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경제학 석사학위논문

One Role of FX reserves and Exchange Rate Volatility

환율 변동성과 외환보유고의 한가지 역할

2014년 12월

서울대학교 대학원

경제학부 경제학 전공

송 민 우

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이 논문을 경제학석사 학위논문으로 제출함.

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서울대학교 대학원
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송민우의 경제학석사 학위논문을 인준함.

2014년 12월

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Abstract

One Role of FX reserves and Exchange Rate Volatility

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The financial crisis in the United States (2007-2009) affected most countries through certain factors such as the exchange rate. Before the crisis, it was generally believed that if a country falls in a recession, then its currency would depreciate. During the financial crisis, however, the US dollar appreciated substantially vis-à-vis all other currencies except for few. The previous papers explained unexpected movement of the exchange rate by investigating transmission channels of the crisis and its main resources. But none of the papers explained the exchange rate volatility between US dollar and other currencies. Therefore, this paper focuses on the volatility and shows that only FX reserves can account for the magnitude of exchange rate volatility in emerging market economy irrespective of economic situations.

Keywords: Exchange rate volatility, FX reserves, OLS

Student Number: 2012-22971

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1. Introduction

On December 18th 2013, Federal Reserve announced that it would start to taper its aggressive bond-buying program to \$75 billion a month beginning in January 2014. After that, not only US but also global economy has affected by this news as revealed by certain factors such as exchange rate. Before the QE tapering, there was a similar situation, the financial crisis of 2007-2009. Both originated from US and their impacts spread all over the world and led to sharper fluctuation in exchange rate.¹ In this regard, this paper investigates the main factors that affected exchange rate volatility during financial crisis and then suggests the impact of tapering based on these findings.

Before the crisis, it was generally believed that if a country falls in a recession, then its currency would depreciate. However, during the financial crisis, US dollar appreciated substantially vis-à-vis all other currencies except for few. The previous papers investigated transmission channels to explain the unexpected exchange rate movements. Fratzscher (2009) and Kohler (2010) presents that the reasons for US dollar appreciation are; a flight-to-safety phenomenon (i.e., safe haven flows) by US and non-US investors, an increased need for US dollar liquidity, and an unwinding of carry trade position. Fratzscher also confirmed that FX reserves, current account position, and direct financial exposure vis-à-vis the US are main factors that explain exchange rate movements during financial crisis with least square method. However, none of the papers explained the exchange rate volatility between US dollar and other currencies during crisis. Therefore, this paper focused on the magnitude of exchange rate volatility to measure the negative impact and consequently find the main factors of the volatility. Before investigating the main factors, understanding the role of exchange rate volatility is necessary to conduct analysis. First of all, exchange rate volatility indicates exchange rate uncertainty in which an increase in exchange rate volatility means high uncertainty of exchange-

1. Someone called it "Economic Tsunami". Its epicenter is influential countries and it spread by exchange rate and impact on the world economy.

rate. Gagnon (1993), Arize et al. (2000), and Barkoulas et al. (2002) show that high uncertainty of exchange rate exerts negative impact on foreign trade. Furthermore, Philippe et al. (2009) argues that large exchange rate volatility can stunt not only productivity growth but also long-run economic growth, especially countries with weak financial development. In accordance with those papers, it is worthwhile to find the main factors of exchange rate volatility and also the period of financial crisis is suitable for analysis since the volatility shows drastic changes that have negative impact on the economy. Indeed, I expanded time period and so compared according to the economic situation, to look at whether factors affected exchange rate volatility as economic condition changed.

