LUND UNIVERSITY
School of Economics and Management

Exchange Rate Volatility and Trade:
The Case of Trade among China and ASEAN Countries

Patima Prajakschitt

Supervisor:
Joakim Gullstrand

Abstract

This study investigates the effect of China's exchange rate volatility on imports among China and ASEAN6 countries during 2001 and 2013, using three different measures of exchange rate volatility: volatility of exchange rate against U.S. Dollar, relative exchange rate volatility, and volatility of bilateral exchange rate. The test is performed by using fixed effects method and gravity model. The result indicates that the relationship between exchange rate volatility and trade seems to be insignificant among these countries; and China's effect of volatility on trade is also insignificant.

Keywords: exchange rate volatility, trade flows, ASEAN, China

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1. Introduction

China is currently under a big economic reform. After China begins to adopt market economy in 1987 under the "Open-up Policy", the Chinese economic policy is gradually reformed in all levels, ranging from industry to macro level. The reformation in e*xchange rate policy* is one of the important change, since this could cause significant impact on capital mobility and foreign trade, which are the important parts of the economy. After China changed its exchange rate regime from *dual exchange rate system* to *strictly managed float* (or de facto Dollar-peg system), with $\pm$ 0.25% trading band in 1994, the most important event on China's economic timeline is the accession to the WTO in 2001. This is the starting point of major changes in the Chinese exchange rate and trade policy; this led to the next important move in July 2005, when the basket regime was adopted instead of Dollar-peg, which allowed the Chinese currency (Chinese Yuan, or RMB) to appreciate 21% against the U.S. Dollar during July 2005 and July 2008. After that, China turned back to control the movement of its currency again to alleviate the effect of the financial crisis in 2008 that hit hardly on China's exports. At that time the CNY/USD barely moved around 6.83 for 22 months. Then in June 2010, when the Chinese authority sent a strong signal to allow *more flexibility* in the Chinese currency, followed by a series of trading band widening from $\pm$ 0.5% to $\pm$ 2% in 2012 and 2014. This led to more fluctuation in Chinese currency until present. The long run plan of the Chinese government to allow a higher degree of capital account liberalization might be viewed as an even stronger trigger for Chinese currency to embrace the market mechanism that leads to more volatility in RMB in the future.

Such a drastic change in exchange rate policy raises one concern: is there any possibility that the increase in the volatility of China's exchange rate will affect the Chinese trade flows in the future? As a matter of fact, exports and imports account for 22.6% and 18.9%, respectively, of China's GDP in 2014 (Worldbank.org, 2015). This is relatively high compared to the U.S.[1] Moreover, China is the biggest export country and the second biggest import country in 2013 (WTO.org, 2015a). Any possible change in China's exports could wave the impact to its export markets and import sources, as well as its supply chains. As it is known by intuition, more fluctuation in exchange rate seems to be danger for trading activities since the volatility could lead to the uncertainty in income for the exporters and cost of goods for the importers; thus this may affect the decision of the buyers and sellers in the market.

When concerning China's trade with its trading partners, ASEAN, if aggregated as one country, is the biggest import source and the third biggest export destination of China (China Statistical Yearbook, 2014). The increasing role of ASEAN as a trading partner is contributed by many factors, such as location, border, and trade agreement (ASEAN-China FTA). This makes ASEAN become a part of China's supply chain and important trading partner. In the 21st century, under the close trade

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[1] 13.5% and 16.5%, respectively in 2013 (Worldbank.org, 2015)

relationship with ASEAN, the mission of the Chinese government in reforming the Chinese exchange rate policy still continues. Therefore, it is expected that the Chinese currency will be even more fluctuated in the near future. One could argue that hedging instruments could protect the trading partners from exchange rate risk. However, in fact, the availability is still questionable in developing countries, where the financial industry is not fully-developed. Therefore, it is too fast to presume that the role of the hedging contracts could alleviate the effect of exchange rate volatility in the case of China and ASEAN. Hence the relationship between exchange rate volatility of the Chinese exchange rate and trade flows among China and ASEAN countries is still unknown.

To help foresee the future effect of the change in the Chinese exchange rate policy, which has stimulated the Chinese exchange rate volatility, its historical effect could provide the clue for the effect in the future. This leads to the research question: ***does the volatility of China's exchange rate affect trade flows among China-ASEAN countries?*** This relationship is investigated using historical data during 2001 and 2013, in order to reflect the period after China accessed to the WTO, which is a strong signal that China already sets the clear stance to reform its exchange rate and trade policy. The group of trading partners includes ASEAN6 countries: Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Cambodia, Laos, Myanmar, and Brunei are not included because of data availability issue. The gravity model is used to explain trade flows among the countries. Fixed effects method is used to control for multilateral resistances, which are time-invariant variables that could bias the estimated coefficients.

The structure of this study is as follows: earlier studies are reviewed in part 2, followed by theoretical background in part 3. Then the data and descriptive statistics are presented in part 4. The result is provided in part 5, followed by the discussion in part 6.

2. Earlier studies

The aim of this section is to provide a conclusive picture of the studies about the impact of exchange rate volatility on trade. More importantly, this is to emphasize the relevant literature that can provide the important background of the methodology used in this study. Since there are so many works that investigate in this topic, it is impossible to provide a complete view of the studies in this area. Therefore the relevant literature is the main focus of this part.

Along the time span of the studies in this topic, there are variations in many aspects. ***First*****, the choice of trade variable varies from country level to sub-country level; and from aggregate exports/imports of the particular country, to bilateral exports within the country group in concern**. ***Second*****, model and estimation technique are also different**. Several models and techniques ranging from very simple to advanced are used in previous studies. And ***finally,*** **the measure of**

exchange rate volatility also varies. Several methods are used to measure the volatility of exchange rate in previous pieces of literature.

2.1 The Choice of Trade Variable

1) Country or Sub-country Trade Data

It is relatively common to find that the studies on this certain question try to figure out the relationship at *country level*, by using export, import, or bilateral-trade data in country level. The countries used by previous literature are from around the world. In the case of Asia, the studies always focus on East Asian and developing Asian countries. One example is **Bénassy-Quéré, and Lahrèche-Révil (2003)**, which studies on trade between China and various trading partners. This work investigates the effect of China's exchange rate fluctuation and the *de facto* change in the exchange rate regime on China's trade with 11 Asian exporters and 23 importers from developed and emerging countries during 1984-2001. The result shows that the increase in China's exchange rate volatility has a negative impact on China's trade with OECD countries; but the result does not show significant impact on intra-Asian trade.

Meanwhile, some studies try to focus on the effect of the volatility on *industrial-level trade.* The argument is that this would enable the researchers to investigate deeper into the nature of trade flows of each industry. As country-level data could not allow this, industrial-level exports and imports data are used instead. By using the industry-level data, it is highly possible that the result may be different across different industries. Thus the result might have to be interpreted from the majority of the industries. The example is the work of **Nishimura and Hirayama (2013)**, which studies the effect of China's exchange rate volatility and exchange rate reform after 2005 on bilateral trade between China and Japan. The estimated coefficient of exchange rate volatility is not significant in some industries. The author concludes that evidence of the effect of exchange rate volatility on exports from Japan to China is not found. However, in the case of exports from China to Japan after exchange rate reform, the impact is found in this case, since significant negative impact can be found in the majority of the industries. Another example is **Bahmani-Oskooee and Hegerty (2009)**, which studies the effect of exchange rate volatility on industrial level imports and exports between Mexico and the U.S., using annual data during 1962 – 2004. The result suggests a significant short run negative effect of exchange rate volatility on more than half of the industries. Meanwhile, the long run effect is less obvious: the significant effect is found only in one-third industries, while the sign of the relationship is mixed.

It is obvious that when considering the evidence from previous literature, the effect of exchange rate volatility on trade is still inconclusive. The evidence of the effect is significant in some cases, while insignificant in other cases.

2) Aggregate or Bilateral Trade Data

The studies on this topic could also be categorized by the direction of trade flows: aggregate (one-direction trade) or bilateral trade. **Some studies use aggregate trade**, i.e., focusing on exports or imports of the countries in consideration against all of their trading partners. In many studies, the researchers use effective exchange rate, which is weighted by the importance of the trading partners. Thus this represents the countries' exchange rate against their trading partners. The example is the study of **Gotur (1985),** which re-examines the study of **Akhtar and Hilton (1984)**. Firstly, the author increases the scope of the study from Germany and the U.S., to the two countries plus France, Japan, and the UK. Furthermore, the author adjusts the specifications, estimation method, and volatility measure of previous work. Then the result changes dramatically. No significant impact of exchange rate uncertainty is found, which is contrary to the previous study. This yields an important implication that model, estimation method, and volatility measure are important to the result.

In the meantime, **other studies use bilateral trade data between each of the countries in focus.** The reason behind this alternative is that the nature of inflows and outflows of trade could be different; thus the study on one direction trade flow (export or import) could not reflect this as good as the bilateral-trade flows. Therefore, the studies using the two-way trade could be more generally found. As presented by **Bahmani-Oskooee and Hegerty (2007)**, the studies that use bilateral trade data could be found from all eras of the study. In earlier period, the models are closely derived from import demand and export supply. Thus, economic variables (e.g., unit cost of production) always persist in the test specification, such as in the study of **Hooper and Kohlhagen (1978)**. After that, gravity model is widely used, such as the study of **Brada and Mendez (1988)** and **Dell'Ariccia (1998)**. Therefore, the variables appeared in the specifications always include the basic gravity variables (i.e., income, relative price, and distance) and augmented part (e.g., common language, common border, population, and exchange rate volatility). In the later period, more complexed methodology, such as pool regression, ARCH and GARCH model are introduced to help investigate the relationship. However, no consensus could be found from the results as well.

