Preliminary Draft
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Exchange Rate Volatility, Value-added Trade, and Intra-regional trade in East Asia and North America

Yizhe XIE*
Waseda University

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* The author is a Ph.D. student at Graduate School of Asia Pacific Studies, Waseda University. He appreciates your comments and suggestions. And he can be contacted at danielxie39@fuji.waseda.jp

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Abstract

Value-added export is what really matters to an economy in terms of job creation and value generation. Traditional approach 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 of empirical studies on its impact on value-added trade. To fill the gap, the paper empirically re-examine the relationship between exchange rate volatility and trade using new value-added bilateral trade data for 41 countries during 1995~2013 in comparison with gross trade. The results of using Poisson Pseudo-Maximum-Likelihood (PPML) method provide several findings as follows: first, exchange rate volatility discourages trade in general, but more serious for value-added trade. Second, trade costs caused by geographical distance, common language and border effects between two countries became less important in value-added trade. Third, it confirms, like in gross trade, the empirical results of real or nominal exchange on trade are similar in value-added trades and companies do respond to the volatility of previous year in making export decisions for current year. Fourth, developed countries face less 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

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 policy makers. In times of financial crisis, many governments seek to intervene foreign exchange market by arguing that volatile exchange rate will hurt its export and harm its economy. 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 foreign exchange earlier 2016.

But how does exchange rate volatility affect trade? There is no consensus on this topic both theoretically and empirically. In early theoretical studies, exchange rate volatility is often seen as an additional commercial risk and a transaction cost associated in 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 firm to export (Hayakawa and Kimura, 2008). Many empirical researches 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; Chitet et al., 2010). However, these conclusions rely on many theoretical assumptions such as perfect competition, the absence of imported inputs, the high aversion to risk, and the absence of hedging financial instruments.[1] Once those assumptions are relaxed, the relationship between exchange rate volatility and trade become more complicated and ambiguous.

On the other hand, some studies suggest a positive relationship. Depending on the level of risk aversion, greater exchange rate volatility may lead highest risk-aversion firms to increase their overseas sales (income effect is larger than substitution effect) owing to an expected revenue cut per export unite (De Grauwe, 1998). Broll and Eckwert (1999) reconfirmed the positive relationship by studying heterogeneous firms' response to exchange rate volatility. Some researchers also 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 could not find a significant association between exchange rate volatility and trade (Hondroyiannis et al., 2008); Boug and Fagereng, 2010; Tenreyro, 2007; Eicher and Henn, 2009). The ambiguity hints a well-accepted

[1] Marc Auboin and Michele Ruta, 2011, The Relationship between Exchange Rates and International Trade: a Review of Economic Literature, WTO, staff working paper ERSD – 2011-17

view that the study of exchange rate volatility on trade is an empirical issue (Chit et al., 2010) given econometric results rely heavily on the model specification, samples, time periods and estimation method.

Almost all exchange rate and trade literature rely 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 is $179 per unit, which dramatically inflated Chinese exports to the US for 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 chains. UNCTAD (2013) and IMF (2015) noted that the impact of exchange rate on trade have decreased following the rise of production networks together with the availability of hedging products

As demonstrated in the case of 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 in final exports that really matters to the 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.

The study attempts to be, to the best knowledge of the author, the first one to examine the impact of exchange rate volatility on value-added trade using comprehensive bilateral value-added trade data. The exercise intends to contribute to the empirical literature of exchange rate and trade by providing several novel findings in connection with value-added trade. Multiple analyses 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; 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 (2008) and Hayakawa and Kimura (2009)'s work on East Asia;

its impact in different stages of economic development.