In this paper, it discovers that only FX reserves can explain magnitude of exchange rate volatility in the emerging market economy (EME), regardless of economic situations (While, the exchange rate volatility in advanced countries cannot be explained merely by FX reserves and also it is hard to find other variables that cause fluctuation). This result is in accordance with Hviding et al. (2004) which states that a country holding higher FX reserves tend to show small exchange rate volatility in EME. Nevertheless, the existing theories do not clearly present the effect of central bank intervention in exchange rate stability. However, there are empirical analyses presenting the effects of central bank intervention in stabilizing exchange rate markets. For the success is not always guaranteed, there are contradicting arguments on the intervention.² Despite the consequences, it is central banks' role to execute appropriate policies through various channels to control exchange rate. It is by holding sufficient FX reserves that gives the capacity to implement stabilizing tools. The result of this paper also aligns with the evidence that higher FX reserves reduce exchange rate volatility.

The remaining part of the paper is structured as follows. The data for empirical analysis are provided in Section 2 with the rationale. Section 3 presents the empirical model to find main factors that explain exchange rate volatility. Finally, conclusions are drawn

² Bonser-Neal (1996) presents that central bank intervention does not always reduces exchange rate volatility. Indeed, it may even increase or has no effect on volatility.

in Section 4.

2. The Data

This section describes the data that are used to find the determinant of exchange rate volatility before, during, and after the financial crisis.

First, I adopt nominal exchange rates vis-à-vis the US dollar (base currency), since this paper investigates exchange rate volatility caused by the impact of financial crisis from US. Appendix A lists the countries as samples, which consists of 105 countries, classified as either advanced or emerging market economies each (it is classified at the time of the crisis). To obtain robust results, this paper takes a large number of country samples as far as data is concerned.

(Table 2.1 here)

Second, Table 2.1 indicates variables in the empirical model which are based on works done by Bayoumi and Eichengreen (1998), Devereux and Lane (2002), and Fratzscher (2009). I adopted standard OCA (optimum currency areas) variables which were devised by Bayoumi and Eichengreen (1998) to unearth factors that explain exchange rate volatility. They argued that standard OCA variables help to explain patterns of foreign exchange market intervention thus it should be included in the empirical model.³ On the other hand, Fratzscher (2009) analyses the determinant of the exchange rate movements by dividing it into two parts; macroeconomic fundamentals and financial exposures. The macroeconomic fundamentals comprise GDP growth rate, sovereign rating, inflation, FX reserves, and current account balance, while the financial exposures stand for external exposure of countries which are represented by various

3. See Bayoumi and Eichengreen (1998), and Devereux and Lane (2002) for details.

proxies such as foreign direct investment, portfolio equity, CPIS (Coordinated Portfolio Investment Survey, which represents financial liabilities vis-à-vis US), imports from US, and exports to US. All of the data is represented in annual average value so that the analysis can be conducted in cross-sectional perspective. By combining time series of cross-sectional observations, it reduces collinearity among variables and in turn deviates from endogenous problem between explained variable and explanatory variables since annual average value is implemented with lagged value. As a result, he showed that FX reserves, current account position, and financial liabilities vis-à-vis US can explain unexpected exchange rate movements during financial crisis.

Everything taken together, I included variables in the model as shown in Table 2.1. In empirical model, it is hard to determine which variables should be included or not. Therefore, this paper endeavors to justify choice of explanatory variables through adding to previous works on exchange rate movements and volatility. And Figure 2.1 would help to establish the rationale for selecting explanatory variables in this paper.⁴

(Figure2.1 here)

The sample period (2004-2012) is categorized into three situations; before financial crisis (2004-2006), financial crisis (2007-2009), and after financial crisis (2010-2012). The initial point of financial crisis is somewhat arbitrary, but numerous papers generally consider 2007-2009 as the period of the crisis, since there was the collapse of Lehmann Brothers on September 15, 2008 and there existed some portent of crisis around 2007. Since the financial crisis period is defined as 2007-2009, it can yield more robust result than that from specific shorter period (e.g. July 2008 to January 2009).⁵

4. Appendix B shows the correlation among variables.

5. Besides, this paper adopts the variable, CYCLE, so that diving the total period into 3 years (medium-term) would be suited to this papers' methodology.