2.2 Model and Estimation Technique

As mentioned before, there are various models and estimation techniques to investigate the effect of exchange rate uncertainty. Along the timeline of development, new methodologies are developed to get closer to accurate results. The development of model and estimation technique could be briefly presented as follows:

1) Trade market equilibrium and gravity model

The important studies in early period are the works of Hooper and Kohlhagen (1978), Cushman (1983), and Kenen, P. and Rodrik, D. (1986). Based on trade market equilibrium model derived from

import demand and export supply, **Hooper and Kohlhagen (1978)** constructs important models, explaining quantity and price of exports by nominal income (Y), capacity utilization (CU), unit cost (UC and UC^*), domestic price (PD), expected foreign exchange cost (EH and EH^*), and exchange rate volatility (σ_{R1}). The models give the important prediction that in the case of the effect of exchange rate uncertainty *on trade volume*, if both importers and exporters are risk averse, the increase in exchange rate volatility has negative effect on trade volume. In the case of the effect *on price*, if the degree of risk aversion in the exporters increases (i.e., risk aversion of the exporters dominates), the increase in exchange rate uncertainty leads to an increase in export price, since the exporters add the price as risk premium to offset the possible exchange rate loss. If risk averse preference of importers dominates, the volatility has negative effect on price, since the risk decreases import demand of the importers. The models are tested by various trade cases of the U.S. and Germany, against five other industrial countries during 1965-1975, using mean of weekly absolute difference between the current spot and past forward nominal exchange rate as the measure of exchange rate volatility. The results confirm the negative effect of exchange rate uncertainty on price; however, the effect on volume is not significant. The authors explain this as the effect of the inelastic supply of export in short run.

Cushman (1983) develops the models proposed by Hooper and Kohlhagen (1978) by assuming real profit maximization instead of nominal, and also adding the assumption of uncertain foreign and domestic price levels, resulting in the developed version of Hooper and Kohlhagen's models where the firm's decision is based on real variables instead of nominal variables. Cushman uses the models to test the relationship in the same countries as in Hooper and Kohlhagen's work (the U.S. and Germany against other industrial countries). The measure of exchange rate volatility is standard deviation of quarterly change in real exchange rate. The result shows that there is significant negative impact of exchange rate on trade volume in 6 from 16 cases and on trade price in only one case. **Kenen and Rodrik (1986)** makes further contribution by using several measures of exchange rate volatility and using effective exchange rate instead of bilateral exchange rate. The result indicates that significant negative impact is found in 4 countries (the U.S., Canada, Germany, and the UK). No significant positive impact is found.

After the three important works of Hooper and Kohlhagen (1978), Cushman (1983), and Kenen and Rodrik (1986). **The application of trade equilibrium model containing various economic variables boils down to the gravity variables in the next era.** The variables explaining trade activity are commonly centered with the countries' size (or income), prices, distance (or transportation cost), tariff, and countries' common factor, such as border and language.

One of the first studies that uses gravity model is the work of **Thursby and Thursby (1987).** The authors start the derivation at demand and supply model that explains export volume by export price, spot exchange rate, tariff rate, transportation cost, dummy representing importer's hedging (HI),

consumer price index (*CPI*), country's GNP, and consumer's taste (*Z*), represented by per capita income. The initial models boil down to gravity model, and then it is used to investigate the effect of exchange rate volatility on export value. The model is tested using the data of 17 countries, during 1974-1982. The measure of exchange rate volatility is the variance of spot rate around its predicted trend. Two versions of exchange rate volatility are used: nominal and real rate. The results show that the effect of these two versions is indistinguishable. The conclusion is that the coefficient of exchange rate volatility is negative and significant in 10 countries. Thus exchange rate uncertainty affects trade in more than half of the cases.

After Thursby and Thursby (1987), many studies apply gravity model with more general specification. The test equations usually include common gravity variables, augmented by exchange rate volatility. The examples of the studies in this group are as follows:

Brada and Mendez (1988) investigates the effect of exchange rate movement on the value of exports. Dummy variables: *FIX* and *FLOAT* are introduced to gravity model to take account of fixed and flexible exchange rate. The dependent variable is export value, while explanatory variables are importer and exporter's income, population, distance, and dummy representing common trading area (*PRF*). The data sample includes 43 countries, during 1973 – 1977. The estimation method is OLS. The authors conclude that the level of trade flows among floating-regime countries is higher than the flows among fixed-regime countries. Moreover, exchange rate risk affects volume of trade among the countries in the sample.

Frankel and Wei (1993) tests the effect of exchange rate volatility on bilateral trade among 63 countries in the sample. The specification is constructed from gravity model: the explanatory variables are the importer and exporter's GNP, importer and exporter's GNP per capita, distance, common border dummy, and dummies representing common economic bloc. Nominal, and real exchange rate volatility is added to the gravity model as another explanatory variable. The result could be concluded that the hypothesis of the negative effect of exchange rate uncertainty on trade is supported.

Dell'Ariccia (1999) uses the gravity model explaining bilateral trade by importer and exporter's GDP, distance, importer and exporter's population, dummy variables (i.e., common border, EU membership, and common language), and exchange rate volatility. The author uses 4 measures of exchange rate volatility: standard deviation of the first difference of log of real and nominal exchange rate, sum squared forward error, and percentage difference between maximum and minimum nominal spot rate. The sample covers 14 EU countries plus Switzerland. The period is during 1975 – 1994. The estimation methods are pooled FGLS, two-stage generalized least squares, and fixed and random effects estimates. The result shows that the volatility from sum squared forward error provides the coefficients with relatively low magnitude when using pooled FGLS and random/fixed effects.

However, all of the coefficients are negative and significant, which implies that exchange rate volatility has negative effect on bilateral trade.

2) More advanced models

The development in the field of econometrics enables the researchers to develop more complexed methodology in order to investigate the effect of exchange rate uncertainty. This allows the models to be more flexible and more dynamic, which sometimes could contribute to the significance of the result, as concluded by **Bini-Smaghi (1991)** (cited in McKenzie, 1999, p. 94) that one of the factors leading to the insignificant result is the lack of dynamic qualification in the models.

More advanced econometric models enable the scholars to investigate in long run effect. Some studies use cointegration test, such as the study of **Asseery and Peel (1991)**, which uses two-stage Engle-Granger method, **Chowdhury (1993)**, which uses multivariate error correction model, and **Bahmani-Oskooee and Hegerty (2009)** and **Nishimura and Hirayama (2013)**, which apply ARDL bound test in their work. Meanwhile, some studies use ARCH and GARCH model in the test specification, such as the study of **Kroner and Lastrapes (1993)**, which utilizes GARCH and GARCH-in-mean, and **Qian and Varangis (1994)**, which applies ARCH-M model.

In addition to the works appeared in this section, there are much more studies using advanced models. However, since they are beyond the scope of this study, they could be found from McKenzie (1999), p.93-96 and Bahmani-Oskooee and Hegerty (2007), p.222-225**.**

2.3 The Measure of Exchange Rate Volatility

In literature about the effect of exchange rate volatility, there are many ways to measure the volatility. Up until now, there is no consensus about the most appropriate calculation method. Thus the measures of volatility are chosen by the researchers, depending on the assumption toward the movement of the volatility.

The first group of the measures is relatively simple. The measures in this group are based on common statistical properties, i.e., average and standard deviation, applied to exchange rate data for the specific period. This is the most intuitive, and basic way to reflect the volatility of exchange rate in a certain period. The examples of the studies using these methods are as follows: a**bsolute percentage change (across time)**: Bailey et al (1987); **average of absolute percentage change:** Levy-Yeyati, and Sturzenegger (2003a) and Levy-Yeyati, and Sturzenegger (2003b); **standard deviation within a certain period**: Akhtar and Hilton (1984), Hooper and Kohlhagen (1978); **moving standard deviation:** Cushman (1988), Koray and Lastrapes (1989): **moving average of the standard deviation:** Chowdhury (1993).

The second group of the measures is aimed to take into account expected exchange rate: either market expectation (e.g., forward exchange rate), or theoretical expectation (e.g., estimated trend). The application of these measures arises from the assumption that the firms' reaction to exchange rate is based on the expectation toward the level of exchange rate. Therefore, the volatility, which represents the "surprising" movement of exchange rate should reflect the deviation from the expected value, not the past value. Thus, based on this assumption, the volatility calculated in this way could be more appropriate. The examples of the studies that use the measures in this group are as follows: **average of absolute difference between previous forward and current spot rate:** Hooper and Kohlhagen (1978); and **deviation from trend, e.g., variance of the spot rate around its trend:** Thursby and Thursby (1987).

The final group of exchange rate volatility measures is associated with advanced time series model, such as ARIMA residuals and ARCH models. This enables the researchers to utilize the lag terms in the model; and thus allows them to model the volatility series with more complexed structure. The examples of these studies are Qian and Varangis (1994), which uses ARCH model, and Arize and Ghosh (1994), which uses residual ARIMA process.

Some of the studies show that the choice of exchange rate volatility is matter to the test result. For example, Hooper and Kohlhagen (1978) uses three methods of volatility measurement: 1) standard deviation over weekly observations of spot exchange rate 2) standard deviation over weekly observations of forward rate and 3) average of absolute difference between previous forward and current spot rate. The result indicates that the model using the third measure has the best performance in two aspects: it is the fittest model when applied to the data, and also gives more significant estimated coefficients. As another example, the study of Nishimura and Hirayama (2013) uses two types of volatility: standard deviation of exchange rate and ARCH model. The result indicates that ARCH-type volatility yields more significant coefficients; moreover, the estimated sign of the volatility is different in some industries when using different measure of volatility. Evidently, the choice of volatility measure can affect the test. Thus the correct assumption about the volatility and the market reaction to the exchange rate uncertainty is very important.

3. Theoretical Background

3.1 The Theory of Gravity Model

The theory of gravity model is grounded from the model of trade under monopolistic competition and intra-industry trade, which assumes that countries are specialized in different varieties (Feenstra, 2004, p.144). The main implication of basic gravity model is that trade varies, positively by importer and exporter's income and negatively by the distance between them.

The explanation of the relationship is relatively straightforward. Trade is increased by *importer and exporter's income (or GDP)* because for the importers, income represents demand for imports; meanwhile, for the exporters, the country with a higher level of GDP tends to be specialized in more varieties, thus the country exports more goods. *Distance* decreases trade because the longer length between the trading partners is commonly related to higher transportation cost and time. Therefore, longer distance requires more attempt to transport the goods and thus it hinders trade flows.