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

2. Data and methodology

2.1 Data

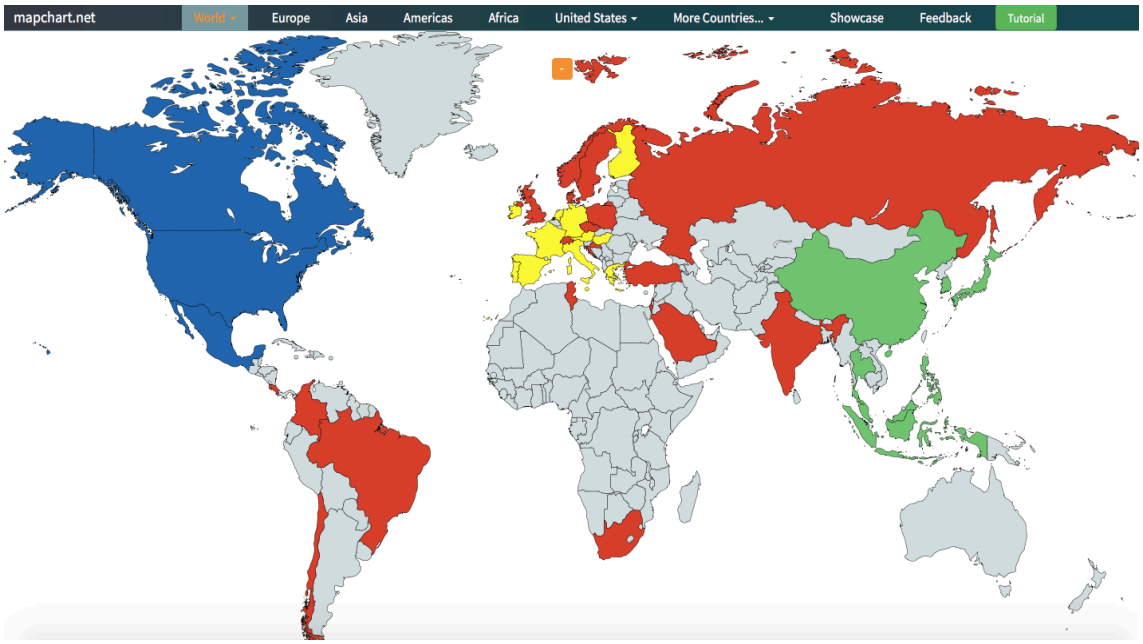
The sample includes annual bilateral trade among 41 countries[2] (see the graph A below) from 1995 to 2013. While the gross trade data is the World Trade Flows (WTF) bilateral data[3], the value-added trade data[4] is received from Duval, Li, Saraf, Seneviratne who constructed the data-set based on the OECD-WTO Trade in Value Added (TiVA) dataset and published their work on *Journal of International Economics* (Duval, et al., 2016). GDP and GDP deflator is 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.

[2] 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.

[3] 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

[4] 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 1 Sample Countries



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[5] at IFS. Control variables related to gravity model such as distance, common language, adjacency (contiguous), Regional Trade Agreement, population, colony are downloaded from the Gravity Dataset from the website of the Centre d'Études Prospectives et d'Informations Internationales (CEPII). The summary statistics of main variables is shown as in table 1.

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

Table 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

Figure 2 and Figure 3 present downward slope between exchange rate volatility and export (TiVA and gross trade). Nominal exchange rate volatility is slightly steep.