3. Empirical Model and Result

This section presents the model specification to find the decisive factor of exchange rate volatility and results with discussion how to eliminate possible problems. I chose least squares procedure, adopting a similar approach used by Mark (1995), Cheung et al. (2005), and Fratzscher (2009). In order to test for the role of variables, the empirical model is set up as

$$VOL_t = \alpha_i + \beta X_{t-1} + \gamma S_{t-1} + \varepsilon, \quad (1)$$

where VOL_t is the vector of exchange rate volatility between US and country i in period (t), X_{t-1} is the set of standard OCA variables (CYCLE, TRADE, and SIZE) in period ($t - 1$), and S_{t-1} is consist of FX reserves, current account balance, and external financial dependence in period ($t - 1$).

The essential parts for model (1) are two things. One is the measure of exchange rate volatility, VOL_t and the other is the lagged explanatory vectors, X and S .⁶

First VOL_t is obtained by using changes in log nominal exchange rate between country i and US from January to December in period (t) as

$$VOL_{t,i} = STDEV[\Delta(\ln e_{t,m,i})] \quad \text{for } m = 1, 2, \dots, 12 \quad (2)$$

Since exchange rate between US and country i is not free from unit of currencies, this paper takes changes in log value so that it enables to compare volatility of 105 countries directly without adjustment.⁷ Second, the lagged explanatory vectors, X and S , are exogenous in the model specification so it is free from endogeneity problem. However, lagged value can possibly bring reverse causality problem. In particular, after the financial crisis, countries endeavor to stabilize their economy made it hard to identify cause and effect. Nonetheless, before and during

6. Bayoumi and Eichengreen (1998), and Devereux and Lane (2002) they did not use lagged value, while they use IV estimation based on gravity model to deviate from endogenous problem.

7. Before run the regression, $VOL_{t,i}$ is multiplied by 100 to adjust coefficients of results.

crisis, using lagged value hardly leads to reverse causality problem and also enables forecast future. For instance, if a country encountered negative events or falls in a recession, then we can gauge the impact by using previous data.

(Figure3.1 here)

Figure 3.1 represents the relationship between FX reserves in period $(t - 1)$ and exchange rate volatility in period (t) in EME. The line of figure indicates regression line. We can confirm the negative relationship from downward slope and also most of countries are fitted around to the regression line.⁸ Thus, we could expect that if a country among EME has sufficient FX reserves, then it will show less exchange rate fluctuations.

Before investigating the main model (1), the model is estimated with only standard OCA variables, which is given as

$$VOL_t = \alpha_i + \beta X_{t-1} + \varepsilon, \quad (3)$$

where VOL_t is obtained from (2), and X_{t-1} is the set of standard OCA variables (CYCLE, TRADE, and SIZE).⁹

(Table3.1 here)

Table 3.1 shows coefficients and standard error of (3) obtained by using ordinary least squares (OLS) estimation in the period from before financial crisis (2004-2006) to after financial crisis (2010-2012). The result shows that lagged standard OCA variables partially explain exchange rate volatility.

First, TRADE seems to reduce exchange rate volatility during and after the crisis. The negative relationship between foreign trade and exchange rate volatility can be inferred and it

8. On the other hand, there exist outliers such as Hong Kong and Singapore. One possible explanation of those outliers is exchange rate regime of country. Since Hong Kong is taking pegged exchange rate system, their exchange rate volatility is very stable, while Singapore is taking floating regime but closely monitored by the Monetary Authority (i.e., managed floating regime).