But not only the *distance*, other *trade resistance factors* of relevant countries, such as tariff rate, trade policy, and countries' common factor (e.g., common border, language, and economic bloc) could also affect trade activities. For example, higher tariff rate between country i and j increases trade cost and thus yields negative effect on trade. On the other hand, supportive trade policy between the trading partners (e.g., tariff reduction) could reduce trade cost. Common language or cultural background could also reduce cost of communication and market research when firms export, thus this also benefits trade activity. It is obvious that such related characteristics of the countries can affect trade flows in both negative and positive way. More importantly, *the influence of country's characteristics is in relation to other countries*, which means that what matters is relative effect, not absolute effect. This is because a country trades with many partners. The change in trading cost factor of one trading partner of the country could change the trading cost of that trading partner when compared to other trading partners. Thus this could deviate/attract trade flows to/from other trading partners. For example, the decrease in import tariff rate of country j, while other countries' rate remains constant, leads to a decrease in export cost from country i to j compared to other export destinations of i. Therefore, this makes j become more attractive; and thus could lead to an increase in exports from i to j. This is the intuitive background of *multilateral resistance*, an important component of gravity model.

Anderson and van Wincoop (2003) makes contributions to the theory of gravity model in several aspects. Firstly, this study decomposes *trade resistance factors* into three components: 1) bilateral resistance 2) importer (j)'s trade barrier with all countries 3) exporter (i)'s trade barrier with all countries. 2), together with 3) could be called as multilateral resistance. Secondly, the work of Anderson and van Wincoop presents the model in more operational form, which makes estimations become more possible. The inclusion of trade resistance factors in the model helps the authors avoid the variable omission problem, which could bias the coefficients estimated.

In the model, *bilateral resistance* is the function of the bilateral trade cost factors between i and j, e.g., distance, tariff, common language and culture, as described above, while *multilateral resistance terms* are the function of bilateral resistance between i and *all j*, and income shares. Therefore, multilateral resistance terms already take into account the bilateral resistance between i and j, compared to other export partners.

Obviously, from the above relationship, Anderson and van Wincoop derive gravity model explaining export values as a function of GDP shares, bilateral resistance, and multilateral resistance. This can be shown in formal way as

$$x_{ij} = \frac{y_i y_j}{y_w} \left[\frac{t_{ij}}{P_i P_j} \right]^{1-\sigma}$$ (Anderson and van Wincoop, 2003, p.175),

where x_{ij} denotes nominal exports, $\frac{y_i y_j}{y_w}$ is the nominal share of the product of importer and exporter's GDP, t_{ij} is bilateral resistance, P_i and P_j is multilateral resistance of exporter and importer, respectively, and σ is elasticity of substitution between goods.

Practically, when estimating the gravity model, it is important to control for the effect of trade resistance components. Basically, some of the factors are observable, such as distance and common border, but some factors are unobservable; more importantly, they could correlate to other explanatory variables in the model and thus will bias the estimation. Therefore, researchers try to control the effect of multilateral resistances. The attempt can be executed by several methods, such as the application of official price index data (Feenstra, 2004, p.153) and implicit price index, as presented by Anderson and van Wincoop (2003). However, more simple way is to use *importers and exporters' dummy* and *fixed effects model*. In this way, the influence of unobservable factors can be captured. The important assumption is that these unobservable trade costs are time invariant. This seems hard to be 100% true in practice; but this assumption is imposed in most studies. In fact, the resistance factors, as shown above, change very slowly. Many of them, such as distance and common border are truly constant across time. Therefore, it is reasonable to impose this assumption in this study. The fixed effects method will be used in this study, as will be shown in section 3.3.

3.2 Exchange Rate Volatility and Gravity Model

Exchange rate volatility is time-variant variable that could affect trade activities. From literature, there are many studies trying to explain how the volatility influences trade flows. However, there is no consensus about the direction of the effect: exchange rate volatility could have either negative or positive effect on trade.

The explanation of the studies that argue the negative effect is usually centered on the behavior of risk averse firms in response to the exchange rate uncertainty. This probably is the most intuitive explanation of the exchange rate effect on trade. For the exporters, the unexpected change in exchange rate may affect their income in negative way when converted into local currency. For the importers, the uncertainty in exchange rate may increase the price of goods when converted into local currency. By these effects, exchange rate volatility may lead to the decrease in trade flows as firms want to avoid the uncertain situation.

There are many studies that join this broad explanation, such as Ethier (1973), which argues that exchange rate uncertainty affects firm's financial position and thus has negative impact on the level of trade. Furthermore, the study of Wolf (1995)(cited in McKenzie, 1999, p. 74) argues that for risk averse importers which face exchange rate uncertainty during decision-making period and uncertainty in the price of imported commodities, imports level will be reduced by the exchange rate uncertainty.

However, there are some studies that explain the effect of exchange rate volatility in both negative and positive way. For example, the study of De Grauwe (1988), shows that exchange rate volatility could yield two opposite effects on trade. Firstly, it lowers export income, thus this yields the negative income effect for the exporters. Secondly, it also leads to the substitution effect in the way that firms might export less to avoid the risk raised by export activity. The author explains that, in the case that the exporters are extremely risk averse, they tend to export more to offset the possible income loss. Furthermore, the study of Broll and Eckwert (1999) presents models to explain the different reaction of firms to exchange rate uncertainty. According to the study, export activity could be viewed as a real option for firms (as comparable to financial option). The firms can either sell in domestic country or export to foreign market. The model indicates that an increase in exchange rate volatility increases the value of option, since firms could take advantage of the exchange rate volatility to generate higher income when converted to domestic currency. Thus this generates more exports of the firms. In contrast, exchange rate volatility could still be viewed as a risk factor reducing marginal utility of export income; thus this might reduce export activity. Which effect dominates depends on risk preference of the firms. The analysis shows that firms with relative risk aversion less than one tend to choose to export when exchange rate volatility increases.

Even though there is no conclusion about the mechanism that exchange rate volatility affects trade activities, evidence of the effect is abundantly found from empirical studies. Among those works, there are many ways to investigate the effect, as reviewed in part 2.

The idea of the application of gravity model on this issue is to investigate the "remaining part" of trade flows that is not yet explained by the standard gravity variables, under the hypothesis that exchange rate volatility may explain trade. As appeared in literature, the application of gravity model in investigating the effect of exchange rate volatility could be in the form of augmented gravity model, explaining trade volume or value by standard gravity variables plus exchange rate volatility as another explanatory variable. It is very important to control for the effect of multilateral resistance, to ensure that the estimated coefficients, including that of exchange rate volatility, are not biased.

3.3 Model Specification

From its empirical studies, gravity model is very successful in bilateral trade prediction (Taglioni, 2002, p.235). Moreover, gravity model is beneficial in various applications (Brada and Mendez, 1988, p.267). When using gravity model in helping investigate the effect of exchange rate volatility on trade,

there is more than one way to derive the relationship[2]. However, in this study, the derivation of gravity model is based on the study of Anderson and van Wincoop (2003), which gives an important implication that export values is the function of GDP shares, bilateral resistance, and multilateral resistance. The gravity equation (appeared in part 3.1) is shown as $x_{ij} = \frac{y_i y_j}{y_w} \left[\frac{t_{ij}}{P_i P_j} \right]^{1-\sigma}$.

In a group of countries in concern, the export value is equal to the import value, since the import value of country j is the mirror of the export value of country i. From this relationship, x_{ij} is replaced by m_{ij} . The gravity equation becomes

$$lnm_{ij} = \omega + lnmass_{ij} + (1 - \sigma)lnt_{ij} + (\sigma - 1)lnP_i P_j, \qquad (3.1)$$

where m_{ij} is nominal imports, $mass_{ij}$ is the product of importer and exporter's nominal GDP (i.e., $y_i y_j$), y_w is world's nominal GDP, t_{ij} is bilateral resistance, P_i and P_j is multilateral resistance of exporter and importer, respectively, and σ is elasticity of substitution between goods. Noted that since world's GDP is constant across country pairs, it is replaced by constant term ω.

And since *bilateral resistance* (t_{ij}) includes distance and other relevant factors, as explained in part 3.1, the variable $dist_{ji}$ is included in the test specification. The variable representing exchange rate volatility is introduced into the test equation in natural log form to allow simplicity in result interpretation[3]. **Multilateral resistances are captured by panel fixed effects in order to avoid omitted-variable bias, and included in the intercept φ.** The model becomes

$$lnm_{ijt} = \varphi + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 ln[vol_t] + \epsilon_{ijt}, \qquad (3.2)$$

where m_{ij} denotes nominal imports, $mass_{ij}$ is the product of importer and exporter's nominal GDP, $dist_{ij}$ denotes the distance between exporter i and importer j, $[vol_t]$ is the measure of exchange rate volatility, and ϵ_{ij} is random error.

Fixed effects method

As mentioned before, panel fixed effects method is applied to control the effect of country-specific characteristics that affect trade value. By this method, the slope coefficients of the variables are assumed to be constant across all countries and time. Meanwhile, the intercepts taking account of each entity (country or country pair) are allowed to vary across entities, but assumed to be constant across time, which is appropriate since the country-specific characteristics do not changed from year to

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[2] For example, the study of Thursby and Thursby (1987) starts deriving the gravity from demand and supply side in trade market, including variable representing the effect of exchange rate volatility in each side, and ends up with the test specification consisting the components of gravity variables.
[3] The coefficient can be interpreted as, for example, "1% change in exchange rate volatility of export country leads to β_3% change in import value".

year like import values and GDP. In addition, *time dummy* (or time fixed effects), is added to the model in order to capture the change in global economy that affects trade flows of all countries in concern. The time dummy is allowed to change across time, but not across entity. In this study, fixed effects method is used in two forms: countries' dummy and country pairs' dummy.

In the first form, country-specific dummy is used to capture the country-specific characteristics that are not yet captured by other explanatory variables. There are 7 countries in the sample: China, Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. Time dummies capturing the effect of year 2001 to 2013 are also used. When estimating the equation, all but one country dummy and year dummy are estimated to avoid dummy-variable trap, which generates perfect collinearity (Gujarati, 1978, p.642). The model is

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 ln[vol_t] + \pi_i + \delta_j + \theta_t + \varepsilon_{ijt}, \qquad (3.3)$$

m_{ijt} denotes nominal imports of *j* from *i*, $mass_{ijt}$ is the product of exporter *i* and importer *j*'s nominal GDP, $dist_{ij}$ denotes the distance between exporter *i* and importer *j*, $[vol_t]$ is the measure of exchange rate volatility, π_i, is exporter *i*'s dummy, δ_j is importer *j*'s dummy, and θ_t is time dummy. ε_{ijt} is random error.

