*** | 0.534*** | 0.423*** | 0.423*** | 0.426*** |
| | (0.0229) | (0.0393) | (0.0229) | (0.0229) | (0.0229) |
| 1994 reform | -0.0898*** | -0.0980*** | -0.0885*** | -0.0886*** | -0.0894*** |
| | (0.0211) | (0.0345) | (0.0210) | (0.0211) | (0.0211) |
| afc | -0.128*** | -0.156*** | -0.128*** | -0.128*** | -0.128*** |
| | (0.0122) | (0.0210) | (0.0122) | (0.0122) | (0.0122) |
| wto | 0.128*** | 0.0388 | 0.107*** | 0.129*** | 0.126*** |
| | (0.0181) | (0.0314) | (0.0234) | (0.0181) | (0.0181) |
| dotcom | -0.274*** | -0.264*** | -0.274*** | -0.275*** | -0.273*** |
| | (0.0167) | (0.0289) | (0.0167) | (0.0167) | (0.0167) |
| gfc | -0.0399** | -0.148*** | -0.0400** | -0.0763*** | -0.0408** |
| | (0.0162) | (0.0274) | (0.0162) | (0.0211) | (0.0162) |

| | | | | | |
|---|---|---|---|---|---|
| Constant | -47.92*** | -28.32*** | -47.93*** | -47.96*** | -47.98*** |
| | (1.763) | (3.117) | (1.763) | (1.763) | (1.762) |
| Observations | 250,690 | 90,351 | 250,690 | 250,690 | 250,690 |
| R-squared | 0.449 | 0.389 | 0.449 | 0.449 | 0.450 |
| Number of commodity | 21,549 | 7,259 | 21,549 | 21,549 | 21,549 |

*Note*: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Dummy variable labor industry and differentiated products are omitted due to collinearity.

Table 3. 16 Exchange rate elasticity of exports

| VARIABLES | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| DV: Export Quantity | Total | Labor & Elec | WTO | GFC | Diff prod |
| ln_er | 1.022*** | 2.249*** | 0.806*** | 0.699*** | 1.009*** |
| | (0.0628) | (0.168) | (0.0696) | (0.0683) | (0.0646) |
| ln_er*labor | | -1.594*** | | | |
| | | (0.161) | | | |
| ln_er*wto | | | 1.500*** | | |
| | | | (0.137) | | |
| ln_er*gfc | | | | 2.218*** | |
| | | | | (0.134) | |
| ln_er*differ | | | | | 0.0911 |
| | | | | | (0.105) |
| ln_gdp | 3.923*** | 2.244*** | 3.115*** | 2.816*** | 3.922*** |
| | (0.153) | (0.254) | (0.163) | (0.162) | (0.153) |
| ln_gdpcn | 0.299*** | 0.483*** | 0.579*** | 0.659*** | 0.299*** |
| | (0.0303) | (0.0496) | (0.0366) | (0.0354) | (0.0303) |
| 1994 reform | -0.681*** | -0.735*** | -0.644*** | -0.600*** | -0.681*** |
| | (0.0415) | (0.0634) | (0.0422) | (0.0422) | (0.0415) |
| afc | -0.0661*** | -0.116*** | -0.0790*** | -0.0818*** | -0.0660*** |
| | (0.0153) | (0.0246) | (0.0154) | (0.0154) | (0.0153) |
| wto | 0.281*** | 0.356*** | -2.960*** | 0.193*** | 0.281*** |
| | (0.0221) | (0.0364) | (0.293) | (0.0222) | (0.0221) |
| dotcom | -0.323*** | -0.517*** | -0.265*** | -0.248*** | -0.323*** |
| | (0.0203) | (0.0342) | (0.0200) | (0.0200) | (0.0203) |
| gfc | -0.00656 | -0.104*** | 0.00653 | -4.604*** | -0.00664 |
| | (0.0201) | (0.0318) | (0.0203) | (0.276) | (0.0201) |

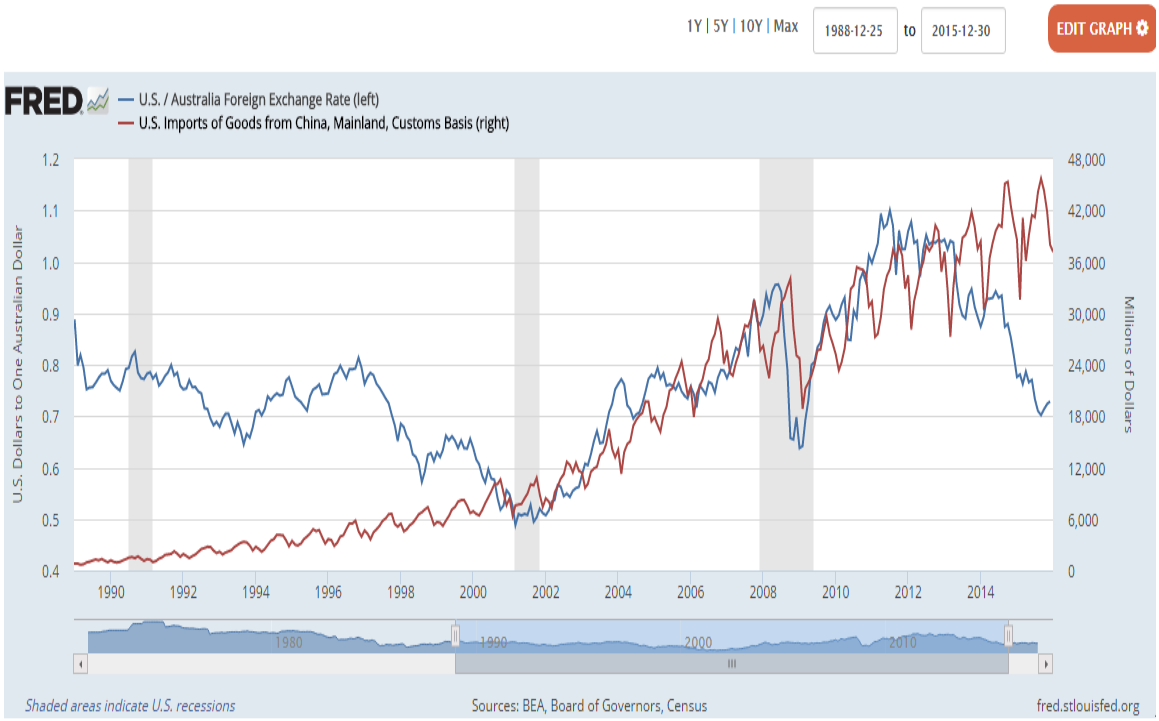
| | | | | | |
|---|---|---|---|---|---|
| Constant | -59.62*** | -34.68*** | -49.92*** | -45.98*** | -59.62*** |
| | (2.126) | (3.535) | (2.238) | (2.232) | (2.126) |
| Observations | 250,690 | 90,351 | 250,690 | 250,690 | 250,690 |
| R-squared | 0.200 | 0.172 | 0.200 | 0.201 | 0.200 |