Figure 2 Scatter plot of exchange rate volatility and TiVA

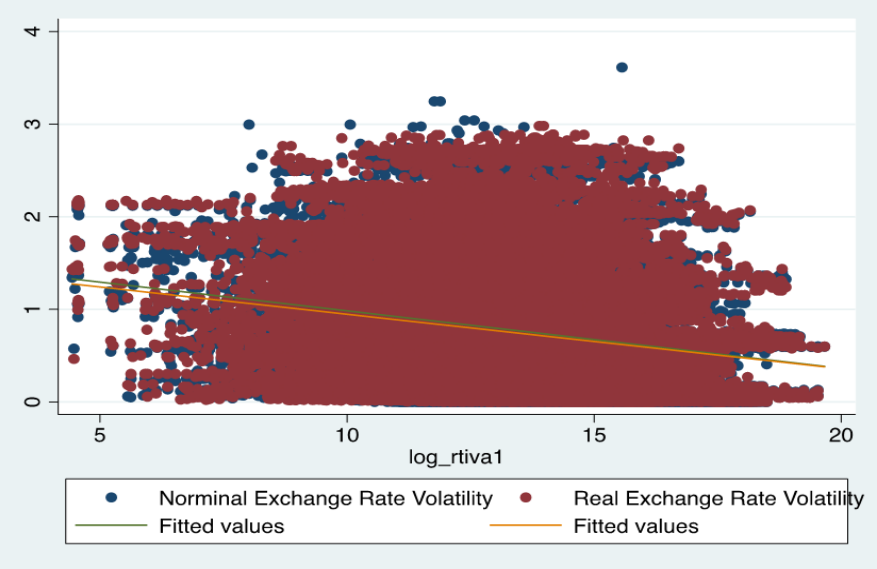
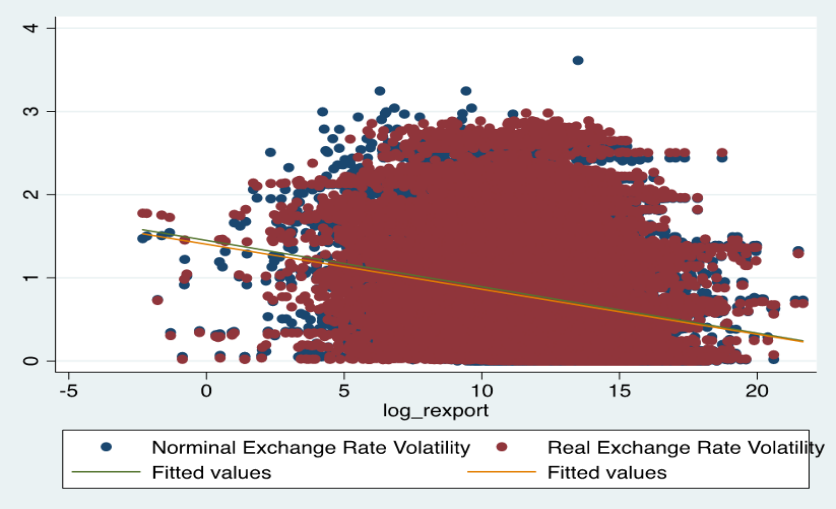


Figure 3 Scatter plot of exchange rate volatility and gross export



2.2 Methodology

The gravity model is often used to examine bilateral trade flows and it 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), the paper also uses gravity model in exploring the impact of exchange rate volatility on trade in value-added and gross trade.

Gravity model usually suffers from "zero trade flow" problem, which causes information loss and potential biased results. The poisson pseudo maximum likelihood

(PPML) estimation method is often used, arguably the best tool, in addressing the "zero trade" issue in gravity model (Santos Siliva and Tenreyro, 2006; 2008). This paper 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 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 model. In this paper, it includes dummy variables, which takes value of 1 if two countries meet share or are common language, common boarder or adjacency, former colony, regional trade agreement, zero 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 rates. Lacking of consensus on what is the best measurement of exchange rate volatility, this study employ the widely used first-difference approach, i.e., the first-difference of the monthly natural logarithm of bilateral exchange rate (real and nominal) in current year and previous year (IMF, 2004). This method captures both the lag and anticipated effect of volatility on firm's 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 current year, is also used for robustness check.

3. Estimation Results

This session reports the econometric results, which include baseline results, extension of baseline equation by controlling more variables, robustness check, and adding interaction variables of East Asia, NAFTA and High Income countries.

3.1 Baseline results

Table 2 reports the baseline results. It 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 – PPML, OLS and Fixed Effects[6]. The rest of gravity variables are as expected.

Table 2 Baseline results of three different estimation methods

	(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$_i$	0.367***	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*

3.2 Extension of more control variables

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

Following previous studies, the paper extended the baseline equation by controlling more variables, namely population and regional trade agreement (RTA) while controlling country-year pair dummy variables as shown in table 3. The major results are consistent and all expected except an unusual, but ok, negative relationship with colony[7] in gross exports. The PPML results suggest that the negative impact of real exchange rate volatility on exports is greater in TiVA than gross exports. One explanation can be that value-added exports measures 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 that lead to a direct impact on the value-added exports to the final market.

Furthermore, it shows that magnitudes of geographic distance, Adjacency, common language are smaller in TiVA. This empirical findings echo the argument that the GVCs reduce the sensitivity of exports to bilateral geographic distance as value-added export can happen via third countries (Johnson, 2014). For the same reason, trade frictions or trade cost caused by common boarder and language barrier also become weaker.