In the second form of fixed effects model, country pairs' dummy is applied to capture any unobservable effect between the trading pairs. In this case, there are 7 countries in concern. Hence there are 7*6=42 country pairs. This model is different from the first model (country-specific dummy) because of the following reasons. First, when using country pairs' dummy, the effect captured by the dummies reflects the factors in between the trading partners. This is closer to the trading situation, since there could be some effects arise specifically between the two countries, such as special cooperation between them. Second, there are dummies to capture each of the 42 pairs, which means that the effect when, for example, Malaysia imports from China is captured separately from when China imports from Malaysia. As the effects may be different for the different trade direction; thus the country pairs' dummy could capture the effects better than country-specific dummy. Noted that the distance variable is not included in the model since distance is already captured by the country pairs' dummy. The model is

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 ln[vol_t] + \gamma_{ij} + \theta_t + \varepsilon_{ijt}, \qquad (3.4)$$

where m_{ijt} denotes nominal imports of *j* from *i*, $mass_{ijt}$ is the product of exporter *i* and importer *j*'s nominal GDP, $[vol_t]$ is the measure of exchange rate volatility, γ_{ij} is the dummy variable for bilateral trade partner *ij*, θ_t is time dummy, and ε_{ijt} is random error.

China's exchange rate effect

Three forms of exchange rate volatility are used in this study: 1) **exchange rate against U.S. Dollar**, denoted by *voli* for exporter and *volj* for importer, 2) **relative exchange rate volatility**, which is *volj/voli*, denoted by *volji*, and 3) **bilateral exchange rate volatility**, which is the direct bilateral exchange rate between the importer and exporter in concern (e.g., Chinese Yuan to Thai Baht) denoted by *voljdi*. The discussion about the reason behind using these measures will be shown in part 4.

In the case of exchange rate against U.S. Dollar, dummy variables representing the role of China as the exporter and importer: $CHNi$ and $CHNj$, respectively are introduced to capture the effect of the volatility of China's exchange rate. $CHNi$ and $CHNj$ are equal to 1 when China is the exporter and importer, respectively, and 0, otherwise. In this sense, the product of exchange rate volatility variable and the China's dummy conveys the meaning of "China's exchange rate volatility", i.e., $lnvol_{it} \cdot CHNi$ means volatility of China's exchange rate against U.S. Dollar when China is the exporter; and $lnvol_{jt} \cdot CHNj$ means volatility of China's exchange rate against U.S. Dollar when China is the importer.

After the China's effect is introduced, (3.3) (i.e., fixed effects using **country-specific dummy**) becomes (3.5).

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{it} + \beta_4 lnvol_{jt} + \beta_5 lnvol_{it} \cdot CHNi + \beta_6 lnvol_{jt} \cdot CHNj + \pi_i + \delta_j + \theta_t + \varepsilon_{ijt}$$

(3.5)

m_{ijt} denotes nominal imports of *j* from *i*, $mass_{ijt}$ is the product of exporter *i* and importer *j*'s nominal GDP, $dist_{ij}$ denotes the distance between exporter *i* and importer *j*, vol_{it} and vol_{it} are exchange rate volatility, $CHNi$ and $CHNj$ are China's dummy, π_i, is exporter *i*'s dummy, δ_j is importer *j*'s dummy, and θ_t is time dummy. ε_{ijt} is random error.

And (3.4), which is fixed effects using **country pairs' dummy** becomes (3.6).

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{it} + \beta_3 lnvol_{jt} + \beta_4 lnvol_{it} \cdot CHNi + \beta_5 lnvol_{jt} \cdot CHNj + \gamma_{ij} + \theta_t + \varepsilon_{ijt}$$

(3.6)

where m_{ijt} denotes nominal imports of *j* from *i*, $mass_{ijt}$ is the product of exporter *i* and importer *j*'s nominal GDP, vol_{it} and vol_{it} are exchange rate volatility, $CHNi$ and $CHNj$ are China's dummy, γ_{ij} is the dummy variable for bilateral trade partner *ij*, θ_t is time dummy, and ε_{ijt} is random error.

The second form of the volatility is the relative exchange rate volatility. The relative volatility is calculated from *volj/voli*. The reasons of using this form will be discussed in part 4. The meaning of this volatility is the "relative risk" between the importer (*j*) and exporter (*i*). In the case that the ratio increases, this means that the risk faced by the importer increases compared to the exporter's risk; this is the risky environment for the importer; and thus this reduces import demand. Conversely, if the ratio decreases, this means that the risk for the importer decreases compared to the risk of exporters, thus this is a better circumstance for the importer; therefore, this increases import demand. For this reason, the expected relationship with import values is negative.

The relative volatility vol_{jit} is again introduced into the model in natural log form. The third China's dummy $CHNij$ represents the role of China when trading with other countries in the group regardless of the role as the exporter or importer. It is introduced to interact with vol_{jit}. The product of $lnvol_{ijt} \cdot CHNij$ contains the meaning of the effect of China's exchange rate volatility in relation to the trading partner's volatility, in the situation that China is the exporter or importer. From (3.3), $lnvol_{jit}$ is introduced together with $lnvol_{jit} \cdot CHNij$ and yields (3.7).

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jit} + \beta_4 lnvol_{jit} \cdot CHNij + \pi_i + \delta_j + \theta_t + \varepsilon_{ijt}$$

(3.7)

where $CHNij$ is the China's dummy representing the trade activity that China involves as exporter or importer.

In the same manner, $lnvol_{jit}$ is introduced together with $lnvol_{jit} \cdot CHNij$ to (3.4), and then gives (3.8).

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{jit} + \beta_3 lnvol_{jit} \cdot CHNij + \gamma_{ij} + \theta_t + \varepsilon_{jit}$$

(3.8)

As a robustness check, the separated China's dummy: $CHNi$ and $CHNj$ are used to demonstrate the effect of China's exchange rate volatility when China is the exporter and importer, respectively. $lnvol_{jit} \cdot CHNi$ contains the meaning of the effect of China's exchange rate volatility in relation to the trading partner's volatility, when China is the exporter. And $lnvol_{jit} \cdot CHNj$ means such effect when China is the importer. This is to allow the investigation on the effect of China's volatility in different role.

$lnvol_{jit}$, together with $lnvol_{jit} \cdot CHNi$ and $lnvol_{jit} \cdot CHNj$ are introduced to (3.3), this yields (3.9).

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jit} + \beta_4 lnvol_{jit} \cdot CHNi + \beta_5 lnvol_{jit}$$
$$\cdot CHNj + \pi_i + \delta_j + \theta_t + \varepsilon_{jit}$$

(3.9)

m_{ijt} denotes nominal imports of *j* from *i*, $mass_{ijt}$ is the product of exporter *i* and importer *j*'s nominal GDP, $dist_{ij}$ denotes the distance between exporter *i* and importer *j*, vol_{jit} is relative exchange rate volatility, $CHNi$ and $CHNj$ are China's dummy, π_i, is exporter *i*'s dummy, δ_j is importer *j*'s dummy, and θ_t is time dummy. ε_{ijt} is random error.

In the same fashion, vol_{jit} , together with $lnvol_{jit} \cdot CHNi$ and $lnvol_{jit} \cdot CHNj$ are introduced to (3.4), then (3.10) is derived.

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{jit} + \beta_3 lnvol_{jit} \cdot CHNi + \beta_3 lnvol_{jit} \cdot CHNj + \gamma_{ij} + \theta_t$$
$$+ \varepsilon_{jit}$$

(3.10)

where m_{ijt} denotes nominal imports of *j* from *i*, $mass_{ijt}$ is the product of exporter *i* and importer *j*'s nominal GDP, vol_{jit} is relative exchange rate volatility, $CHNi$ and $CHNj$ are China's dummy, γ_{ij} is the dummy variable for bilateral trade partner *ij*, θ_t is time dummy, and ε_{ijt} is random error.

The third form of exchange rate volatility is the volatility of bilateral exchange rate between the involved exporter and importer, i.e., the direct exchange rate between local currency of country *i* and *j* without U.S. Dollar denominator. Among the three volatility proxies, it could be said that this one is the least affected by U.S. Dollar. Therefore, this could measure the volatility that arises between the country pairs in the most direct way. This volatility is denoted by vol_{jdit}, which means the volatility of bilateral exchange rate between importer *j* and exporter *i*.

As usual, the interactions between the volatility measures and China's dummies contain the meanings related to China's exchange rate effect. The meaning of $lnvol_{jdit} \cdot CHNij$ is the effect of the volatility of bilateral exchange rate between China and its trading partners, when China is either exporter or importer.

To investigate the combined effect when China is the exporter or importer, the model using country-specific dummy can be derived from (3.3) by introducing $lnvol_{jdit}$ and $lnvol_{jdit} \cdot CHNij$, resulting in (3.11). Since the specification is not changed from (3.7) except only that vol_{jit} is replaced by vol_{jdit}, the specification (3.11) is not shown here to avoid redundancy. However, the model will be appeared in the complete list of the test specifications in appendix A.

The model using country pairs' dummy can be derived from (3.4) by introducing $lnvol_{jdit}$ and $lnvol_{jdit} \cdot CHNij$ and then yields (3.12). The specification is not different from (3.8) except for the replacement of exchange rate volatility measure. The specification is shown in appendix A.

For a robustness check, the dummy $CHNi$ and $CHNj$ are used again to show the China's separated effect. $lnvol_{jdit} \cdot CHNi$ means the effect of the volatility of bilateral exchange rate between China and its trading partners, when China is the exporter; and $lnvol_{jdit} \cdot CHNj$, is the effect of the volatility when China is the importer. $lnvol_{jdit}$, together with $lnvol_{jdit} \cdot CHNi$ and $lnvol_{jdit} \cdot CHNj$ are introduced to (3.3) to derive the model with country-specific dummy (3.13), and introduced to (3.4) to derive the model with country pairs' dummy (3.14). The models will be shown in Appendix A.