9. For instance, before financial crisis (2004-2006), the equation (3) is represented by

$$VOL_{2004-2006} = \alpha_i + \beta_1 CYCLE_{1994-2004} + \beta_2 TRADE_{2001-2003} + \beta_3 SIZE_{2001-2003} + \varepsilon$$

corresponds with previous papers. Second, SIZE narrowly accounts for the volatility in EME during the crisis. The positive relationship between SIZE and the volatility indicates that a country in EME with large economic scale is less exposed to exchange rate fluctuations. Third, however, CYCLE does not account for the volatility regardless of situations and countries. There are two possible interpretations of this result. (a) Since time length is 3 years (medium-term), it is relatively short to explain exchange rate volatility with CYCLE. (b) Also this paper focuses on the time series properties of exchange rates showing value of a currency to a single large currency, US dollars. On the other hand, Bayoumi and Eichengreen (1998), and Devereux and Lane (2002) conducted long-term period study (more than 5 years) and they investigated entire bilateral exchange rate volatility across all countries. To sum up, using lagged value to analyze its effect on exchange rate volatility can be justified.

(Table3.2 here)

Finally, Table 3.2 presents the results based on equation (1) and gives us several interesting features. What is the most interest thing is that exchange rate volatility can be explained by FX reserves in EME irrespective of economic situations and it also grounds for the Figure 3.1. It is statistically significant and the coefficient of FX reserves is consistent over the period. The negative sign indicates that higher FX reserves reduce the exchange rate volatility and it is not only consistent from 2004 to 2012 but also its magnitude changes according to riskiness of financial crisis. As the economic situation become worse in financial crisis, the absolute value of coefficient of FX reserves got larger (i.e., the role of FX reserves become more important). Also, the significance level increased between 2010 and 2012 and it was possibly due to government measure to stabilize the economy. Meanwhile, in the case of advanced country, there is no variable that explains the exchange rate volatility with consistency. However, during financial crisis, it looks as if FINDEP affected exchange rate volatility. One possible interpretation of this negative effect is that closest connection among advanced countries temporarily formed a kind of union so that exchange rates are not fluctuated. However, this is not enough to corroborate that FINDEP can account for the volatility at all times.

4. Conclusions

This paper attempts to unearth factors which can account for exchange rate variability during financial crisis times including before and after the crisis and it reveals that only FX reserves ($t - 1$) can explain exchange rate volatility (t) in EME. The most important finding is that exchange rate volatility can be explained by FX reserves irrespective of economic situations. Moreover, the role of FX reserves becomes larger during crisis. In other words, one can forecast the level of exchange rate variability though examining previous data of FX reserves. Even though it is hard to deviate from reverse causality problem, the result presents the strong negative relationship between FX reserves ($t - 1$) and exchange rate volatility (t).¹⁰ Furthermore, based on the result, we can also gauge the impact of QE tapering (2014) by investigating FX reserves (2013). Indeed, a country in EME which had relatively insufficient FX reserves compared to other countries of EME generally showed larger exchange rate fluctuations.¹¹ Thus, these observations buttress the result, and it is possible to forecast which countries in EME will fluctuate more when negative event occurs in leading countries. Consequently, it is a very simple but an effective way to accumulate FX reserves for a country of EME to stabilize their exchange rate volatility.

10. In particular, the result from 2004-2006 in EME supports the relationship and causal effect.

11. Argentina, Colombia, Indonesia, Pakistan, South Africa, and Turkey had the amount of FX reserves which is less than 1/2 standard deviation from the mean of EME and consequently suffered from large fluctuations.

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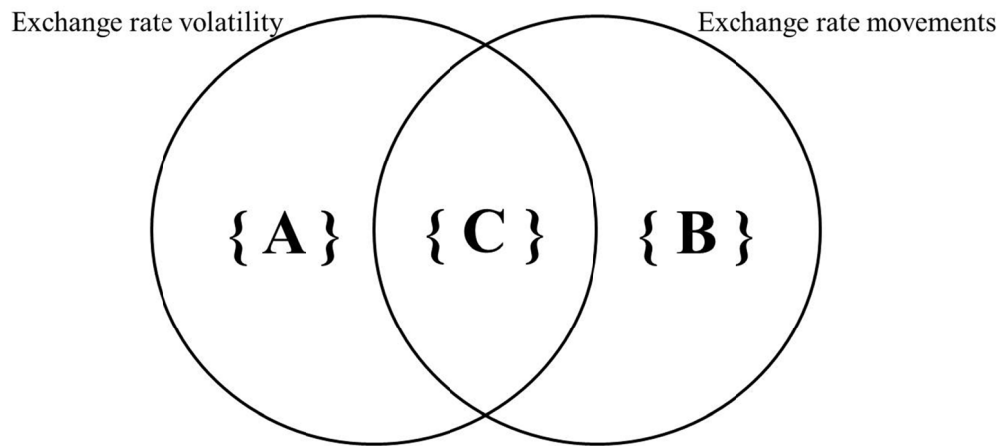
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Table 2.1 Variables in the Model