*Note*: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1. Dummy variable labor industry and differentiated products are omitted due to collinearity.

Appendix C

Australian dollars have a strong correlation with the performance of Chinese exports as shown in Figure 3.3.

Figure 3. 3 Movements of AUD-USD exchange rate and US imports from China




*Source:* Federal Reserve Bank of St. Louis

Table 3. 17 Regression results by including an interaction term between JPY and GFC

| VARIABLES | (1)<br>JPYall | (2)<br>Labor | (3)<br>K:elec |
|---|---|---|---|
| ln_er | 0.448*** | 0.179* | 1.092*** |
| | (0.0522) | (0.0981) | (0.178) |
| ln_jpy | 0.0876* | -0.0411 | 0.420** |
| | (0.0528) | (0.107) | (0.186) |
| jpygfc | -0.274*** | 0.231** | -1.038*** |
| | (0.0580) | (0.117) | (0.207) |
| ln_gdp | 3.903*** | 1.054*** | 5.362*** |
| | (0.119) | (0.254) | (0.421) |
| ln_gfcf | 0.309*** | 0.421*** | 0.511*** |
| | (0.0216) | (0.0454) | (0.0733) |
| Phase 1 | -1.256*** | 0.934* | -4.319*** |
| | (0.270) | (0.548) | (0.964) |
| Phase 2 | -1.528*** | 0.738 | -4.662*** |
| | (0.274) | (0.553) | (0.976) |
| Phase 3 | -1.209*** | 1.277** | -4.589*** |
| | (0.275) | (0.554) | (0.984) |
| Phase 4 | 0.0351*** | 0.00362 | 0.276*** |
| | (0.0120) | (0.0242) | (0.0427) |
| wto | 0.0114 | 0.0301 | -0.0987* |
| | (0.0149) | (0.0308) | (0.0509) |
| Constant | -59.32*** | -17.30*** | -86.72*** |
| | (1.495) | (3.134) | (5.343) |
| Observations | 284,692 | 74,337 | 21,777 |
| R-squared | 0.331 | 0.195 | 0.450 |

*Note*: Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.10 and clustered with product id

Appendix D

The negative correlation between exchange rate volatility and exports (Value-added and gross trade) can be illustrated by simple two-way graphs as shown in Figures 4.2 and 4.3. Without controlling other variables, the slope for gross trade seems to be steeper than value-added trade and the effects of nominal and real exchange rate volatility on trade are very similar.

Figure 4. 2 Scatter plot of exchange rate volatility and TiVA

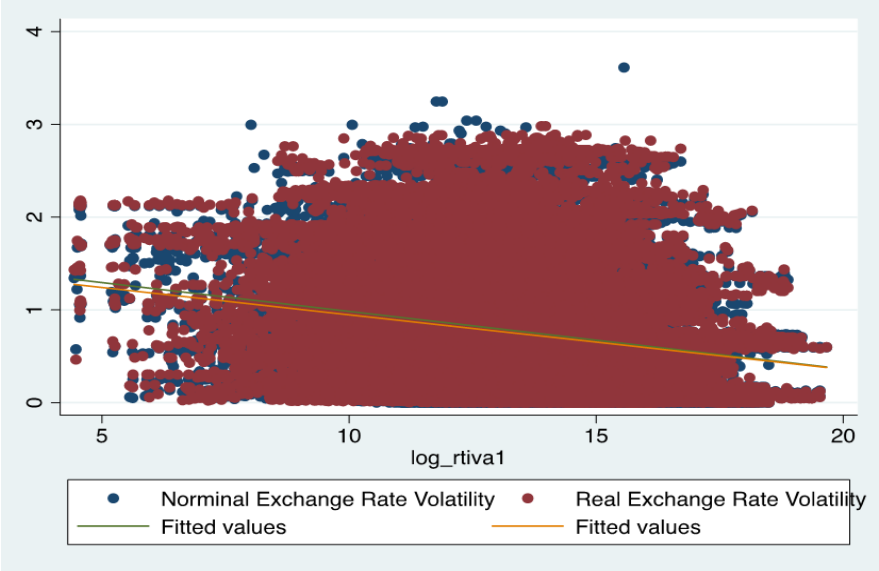


Figure 4. 3 Scatter plot of exchange rate volatility and gross export