4. Data and Descriptive Statistics

This study uses the data of China and the 6 ASEAN countries: Indonesia, Malaysia, Philippines, Singapore, Thailand, and Vietnam. The remaining 4 ASEAN countries: Cambodia, Laos, Myanmar, and Brunei are not included because the data are not available during the observation period: 2001 to 2013. The data are collected from DATASTREAM; to be more specific, the data sources can be shown as follows: import values from UN Comtrade, the countries' GDP from IMF's World Economic Outlook Database, the distance between countries from the website of European Commission's Erasmus-plus Program (Ec.europa.eu, 2015), and each countries' exchange rate from Reuters.

The importers and exporters' GDP are used further in the gravity model in the form of "economic mass", calculated by the multiplication between the GDP of importers (*gdpj*) and exporters (*gdpi*).

The exchange rate volatility variable in this study is calculated from the average of absolute of log (monthly) change of the exchange rate. The reason for using this measure is that, this is one of the simple and intuitive ways to measure the volatility of exchange rate. Moreover, this measure also appears in other literature, such as Levy-Yeyati, and Sturzenegger (2003a) and Levy-Yeyati, and Sturzenegger (2003b).

This study uses three forms of exchange rate volatility. The first form is **local currency against U.S. Dollar.** After applying the above volatility calculation method to the importers' currency against U.S. Dollar, this yields the variable *volj*. In the same way, when applied to the exporters' currency against U.S. Dollar, this yields the variable *voli*.

The second form is **relative volatility**, which is calculated from *volj/voli*, denoted by *volji*. The reasons behind the application of this proxy are as follows: **first, this proxy measures the relative volatility between the importers and exporters; thus, this reflects the relative risk.** The increase in importers' volatility compared to exporters' volatility, which increases *volji*, means more risky

environment for the importers; and thus this affects trade negatively. Meanwhile, the decrease in *voli* compared to *volj* means that the importers face higher risk; and also means more risky environment for the exporters compared to when they do not export. Thus this situation also dampens trade activity.

Second, *volji* reduces the effect of U.S. Dollar from individual series of *volj* and *voli*. Since the U.S. Dollar is the denominator of both series, the change in the same direction (i.e., appreciation or depreciation) of U.S. Dollar against both currencies is cancelled out. For this reason, the influence of U.S. Dollar is alleviated; thus *volji* reflects the influence of bilateral exchange rate between *j* and *i* better than using *volj* and *voli* separately. However, since **China used fixed exchange rate system in 2001 and Malaysia also used such system in 2003 and 2004. This causes *volj* and *voli* of the two countries become zero during the certain period; and thus makes some observations of *volj/voli* become mathematically undefined.** It could be seen further from **table 4.1** that the number of observations of *volji* is reduced to 528 from 546 because of the zero denominator problem. This issue will be treated further in the estimation process by eliminating the observations that have zero *volj* or *voli*.

The third form of exchange rate volatility is **direct bilateral exchange rate between trading partners in concern** (e.g., Chinese Yuan per Thai Baht). The above volatility calculation is applied to the direct bilateral exchange rate of importer against exporter; this yields the variable *voljdi*. The reason for using this volatility proxy is to treat the problem of zero volatility as stated above. By using this proxy, no observation is cut off from the estimation. At the same time, this also alleviates the effect of U.S. Dollar and enhances direct bilateral effect between *i* and *j* as *volji* does.

The summary statistics of the variables are shown as follows:

Table 4.1: Summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
import	546	8.69e+09	1.03e+10	5.35e+07	6.21e+10
gdpj	546	808.2718	1751.507	32.524	9469.125
gdpi	546	808.2718	1751.507	32.524	9469.125
mass	546	397949.1	1021191	2480.345	8640596
distance	546	2362.276	1213.119	316.5	5221.35
volj	546	.0063006	.0053597	0	.0345915
voli	546	.006229	.0052131	0	.0345915
volji	528	97.99157	667.3146	0	8292.971
voljdi	546	.0151619	.0095429	1.01e-06	.0635474

Referring the table 4.1, since there are 7 countries and 13 years in concern; and the number of country pair is 42; thus the number of observations is 546. The variable *import* refers to import values of the countries in U.S. Dollar. The variables *gdpj* and *gdpi* denote the GDP value in billion U.S. Dollar

of the importers and exporters. The variable *mass* denotes economic mass. The *distance* is shown in kilometers. The variable *volj* and *voli* denote volatility of exchange rate against U.S. Dollar of the importers and exporters, respectively. The relative volatility *volji* is calculated from *volj/voli*. And *voljdi* denotes direct bilateral exchange rate between the importer and exporter.

Noted that since each country is used as both importer and exporter, the summary statistics of *gdpj* are the same as the statistics of *gdpi*. In the same way, the statistics of *volj* and *voli* are the same.

Considering the relationship between the variables. Since the model used in this study is the gravity model, it is important to picture the relationship between the dependent variable: import values, and the explanatory variables: economic mass (derived from the multiplication between importer's GDP and exporter's GDP), distance, and exchange rate volatility as shown in figure 4.1, 4.2, and 4.3. Noted that the data points shown are in log form.

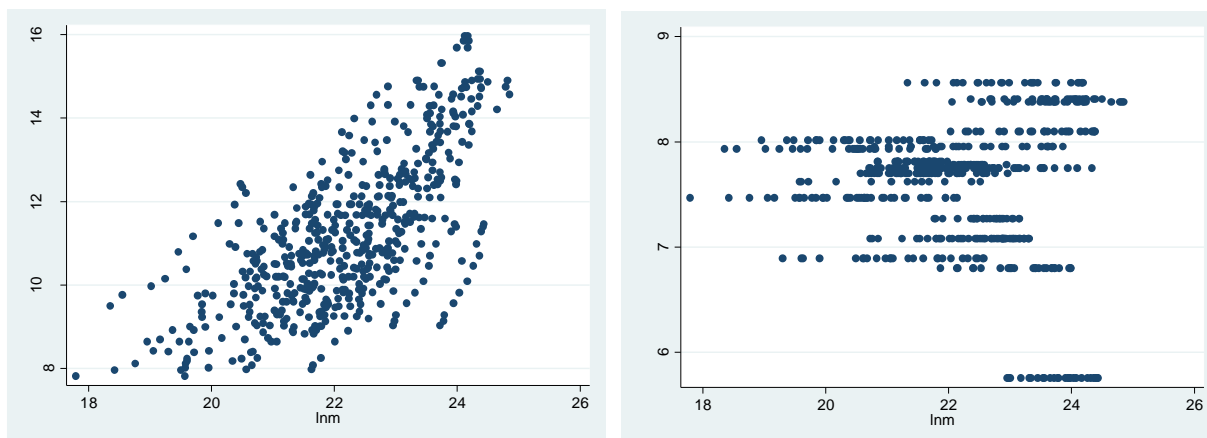**Figure 4.1: Economic mass and distance in relation to imports**

Figure 4.2: Exchange rate volatility of importers and exporters in relation to imports
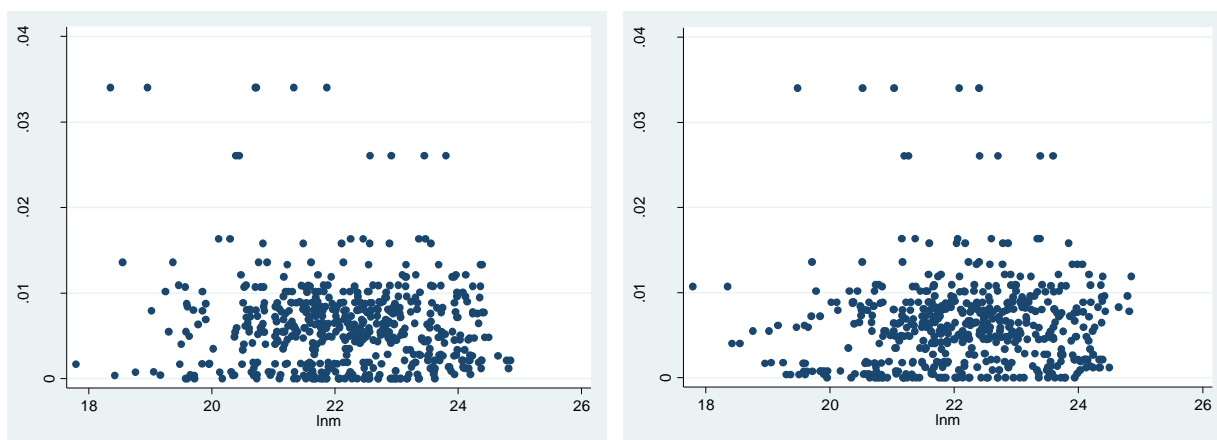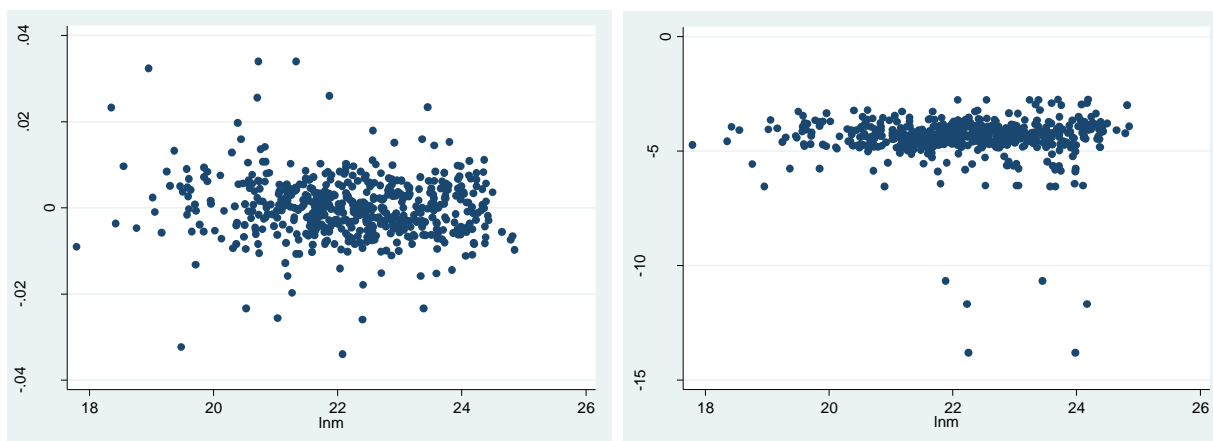
Figure 4.3: Relative and bilateral exchange rate volatility in relation to imports

According to figure 4.1, it can be seen that there is a strong positive relationship between economic mass and imports, which conforms to the gravity model. The relationship between distance and imports is less clear; however, it can be seen as (weak) negative relationship, which is also the correct direction based on the gravity model. When considering the relationship graphs between exchange rate volatility and import values as appeared in figure 4.2 and 4.3, the relationship appears to be unclear. In the next section, the relationship between these variables will be estimated using gravity model.