	Data Description	Source
Exchange rate	Nominal exchange rate (Target currency / Base currency)	IMF
CYCLE	CYCLE = std (growth _{US} -growth _j) (It is obtained over the period 1994 to 2004, 1997 to 2007, and 2000 to 2010)	The World Bank
TRADE	TRADE = $\ln \frac{\text{Export to US} + \text{Import from US}}{GDP_i}$	United States International Trade and The World Bank
SIZE	SIZE = $\ln(GDP_{US} - GDP_i)$	IMF
FINDEP	International and foreign claims which is proxy the level of financial dependence. (It is implemented in the form of $\ln(1 + \text{FINDEP})$)	BIS
FX (FX reserves scaled by country's GDP)	Foreign exchange reserves are assets held by each country's central banks and monetary authorities in different currencies excluding gold.	IMF
CUR (Current account balance scaled by country's GDP)	Current account balance is the sum of net exports of goods and services, net primary income, and net secondary income.	IMF

Notes: TRADE, SIZE, FINDEP, FX, and CUR are averaged over the period 2001 to 2003, 2004 to 2006, and 2007 to 2009.

Figure 2.1 The Rationale for the Explanatory Variables

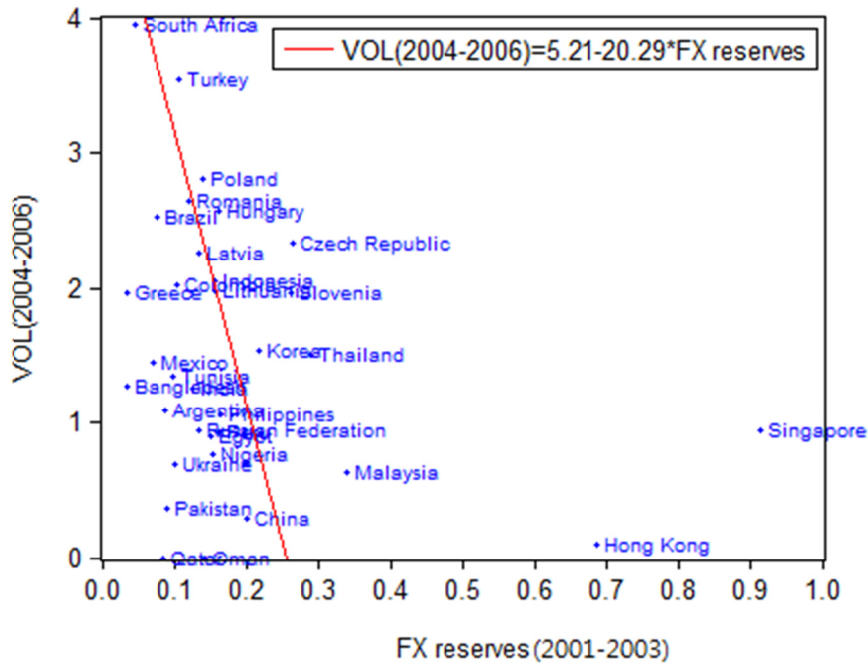


$\{A\}$: Possible determinants of exchange rate volatility

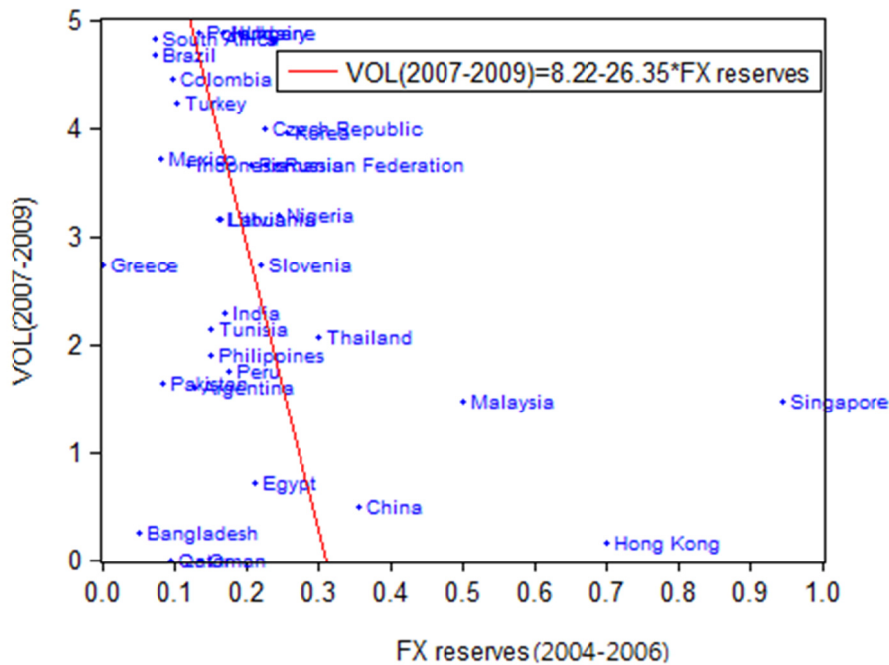
$\{B\}$: Possible determinants of exchange rate movements

$\{C\}$: Possible determinants of exchange rate volatility and movements

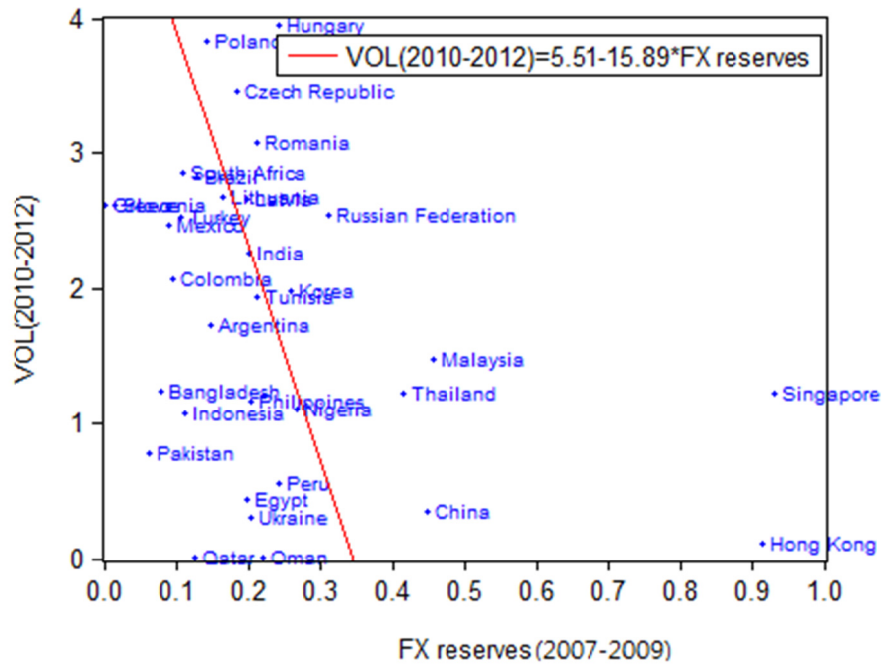
Figure 3.1 The Relationship between FX reserves and Exchange Rate Volatility in EME



