Monetary Policy, Volatility Spillovers to Emerging Market Economies and Impact of Exit Strategies*

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Abstract

The recent announcements by the Federal Reserve of its gradual exit from unconventional monetary policies along with the gradual reduction of the European Central Bank's balance sheet and the ensuing volatility of financial markets have prompted discussions regarding volatility spillovers. Since the financial crisis started in 2008, Central Banks in developed countries have significantly increased their balance sheets by buying assets and embarking on other unconventional monetary policies in an attempt to revive their economies. However, the impact of these unconventional monetary policies is likely to have spread beyond developed countries to emerging market economies. The impact of unconventional monetary policy has been discussed by the literature but limited attention has been paid to the volatility spillover from developed to developing countries. Our paper measures the volatility spillover from the changes in the Federal Reserve and the European Central Bank's balance sheets to emerging market economies. We find that there are volatility spillovers from the changes in those Central Banks' balance sheets to emerging markets and we build on the recent literature by estimating these volatility spillovers on financial and macroeconomic variables.

JEL Classification: F3, F4, F16, G1

Keywords: unconventional monetary policy, macroeconomic interdependence, spillovers, financial markets

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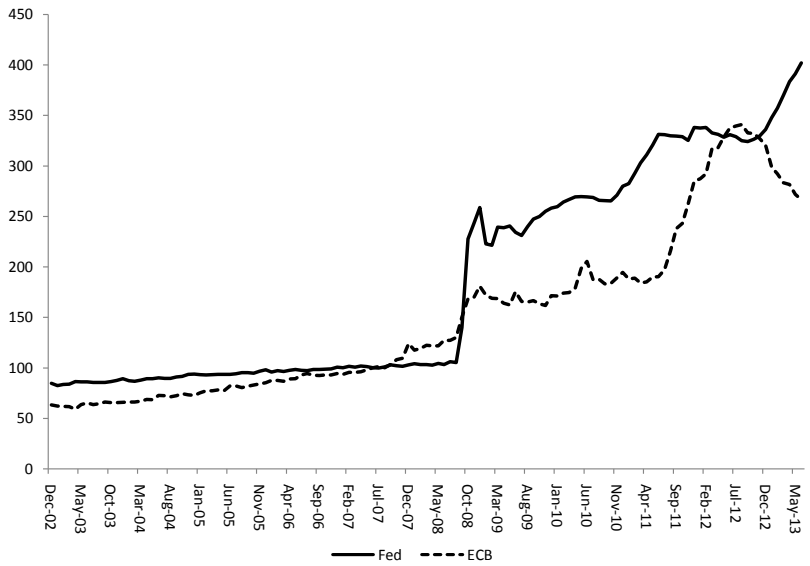
1 Introduction

"...frankly the ECB has not done anything to increase volatility in the markets. If you think that the ECB has done anything that is comparable to what is happening in the other central banks, we would not agree with this perception...But, certainly, we have observed an increase in global volatility, coming from major monetary policy decisions or announcements of decisions that may be taken in the coming months. However, I do not think that the ECB has in any way been a source of this; I cannot really find any data to support this" said Mario Draghi, the ECB's President in June 2013. Since the announcement of the Federal Reserve's (henceforth Fed) intention to slow its monetary stimulus, emerging markets' currencies have begun to depreciate significantly against the U.S. dollar. The spillover from unconventional monetary policies in developed countries to developing countries and especially the increase in major Central Bank's balance sheets have been explored by the recent literature. However, the volatility that has been observed in the financial and real variables in many developing countries has largely been ignored. Nevertheless, there has been renewed interest in the volatility spillover since the Federal Reserve announced its intention to scale back its bond purchases in May 2013.