5. Result

As discussed in part 3, the relationship between import values within the economic group (China and ASEAN 6) and the explanatory variables is investigated by using **the gravity model. Fixed effects method is used in two forms: country-specific dummy and country pairs' dummy.** There are three proxies of exchange rate volatility:

1) Exchange rate against U.S. Dollar (*volj* and *voli*)

2) Relative exchange rate volatility (*volji*)

3) Bilateral exchange rate volatility (*voljdi*)

Exchange rate against U.S. Dollar (*volj* and *voli*).

The first fixed effects model: country-specific dummy. Using this model, importers' dummy, exporters' dummy and year dummy are introduced to control for multilateral resistance. Furthermore, exchange rate volatility variables (*volj* and *voli*) are introduced to capture the effect of exchange rate volatility. China's dummy: *CHNj* and *CHNi* are introduced to capture the effect of exchange rate volatility when China is the importer and exporter, respectively. The model is already demonstrated as equation **(3.5)** in part 3.

The expected sign and size of the coefficients are shown in table 5.1. It can be seen that the expected coefficient of $lnmass_{ijt}$ is + (near)1. This is in line with the evidence of gravity model, which expects the unitary relationship between trading values and GDP of the importers (*j*) and exporters (*i*), as discussed in Anderson and van Wincoop (2003). The expected sign of the coefficient of $lndist_{ij}$ is negative, since the trading activity is obstructed by the long distance between the exporter and importer, thus requiring more transportation cost. Therefore, the import value is reduced by the longer length between the exporter and importer. The expected size is between -1.5 and -0.7, according to its empirical evidence (WTO, 2015b).

Considering the coefficient of $lnvol_{jt}$ *and* $lnvol_{it}$, by intuition, the expected sign is negative, since exchange rate volatility is another risk factor for trading activity. It increases trade costs for both importers and exporters. On one hand, exchange rate volatility creates price uncertainty for the importers. On the other hand, it leads to income uncertainty for the exporters. Therefore, exchange rate volatility is expected to hurt import values if the volatility increases. Hence, the coefficient of $lnvol_{jt} \cdot CHNj$ and $lnvol_{it} \cdot CHNi$ is expected to be negative. In the case of importers' dummy and exporters' dummy: π_i and δ_j that are used to control the multilateral resistance, the expected sign can be either positive or negative, as well as the time dummy: θ_t used to control for global economic circumstances.

Table 5.1: Expected coefficients of (3.5) and (3.6)

Coefficient of	Expected Sign	Expected Size
$lnmass_{ijt}$	+	Near 1
$lndist_{ij}$	-	Between -1.5 and -0.7 (WTO, 2015b)
$lnvol_{jt}, lnvol_{it}$	-	
$lnvol_{jt} \cdot CHNj,$ $lnvol_{it} \cdot CHNi$	-	
π_i	+ or -	
δ_j	+ or -	
γ_{ij}	+ or -	
θ_t	+ or -	

The second fixed effects model: country pairs' dummy. The country pairs' dummy is used in addition to country-specific dummy in (3.5) for better control for unobserved trade costs of each country pair; this yields model **(3.6)**. As discussed in part 3, the difference is that the bilateral partner dummy (γ_{ij}) is used to absorb the effect of distance and also other effects between *i* and *j*. Thus the variable $lndist_{ij}, \pi_i, \delta_j$ do not appear anymore.

It is relatively common that after bilateral partner dummy is introduced, the coefficient of $lnmass_{ijt}$ might fall; the effect of economic mass might be partially reduced by the effects between the trading partners. Thus the smaller coefficient of $lnmass_{ijt}$ could be seen from the result; but it

should still be positive and close to one. The expected sign of γ_{ij} is either positive or negative. For other variables, the expected sign is the same as in **table 5.1**. The result of (3.5) and (3.6) is appeared in **table 5.2**. Noted that since the full dataset includes 7 countries and 13 years, thus the number of country pair is 42 and then the number of observations is 546. However, as mentioned before, since China used fixed exchange rate regime during 2001 and also for Malaysia during 2003 and 2004, the exchange rate volatility is equal to zero for the two countries during that period. The observations with zero volatility are excluded for unbiased result, reducing the number of observations to 510.

Table 5.2: Results, using exchange rate against U.S. Dollar (*volj* and *voli*)

VARIABLES	(a)[+] Vol_ OLS	(b)[+] Vol_ c.d./	(c)[+] Vol_ p.d./	(3.5) CHN Effect_ c.d./	(3.6) CHN Effect_ p.d./
lnmass	0.671***	1.202***	1.180***	1.237***	1.221***
	(0.0229)	(0.137)	(0.175)	(0.143)	(0.168)
lndist	-0.984***	-0.408***		-0.407***	
	(0.0576)	(0.0435)		(0.0436)	
lnvoli	0.00473	0.00828	0.00582	0.0151	0.0116
	(0.0207)	(0.0127)	(0.0146)	(0.0178)	(0.0200)
lnvolj	-0.0599***	-0.0166	-0.0195	-0.0121	-0.0121
	(0.0175)	(0.0155)	(0.0202)	(0.0194)	(0.0279)
lnvoliCHNi				-0.0201	-0.0175
				(0.0265)	(0.0235)
lnvoljCHNj				-0.0136	-0.0224
				(0.0318)	(0.0266)
Constant	21.83***	9.335***	9.655***	8.657***	9.300***
	(0.357)	(2.096)	(1.711)	(2.264)	(1.635)
Observations	510	510	510	510	510
R-squared	0.665	0.904	0.850	0.904	0.850
Country-specific Dummy		YES		YES	
Country pairs' Dummy			YES		YES
Year Dummy		YES	YES	YES	YES
Measure CHN Effect				YES	YES

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
/c.d. country-specific dummy, p.d. country pairs' dummy
[+]The specifications without China's effect are shown in appendix B.

From the result, it can be seen that the R-squared values of the last four gravity models (i.e., the models after controlling for multilateral resistance) are relatively high when compared to the first model, which is not yet controlled for the multilateral resistance. The coefficient of $lnmass_{ijt}$ in (3.5) and (3.6) are significant, positive and close to one, in line with the theory of gravity model. The coefficient of $lndist_{ij}$ is significant and negative. In the meantime, the coefficients of the total effect of exchange

rate volatility ($lnvol_{it}$ and $lnvol_{jt}$) are not significant in all cases except the first specification, which is the gravity model without controlling multilateral resistances. This means that the coefficient in the first column captures the effect of multilateral resistances; and thus it is biased. The coefficient of China's effect ($lnvol_{it} \cdot CHNi$ and $lnvol_{jt} \cdot CHNj$) are also not significant, which means that the effect of China's exchange rate volatility on import values in the country group is not significant, not different from the total effect of all countries.

Relative exchange rate volatility (*volji*)

As discussed above, since the variable *volji* could reflect the effect of relative exchange rate volatility between importers and exporters; moreover, *volji* could reduce the influence of U.S. Dollar. Thus *volji* is also tested in this study. As compared to the application of separated volatility of exchange rate against U.S. Dollar, the two fixed effects models: **country-specific dummy and country pairs' dummy** are used.

As shown in part 3, $CHNij$ is introduced to take into account the influence of China when involving in trade activities as exporter or importer. The test specifications are **(3.7)** and **(3.8)**. And as a robustness check, the separated China's dummy $CHNj$ and $CHNj$ are used instead of $CHNij$ in (3.7) and (3.8) to demonstrate the effect when China is an exporter and importer separately. This yields the specification **(3.9)** and **(3.10)**.

The expected coefficients are appeared in table 5.3. The expected coefficient of $lnvol_{jit}$ is negative. The increase (decrease) in relative exchange rate volatility, by either the increase (decrease) in importers' volatility (*volj*) or the decrease (increase) in exporters' volatility (*voli*), reduce (increase) trade value.

This is because the decrease in exporters' volatility leads to the circumstance that the relative exchange rate volatility of the importers (against the volatility of exporters) increases. This is a risky situation for the importers and thus could affect import demand. This is not a good situation for the exporters compared to when they sell only in domestic market. Therefore, this negatively affects trade. Conversely, the increase in exporters' volatility leads to the decrease in importers' relative exchange rate volatility. Thus this has a positive effect on imports.

The expected coefficients are shown in **table 5.3;** and the results are shown in **table 5.4**. Again, the observations are reduced to 510 because of the zero volatility in some observations.

Table 5.3: Expected coefficients of (3.7), (3.8), (3.9), and (3.10)

Coefficient of	Expected Sign	Expected Size
$lnmass_{ijt}$	+	Near 1
$lndist_{ij}$	-	Between -1.5 and -0.7 (WTO, 2015b)
$lnvol_{jit}$	-	
$lnvol_{jit} \cdot CHNij$, $lnvol_{jit} \cdot CHNi$, $lnvol_{jit} \cdot CHNj$	-	
π_i	+ or -	
δ_j	+ or -	
γ_{ij}	+ or -	
θ_t	+ or -	

Table 5.4: Results, using relative exchange rate volatility (*volji*)

VARIABLES	(d)[+] Vol_ OLS	(e)[+] Vol_ c.d./	(f)[+] Vol_ p.d./	(3.7) CHN Effect_ c.d./	(3.9) CHN Effect_ c.d./	(3.8) CHN Effect_ p.d./	(3.10) CHN Effect_ p.d./
lnmass	0.664***	1.206***	1.188***	1.206***	1.205***	1.188***	1.195***
	(0.0224)	(0.136)	(0.178)	(0.136)	(0.137)	(0.178)	(0.177)
lndist	-0.963***	-0.408***		-0.408***	-0.408***		
	(0.0564)	(0.0434)		(0.0433)	(0.0433)		
lnvolij	-0.0323**	-0.0125	-0.0127	-0.00836	-0.00836	-0.0132	-0.0132
	(0.0139)	(0.00877)	(0.0114)	(0.0129)	(0.0129)	(0.0193)	(0.0193)
lnvolijCHNij				-0.00954		0.00119	
				(0.0159)		(0.0204)	
lnvolijCHNi					-0.0109		0.0118
					(0.0187)		(0.0237)
lnvolijCHNj					-0.00818		-0.00937
					(0.0228)		(0.0202)
Constant	22.05***	9.342***	9.665***	9.340***	9.361***	9.665***	9.588***
	(0.367)b	(2.096)	(1.709)	(2.095)	(2.107)	(1.710)	(1.701)
Observations	510	510	510	510	510	510	510
R-squared	0.663	0.903	0.849	0.904	0.904	0.849	0.850
Country-specific Dummy		YES		YES	YES		
Country pairs' Dummy			YES			YES	YES
Year Dummy	YES	YES	YES	YES	YES	YES	YES
Measure CHN Effect				YES	YES	YES	YES

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1
/c.d. country-specific dummy, p.d. country pairs' dummy
[+]The specifications without China's effect are shown in appendix B.