A. Before the Financial Crisis



B. During the Financial Crisis



C. After the Financial Crisis

Table 3.1 Regression Results of Equation (3)

	Full Sample				Advanced Country				EME		
	<i>VOL</i> (2004-2006)	<i>VOL</i> (2007-2009)	<i>VOL</i> (2010-2012)	<i>VOL</i> (2004-2006)	<i>VOL</i> (2007-2009)	<i>VOL</i> (2010-2012)	<i>VOL</i> (2004-2006)	<i>VOL</i> (2007-2009)	<i>VOL</i> (2010-2012)		
CYCLE	-0.07 (0.69)	0.03 (0.11)	-0.01 (0.09)	-0.02 (0.14)	-0.25 (0.50)	-0.04 (0.25)	-0.09 (0.07)	-0.07 (0.12)	-0.10 (0.11)		
TRADE	-1.49 (6.80)	-1.62* (0.73)	-1.47* (0.60)	-0.78 (0.50)	-0.37 (1.95)	-2.70** (1.22)	-1.15 (0.52)	-1.98*** (0.71)	-1.18** (0.57)		
SIZE	0.09 (0.68)	-0.08 (0.08)	0.04 (0.06)	-0.05 (0.04)	-0.0 8(0.14)	-0.12 (0.09)	0.19 (0.16)	0.63*** (0.24)	0.23 (0.20)		
R-squared	0.000	0.065	0.058	0.278	0.047	0.453	0.183	0.265	0.171		

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Table 3.2 Regression Results of Equation (1)

	Full Sample			Advanced Country			EME		
	<i>VOL</i> (2004-2006)	<i>VOL</i> (2007-2009)	<i>VOL</i> (2010-2012)	<i>VOL</i> (2004-2006)	<i>VOL</i> (2007-2009)	<i>VOL</i> (2010-2012)	<i>VOL</i> (2004-2006)	<i>VOL</i> (2007-2009)	<i>VOL</i> (2010-2012)
CYCLE	-0.09 (0.72)	0.06 (0.12)	0.02 (0.09)	0.13 (0.16)	-0.42 (0.54)	-0.29 (0.36)	0.00 (0.08)	0.07 (0.17)	-0.19 (0.11)
TRADE	-1.67 (6.96)	-1.46** (0.75)	-1.20** (0.60)	-0.82 (0.49)	-0.90 (1.80)	-2.80* (1.36)	-0.76 (0.52)	-1.37* (0.79)	-0.85 (0.57)
SIZE	0.07 (0.73)	-0.09 (0.08)	0.01 (0.07)	-0.07 (0.05)	-0.13 (0.16)	-0.12 (0.11)	0.08 (0.16)	0.66*** (0.26)	0.32 (0.19)
FINDEP	-2.95 (7.87)	-0.08 (0.97)	0.59 (0.69)	-0.44 (0.24)	-1.49* (0.69)	-0.08 (0.37)	7.33* (4.16)	8.27 (6.25)	4.67 (3.51)
FX	-0.16 (10.04)	-1.37 (1.20)	-1.28* (0.72)	-1.42 (1.70)	-2.23 (3.98)	-1.14 (1.86)	-3.83* (2.09)	-4.35* (2.41)	-3.56*** (1.27)
CUR	-0.11 (0.28)	0.00 (0.03)	-0.01 (0.02)	0.03 (0.04)	0.10 (0.07)	0.07 (0.06)	-0.08* (0.05)	-0.04 (0.08)	0.06 (0.05)
R-squared	0.004	0.077	0.103	0.498	0.425	0.527	0.348	0.353	0.368

Notes: ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels respectively.