[7] 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 3 Estimation results by controlling more variables using PPML method

VARIABLES	(1) TiVA	(2) TiVA	(3) TiVA	(4) Gross Export	(5) Gross Export	(6) 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.*

3.3 Robustness check

Three methods are used in robustness check for the interest variable, i.e. 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 shows the results of robustness check using OLS and Fixed Effects. Both OLS and Fixed Effects results confirm the direction of exchange rate volatility using PPML method. Yet, 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 due to the choice of estimation method is usually acceptable given it does not change the sign of the relationship.

Table 4 Robustness check using OLS and Fixed Effects

VARIABLES	(1) PPML TivA	(2) OLS TiVA	(3) Fixed Effects TiVA	(4) PPML Gross Export	(5) OLS Gross Export	(6) Fixed Effects Gross Export
$Log\_Real\ GDP_i$	0.281***	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 5, the results are robust. Besides, it reconfirms that the choice of real or nominal exchange rate makes no significant difference in empirical studies on volatility on trade (IMF, 2004). This empirical evidence is also true in value-added trade.

Table 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 6 presents, results are as expected and also robust using different measurement 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 current year. This measurement is contemporaneous and short-term, and it removes partial effect of the volatility of previous year. Consistent with our expectation, exports are slightly less sensitive to short-term volatility. In other words, companies do respond to the volatility observed in previous year when making export decisions though the effect may be very small.

Table 6 Robustness check using different measurement of real 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***	0.378***	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.*

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 North American Free Trade Agreement in 1990s, the share of intra-regional trade has been increasing dramatically in two regions thanks to regional production network (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 large amount of the trade is in intermediate goods (Thorbecke, 2008; Hayakawa and Kimura, 2009). In order to reexamine volatility on intra-regional trade more generally, I include interaction variable intra-Asia and intra-NAFTA trade with exchange rate volatility.

Different from previous studies by Thorbecke (2008) and Hayakawa and Kimura (2009), table 7 suggests that intra-regional trade in East Asia[8] and NAFTA actually 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. And NAFTA countries all observe a positive relationship with exchange rate volatility. In another word, companies being in a production network 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 model specification, estimation techniques, most importantly, sample and products[9].

Then, a natural question is that why intra-regional trade is less sensitive to exchange rate volatility in East Asia, particularly in NAFTA. Conceptually, these results may attribute to 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 volatility to exchange rate volatility and other external disturbance. And NAFTA's concentration on automobile with a few players and East Asia's focus on electronics with relatively more players (market competition structure) may be the reason. Future study of firms' export behavior in intra-regional trade in response to exchange rate volatility will probably give a more detailed and comprehensive answer.

Table 7 also suggests that developed countries or high-income economies[10] 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.

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

[9] 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.

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

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

VARIABLES	(1) TiVA	(2) TiVA	(3) TiVA	(4) Gross Export	(5) Gross Export	(6) 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. Conclusion

In the literature of exchange rate volatility on trade, there is no consensus on its relationship (though many findings show a negative relationship) with gross trade and, yet, lacking of any empirical study on its impact on value-added trade. This happens at a time when traditional approach to measure and study international trade encountered increasing number of criticisms thanks to "double counting" problems and multi-country production chains following the rise of GVCs and global production networks.

This paper empirically investigated the relationship between exchange rate volatility and value-added trade in comparison with 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 an 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 level of labor and capital inputs by removing the indirect foreign inputs. Second, trade frictions or costs caused by geographical distance, common language, 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 previous year and, consistent with literature, nominal and real exchange rate makes no significant difference in this type of empirical exercises even in value-added trade. Fourth, high-income countries face a smaller 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 (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 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 the argument. Nevertheless, the different results may be due to the choices of estimation method and difference in sampling and products. Another explanation can be the timing, i.e., before and after the set-up of regional production network can produce very different picture. My findings indicate that many exporters rely on overseas sourcing, supplies and other foreign inputs in the process of production and change of supplies often is costly and time-consuming once the fixed costs have occurred or the regional production network has already been established. Therefore, the impact of exchange rate volatility on trade is reduced in intra-regional trade where the regional production network has already formed.

The paper has three policy implementations. First, policy makers should pay more

attention to exchange rate volatility as it affects even more on value-added trade and government should encourage. Second, governments should encourage global production networks because exports can be more stable once they are established in times of volatile exchange rates movements and they can bypass the bilateral trade barriers such as geographical distance and export via third countries. Third, countries should support the development of financial markets and hedging products.

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