The results show that there is not much change from the result in the case using *voli* and *volj*. The R-squared values in (3.7), (3.8), (3.9), and (3.10) are relatively high compared to the specification without multilateral resistance control. The coefficients of $lnmass_{ijt}$ are significant, positive and close

to one, in accordance to the expectation. The coefficients of $lndist_{ij}$ are significant and negative. The coefficient of exchange rate volatility terms ($lnvol_{jit}$, $vol_{jit} \cdot CHNij$, $lnvol_{jit} \cdot CHNi$, and $lnvol_{jit} \cdot CHNj$) are not significant in the test specifications. And again the coefficients are changed from significant to insignificant after multilateral resistances are controlled; therefore, it could be interpreted that the actual effect of exchange rate volatility variables is insignificant.

Bilateral exchange rate volatility (*voljdi*)

The volatility of bilateral exchange rate between the importer and exporter is used for two reasons: first, this is to treat the problem of zero volatility; second, this helps reduce the influence of U.S. Dollar. The test specifications are **(3.11)** and **(3.12)** as derived in part 3. And for a robustness check, the test equations using $CHNi$ and $CHNj$ are derived as **(3.13)** and **(3.14)**. The expected coefficients are shown in **table 5.5**. The results are shown in **table 5.6**.

Table 5.5: Expected coefficients of (3.11), (3.12), (3.13), and (3.14)

Coefficient of	Expected Sign	Expected Size
$lnmass_{ijt}$	+	Near 1
$lndist_{ij}$	-	Between -1.5 and -0.7 (WTO, 2015b)
$lnvol_{jdit}$	-	
$lnvol_{jdit} \cdot CHNij$, $lnvol_{jdit} \cdot CHNi$, $lnvol_{jdit} \cdot CHNj$	-	
π_i	+ or -	
δ_j	+ or -	
γ_{ij}	+ or -	
θ_t	+ or -	

Table 5.4: Results, using bilateral exchange rate (*voljdi*)

VARIABLES	(g)[+] Vol_ OLS	(h)[+] Vol c.d./	(i)[+] Vol_ p.d./	(3.11) CHN Effect_ c.d./	(3.13)	(3.12) CHN Effect_ p.d./	(3.14)
lnmass	0.664***	1.200***	1.201***	1.200***	1.196***	1.201***	1.201***
	(0.0217)	(0.126)	(0.186)	(0.126)	(0.126)	(0.186)	(0.187)
lndist	-0.963***	-0.397***		-0.397***	-0.397***		
	(0.0528)	(0.0412)		(0.0414)	(0.0414)		
lnvoljdi	0.0628***	-0.0148	-0.00839	-0.0184	-0.0191	-0.00705	-0.00705
	(0.0237)	(0.0156)	(0.00680)	(0.0223)	(0.0224)	(0.00972)	(0.00973)
lnvoljdiCHNij				0.00823		-0.00314	
				(0.0274)		(0.0132)	
lnvoljdiCHNi					0.0211		-0.00358
					(0.0305)		(0.0150)
lnvoljdiCHNj					-0.0196		-0.00193
					(0.0329)		(0.0155)
Constant	22.35***	9.229***	9.459***	9.289***	9.261***	9.461***	9.460***
	(0.355)	(1.912)	(1.799)	(1.927)	(1.922)	(1.802)	(1.804)

Observations	546	546	546	546	546	546	546
R-squared	0.653	0.901	0.853	0.901	0.901	0.853	0.853
Country-specific Dummy		YES		YES	YES		
Country pairs' Dummy			YES			YES	YES
Year Dummy		YES	YES	YES	YES	YES	YES
Measure CHN Effect				YES	YES	YES	YES

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

/c.d. country-specific dummy, p.d. country pairs' dummy

[+]The specifications without China's effect are shown in appendix B.

The results when using vol_{jdit} are not much different from other volatility proxies, even though all observations are preserved. From the result, R-squared value of (3.11), (3.12), (3.13), and (3.14) are relatively high compared to the model without multilateral resistance control. The coefficient of $lnmass_{ijt}$ is significant and close to one. The coefficient of $lndist_{ij}$ is significant and negative. Both of them are in line with the theory of gravity model. However, the coefficients of exchange rate volatility are again insignificant in all cases except the gravity model without multilateral resistance control. This means that the coefficient in such case is biased because it captures the effect of unobservable trade costs that explain the import flows.

Comparing between the results from using different proxy of exchange rate volatility, it could be seen that the result is not much different. In all specifications, i.e., from (3.5) to (3.14), R-squared value is relatively high, ranging from the lowest: 0.849 in specification (3.8) to 0.904 in specification (3.5), (3.7), and (3.9). This might be interpreted that the total explanatory power of the independent variables is relatively high. This means that around 85% to 90% variation in the dependent variable can be explained by the model. It can be seen that the coefficient of $lnmass_{ijt}$ in all test models is significant, positive and close to one, which is in accordance with the empirical evidence and also close to the theoretical expectation of the gravity model. The estimated coefficients are in the range of 1.188 in (3.8) to 1.237 in (3.5). This means that 1% increase in economic mass leads to around 1.188% - 1.237% increase in import values within China and ASEAN 6. The coefficient of $lndist_{ij}$ in specification (3.5) to (3.14) is also significant, negative and not much different in magnitude, ranging from -0.408 in specification (3.7) and (3.9) to -0.397 in (3.11) and (3.13). The direction of the relationship is in line with the theory of the gravity model. But the magnitude is somewhat lower than the empirical results of the gravity model, which is in the range between -1.5 and -0.7 (WTO, 2015b). This is because the countries in the sample are limited in the China-ASEAN continent, the number of countries and the area coverage are small compared to many other empirical studies of gravity model. This reflects that the increase in the distance between the importers and exporters by 1% decreases the

import values within the economic group by approximately 0.4%. It could be interpreted that the solid evidence of gravity model is presented, confirmed by the coefficient of gravity variables: $lnmass_{ijt}$ and $lndist_{ij}$.

Considering the coefficient of exchange rate volatility variables: the importers' effect, exporters' effect, total effect, and the China's effect, it could be seen that they are insignificant even after country pairs' dummy is applied and several proxies of exchange rate volatility are used. By the country pairs' dummy, time-invariant characteristics of each country pair are controlled. Thus all time-invariant effects between the two trading partners, such as distance, tariff, common border, language, culture, etc., are controlled. This allows more precise measurement for other variables' effect on the dependent variable (imports). After country pairs' dummy is used, comparing to the country-specific dummy, there is an effect on the coefficient of *lnmass*: the coefficient is slightly changed but still significant. However, the coefficients of volatility variables are still insignificant.

Furthermore, there is more attempt to reveal the influence of exchange rate volatility on trade, by trying to alleviate the effect of U.S. Dollar denominator in individual exchange rate series. The first attempt is to use the relative exchange rate volatility (*volji*) instead of volatility of exchange rate against U.S. Dollar, as shown in **table 5.4**. The second attempt is to use the volatility of bilateral exchange rate (*voljdi*), as in **table 5.6**. However, the coefficients of volatility variables are still insignificant.

Since among the test specifications, there is no significant volatility coefficient, including the case of China's effect coefficients. Therefore, evidence of the impact of China's exchange rate volatility on import values among China and ASEAN6 countries could not be found.

The directions of the estimated values are not interpreted because they are not different from zero, from statistical perspective. Because of this, the estimated coefficients of exchange rate volatility convey not much statistical meaning.

It is important to note that the coefficients of volatility variables in all of the test specifications are insignificant except the specification of gravity model without multilateral resistance control (the first column of each result table). This means that the coefficient in such case is biased by the effect of multilateral resistances. Therefore, it is important to control for unobserved trade costs arise from multilateral resistances.

6. Discussion

The relationship between the exchange rate volatility and trade seems to be insignificant for the countries in the trading group; and China's effect of volatility on trade is not different. There could be more than one explanation for this phenomenon. First, it seems that the change in China's exchange rate policy during the period after the accession to WTO until 2013 did not change the exchange rate

behavior as much as understood; and thus this did not affect trade decision of the exporters and importers. As it could be seen in the first part that the RMB trading band was widened very slow from time to time. Hence this might allow the firms to adjust themselves to more flexible exchange rate. And thus their decision did not affected much by "fear", i.e., the effect of risk aversion. It is widely known that the policy moves executed by the Chinese government are always done gradually; the government always try to avoid any sudden change that could affect the economy. And since trade sector is an important engine driving the Chinese economy, the government has even bigger concern about the effect of exchange rate volatility on trade, compared to other policy issue. This is the incentive for the Chinese government to avoid from allowing too flexible trading band. Second, it is possible that the trading firms have enough access to hedging instruments; thus they can maintain their selling/buying decision regardless of the exchange rate uncertainty. Even though financial industry in these countries are not totally developed (except for Singapore), the financial institutions may already have enough financial products that could help protect the firms from exchange rate risk, or at least from "fear of uncertainty".

The insignificant effect of exchange rate volatility on trade is not uncommon. From empirical evidence, **many studies show some insignificant results**, such as Bahmani-Oskooee and Hegerty (2009), which presents insignificant effect of exchange rate volatility on some industries' exports and imports, and Nishimura, Y. and Hirayama, K. (2013), which concludes that the effect of exchange rate volatility on exports of Japan to China is insignificant. Another evidence is Sauer (2001), which concludes significant negative effect on exports in Least Developed Countries (LDC) in Africa and Latin America, but not in the case of Asian and developed countries, which is consistent with the results in this study.