Appendix A

Country Sample

Full Sample		
	Advanced Country	EME
<p>Algeria, Angola, Argentina, Armenia, Australia, Austria, Bangladesh, Belarus, Belgium, Belize, Bhutan, Bolivia, Botswana, Brazil, Brunei, Darussalam, Bulgaria, Burundi, Cambodia, Canada, China, Colombia, Comoros, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, El Salvador, Fiji, Finland, France, Georgia, Germany, Ghana, Greece, Guyana, Haiti, Honduras, Hong Kong, Hungary, India, Indonesia, Ireland, Italy, Japan, Jordan, Kazakhstan, Kenya, Korea, Kuwait, Latvia, Lesotho, Lithuania, Luxembourg, Malawi, Malaysia, Malta, Mauritius, Mexico, Moldova, Mongolia, Morocco, Nepal, Netherlands, New Zealand, Nicaragua, Nigeria, Oman, Pakistan, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Romania, Russia, Sao Tome and Principe, Saudi Arabia, Seychelles, Singapore, Slovenia, Solomon Islands, South Africa, Spain, Sri Lanka, Swaziland, Sweden, Switzerland, Tajikistan, Tanzania, Thailand, Tonga, Tunisia, Turkey, Uganda, Ukraine, United Kingdom, Vanuatu, Vietnam</p>	<p>Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Luxembourg, New Zealand, Sweden, Switzerland, United Kingdom</p>	<p>Argentina, Bangladesh, Brazil, China, Colombia, Czech Republic, Egypt, Greece, Hong Kong, Hungary, India, Indonesia, Korea, Latvia, Lithuania, Malaysia, Mexico, Nigeria, Oman, Pakistan, Peru, Philippines, Poland, Qatar, Romania, Russia, Singapore, Slovenia, South Africa, Thailand, Tunisia, Turkey, Ukraine</p>

Appendix B

Correlation among Variables

2004-2006	TRADE	CYCLE	SIZE	FINDEP	FX	CUR
TRADE		-0.09	0.11	0.14	0.09	-0.03
CYCLE			-0.25	-0.28	0.05	0.14
SIZE				0.34	-0.20	-0.26
FINDEP					0.15	0.06
FX						0.26
CUR						

2007-2009	TRADE	CYCLE	SIZE	FINDEP	FX	CUR
TRADE		0.00	0.12	0.12	0.17	-0.03
CYCLE			-0.21	-0.26	0.24	0.27
SIZE				0.31	-0.14	-0.21
FINDEP					0.17	0.04
FX						0.29
CUR						

2010-2012	TRADE	CYCLE	SIZE	FINDEP	FX	CUR
TRADE		-0.08	0.14	0.11	0.16	-0.01
CYCLE			-0.35	-0.32	0.10	0.29
SIZE				0.31	-0.12	-0.29
FINDEP					0.08	-0.03
FX						0.24
CUR						

One Role of FX reserves and Exchange Rate Volatility

환율 변동성과 외환보유고의 한가지 역할

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미국의 금융위기 (2007-2009)는 대부분의 국가에 환율을 통해 영향을 미쳤다. 금융위기 전에는 한 국가의 불황이 닥치면 그 나라의 통화가치는 떨어진다는 것이 일반적이었다. 하지만 금융위기 당시, 미국 달러의 가치는 일부 국가를 제외한 모든 국가의 통화 가치에 대하여 상승하였다. 그래서 이전의 논문들은 예측과 달랐던 환율의 변화에 대한 원인과 전달경로에 대해 설명하였다. 하지만 그 중 어느 논문에서도 미국 달러와 다른 통화에 대한 환율의 변동성에 관한 설명은 없었다. 따라서 이 논문에서는 환율의 변동성에 관한 연구를 하였고, 그 결과 환율변동성의 크기는 emerging market economy의 경우, 경제상황에 상관없이 오직 FX reserves에 의해 설명된다는 것을 밝혀내었다.

주요어: Exchange rate volatility, FX reserves, OLS

학번: 2012-22971