Despite the fact that the effect of exchange rate volatility on trade could actually be insignificant and has mixed direction in some observation groups (i.e., country, year, industry); such results could also be caused by different volatility measure and estimation technique. As presented by Mckenzie (1999), the estimated effect could depend on three main factors 1) measurement of volatility 2) estimation technique and 3) industrial sector and country in the sample.   This is understandable, since the different volatility measure could yield different volatility series; and this may lead to different coefficient. Being presented by Bahmani-Oskooee and Hegerty (2007) and Mckenzie (1999), there are several measures of exchange rate volatility, such as within-period standard deviation, moving standard deviation, absolute percentage change, ARCH and GARCH models, ARIMA residuals, deviation around trend, non-parametric technique, etc. These methods are used in different literature, which results in different estimated effect of volatility. For example, the study of Nishimura, Y. and Hirayama, K. (2013) shows that ARCH-type volatility yields more significant exchange rate volatility effect than standard deviation-type volatility; moreover, the different proxy of volatility also gives different sign of estimated effect in some industries. Furthermore, Hooper and Kohlhagen (1978)

also shows that the volatility taking into account market expectation performs better than standard deviation-type volatility: it fits to the data better than other volatility measures and also gives more significant estimated coefficients.

Furthermore, the different estimation technique could also affect the result. As reviewed in part2, modern time series model, such as VAR, ARCH and GARCH are also used to model the effect of exchange rate volatility on trade in previous pieces of literature. More importantly, the choice of testing specification could affect the result, as indicated in Bini-Smaghi (1991) (cited in McKenzie, 1999, p. 94). Moreover, the scope and level of trade data is also important. As suggested in Taglioni (2002) that the application of industry-level trade data is likely to reflect the influence of exchange rate volatility better than using aggregate-level data.

This boils down to the suggestions for further study. The effect of exchange rate risk on trade within China-ASEAN could be investigated further. The suggestions are as follows. **First, other types of the proxy for exchange rate volatility could also be used.** It could potentially perform better than the measure used in this study. The reason is that the more accurate assumption about the volatility and the market response to the volatility means more appropriate model for the volatility estimation**. Second, other models could be used to explain the relationship**. This might lead to better estimation result. **Finally, studies using subnational level (e.g., industry and commodity level) could be carried out to reflect the influence of exchange rate volatility in a deeper level.** This could help reveal more exact influence of exchange rate risk on trade; and thus provide a clearer explanation of this unsolved issue.

In conclusion, from using the data of China and ASEAN6 during 2001 and 2013, using three different measures of exchange rate volatility: volatility of exchange rate against U.S. Dollar (*volj* and *voli*), relative exchange rate volatility (*volji*), and bilateral exchange rate volatility (*voljdi*), the effect of economic mass is significant and close to one, in line with evidence and theoretical expectation of gravity model. The coefficient of the distance between the trading partners is significant and negative; the size is close to the empirical results of the gravity model. Therefore, this could be an evidence to confirm the gravity model. However, the coefficients representing the total effect of exchange rate volatility and the effect of China's volatility are insignificant when using all the volatility measures. Therefore, significant effect of neither exchange rate volatility nor China's exchange rate volatility could be found in this study. It could be concluded that the importance of the effect of China's exchange rate volatility is insignificant, not different from the other countries in this trading group.

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Appendix A

List of test specifications

The following specifications are used as the test equations in this study. The discussion about the models is given in part 3.

The volatility of exchange rate against U.S. Dollar: vol_{it} and vol_{jt}

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{it} + \beta_4 lnvol_{jt} + \beta_5 lnvol_{it} \cdot CHNi$$
$$+ \beta_6 lnvol_{jt} \cdot CHNj + \pi_i + \delta_j + \theta_t + \varepsilon_{ijt}$$

$$(3.5)$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{it} + \beta_3 lnvol_{jt} + \beta_4 lnvol_{it} \cdot CHNi + \beta_5 lnvol_{jt} \cdot CHNj$$
$$+ \gamma_{ij} + \theta_t + \varepsilon_{ijt}$$

$$(3.6)$$

m_{ijt}: nominal imports of j from i, $mass_{ijt}$: product of exporter i and importer j's nominal GDP, $dist_{ij}$: distance between exporter i and importer j, vol_{it} and vol_{jt}: the volatility of exchange rate against U.S. Dollar of exporter i and importer j, respectively, $CHNi$ and $CHNj$: China's dummy, representing the situation that China is the exporter and importer, respectively, π_i, is exporter i's dummy, δ_j is importer j's dummy, γ_{ij}: bilateral trade partner ij's dummy, θ_t: time dummy, and ε_{ijt}: random error.

Relative exchange rate volatility: vol_{jit}

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jit} + \beta_4 lnvol_{jit} \cdot CHNij + \pi_i + \delta_j + \theta_t$$
$$+ \varepsilon_{ijt}$$

$$(3.7)$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{jit} + \beta_3 lnvol_{jit} \cdot CHNij + \gamma_{ij} + \theta_t + \varepsilon_{jit}$$

$$(3.8)$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jit} + \beta_4 lnvol_{jit} \cdot CHNi + \beta_5 lnvol_{jit}$$
$$\cdot CHNj + \pi_i + \delta_j + \theta_t + \varepsilon_{jit}$$

$$(3.9)$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{jit} + \beta_3 lnvol_{jit} \cdot CHNi + \beta_3 lnvol_{jit} \cdot CHNj + \gamma_{ij} + \theta_t$$
$$+ \varepsilon_{jit}$$

$$(3.10)$$

m_{ijt}: nominal imports of j from i, $mass_{ijt}$: product of exporter i and importer j's nominal GDP, $dist_{ij}$: distance between exporter i and importer j, vol_{jit}: relative volatility measure j, $CHNij$: China's dummy representing trade activities that China is the exporter or importer, $CHNi$ and $CHNj$: China's dummy, representing the situation that China is the exporter and importer, respectively, π_i: exporter i's dummy, δ_j: importer j's dummy, γ_{ij}: bilateral trade partner ij's dummy, θ_t: time dummy, and ε_{ijt}: random error.

Bilateral exchange rate volatility: vol_{jdit}

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jdit} + \beta_4 lnvol_{jdit} \cdot CHNij + \pi_i + \delta_j + \theta_t + \varepsilon_{jit}$$

(3.11)

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{jdit} + \beta_3 lnvol_{jdit} \cdot CHNij + \gamma_{ij} + \theta_t + \varepsilon_{jit}$$

(3.12)

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jdit} + \beta_4 lnvol_{jdit} \cdot CHNi + \beta_4 lnvol_{jdit} \cdot CHNj + \pi_i + \delta_j + \theta_t + \varepsilon_{jit}$$

(3.13)

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{jdit} + \beta_3 lnvol_{jdit} \cdot CHNi + \beta_3 lnvol_{jdit} \cdot CHNj + \gamma_{ij} + \theta_t + \varepsilon_{jit}$$

(3.14)

m_{ijt}: nominal imports of j from i, $mass_{ijt}$: product of exporter i and importer j's nominal GDP, $dist_{ij}$: distance between exporter i and importer j, vol_{jdit}: the volatility of bilateral exchange rate between importer j and exporter i, $CHNij$: China's dummy representing trade activities that China is the exporter or importer, $CHNi$ and $CHNj$: China's dummy, representing the situation that China is the exporter and importer, respectively, π_i: exporter i's dummy, δ_j: importer j's dummy, γ_{ij}: bilateral trade partner ij's dummy, θ_t: time dummy, and ε_{ijt}: random error.

Table A.1: Summary of the test specifications

Equation	Fixed effects model/	$mass$	$dist$	Total effect				China's effect							
				vol_{it}	vol_{jt}	vol_{jit}	vol_{jdit}	vol_{it} $\cdot CHNi$	vol_{jt} $\cdot CHNj$	vol_{jit} $\cdot CHNij$	vol_{jit} $\cdot CHNi$	vol_{jit} $\cdot CHNj$	vol_{jdit} $\cdot CHNij$	vol_{jdit} $\cdot CHNi$	vol_{jdit} $\cdot CHNj$
(3.5)	c.d.	YES	YES	YES	YES			YES	YES						
(3.6)	p.d.	YES		YES	YES			YES	YES						
(3.7)	c.d.	YES	YES			YES				YES					
(3.8)	p.d.	YES				YES				YES					
(3.9)	c.d.	YES	YES			YES					YES	YES			
(3.10)	p.d.	YES				YES					YES	YES			
(3.11)	c.d.	YES	YES				YES						YES		
(3.12)	p.d.	YES					YES						YES		
(3.13)	c.d.	YES	YES				YES							YES	YES
(3.14)	p.d.	YES					YES							YES	YES

/c.d. country-specific dummy, p.d. country pairs' dummy

Appendix B

Gravity specifications without "China's effect"

The specification **(a)** to **(i)**, which are the gravity models without the "China's effect" variables are estimated and shown in **table 5.2, 5.4, and 5.6** to compare with the test specifications. The equations are shown as follows:

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{it} + \beta_4 lnvol_{jt} + \varepsilon_{ijt} \tag{a}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{it} + \beta_4 lnvol_{jt} + \pi_i + \delta_j + \theta_t + \varepsilon_{ijt} \tag{b}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{it} + \beta_3 lnvol_{jt} + \gamma_{ij} + \theta_t + \varepsilon_{ijt} \tag{c}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jit} + \varepsilon_{ijt} \tag{d}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{ijt} + \pi_i + \delta_j + \theta_t + \varepsilon_{ijt} \tag{e}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{ijt} + \gamma_{ij} + \theta_t + \varepsilon_{ijt} \tag{f}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jdit} + \varepsilon_{ijt} \tag{g}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lndist_{ij} + \beta_3 lnvol_{jdit} + \pi_i + \delta_j + \theta_t + \varepsilon_{ijt} \tag{h}$$

$$lnm_{ijt} = \alpha + \beta_1 lnmass_{ijt} + \beta_2 lnvol_{jdit} + \gamma_{ij} + \theta_t + \varepsilon_{jit} \tag{i}$$