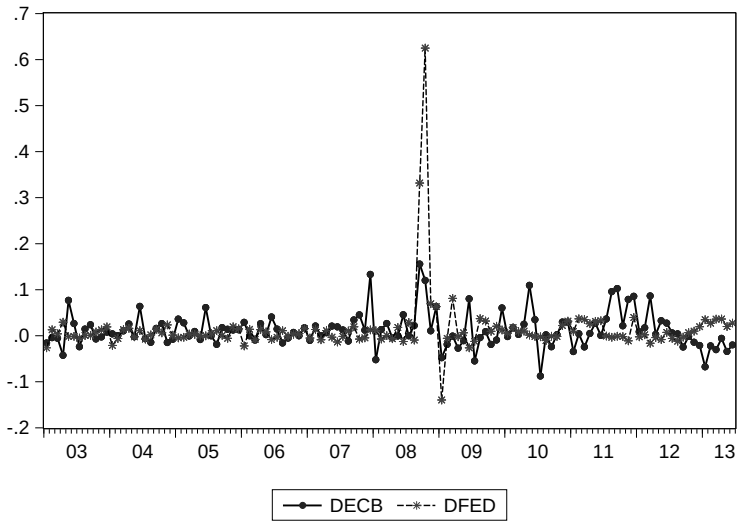
Figure 1: Scaled Assets of the Fed and the ECB (June 2007=100)



We examine the effects of unconventional monetary policies in the U.S. and the Eurozone by the change in their respective Central Banks' balance sheet, and the spillovers of these policies to

the volatility of Brazil, Russia, India, China and South Africa's (henceforth BRICS) financial and macroeconomic variables. In recent years, we have witnessed an unprecedented expansion in international trade and a significant increase in cross-border capital flows. However, the size, structure and capital flows of a more globalized economy have dramatically changed with developing countries growing fast and accounting for an increasing share of the world output and wealth. The recent crisis has reversed some of these capital flows to and from emerging market economies and has increased volatility in both macroeconomic and financial variables. Nevertheless, the unprecedented actions by major Central Banks, which still affect the world interest rate, are likely to have had an impact on the volatility of financial and macroeconomic variables in emerging markets.

Figure 2: Changes in the Fed and the ECB's balance sheets



The actions of the Fed and the ECB are of particular importance not only because of the size of their respective economies, and the size of their balance sheets, but also because of the international role of the U.S. dollar and the Euro, and their influence on the world interest rate. Given the volume of trade and the significant current account surpluses and deficits in a much more globalized world, combined with the activist stance of major Central Banks the issue of volatility spillovers from monetary policies has come to the forefront of international policy discussions. Moreover, recently policy makers in the U.S. have been contemplating, and witnessing, the impact of a potential exit from unconventional

policies.

The impact of unconventional monetary policies has come to the forefront of policy discussions mainly for two reasons. Firstly, since the Asian financial crisis and the Russian sovereign default, we have observed an increase in foreign reserves held by many emerging market countries as a means of protection from adverse shocks including capital outflows, bank runs and sharp exchange rate depreciation, or the risk of being cut off from the foreign exchange market. Most foreign reserves have been kept in the major currencies such as the U.S. dollar, the Euro and, to a lesser extent the British Pound, the Swiss Franc and the Japanese Yen, because these currencies are considered to be safe and liquid. These countries, as the most financially developed countries, have attracted most of these foreign reserves and provided assets, which foreigners purchased benefiting from low transaction costs and deep liquidity. However, the recent crisis and the fall in asset prices, have prompted Central Banks to take unprecedented measures that are likely to have had an impact beyond exchange rates, to affect the prices of assets held by emerging market Central Banks and private individuals. However, by intervening Central Banks in some cases have increased volatility of some assets, while increasing volatility in some other assets and have affected portfolio allocation decisions.

Secondly, because of international trade and output linkages between developed and emerging countries we have observed comovement of output during the crisis. Nevertheless, the growth differentials among countries is noticeable. This has prompted Central Banks in the developed world to stimulate their economies, by increasing their balance sheets and intervening in asset markets. However, growth disparity continues even thought emerging market economies growth rates have decreased significantly, while some countries especially in the Eurozone, are still in recession and monetary stimulus is continuing.

We explore this dual transmission channel of monetary policy using a two step volatility spillover specification. We build on the results of the recent literature such as Fratzscher, Lo Duca and Straub (2013), who find that the actual actions of the Fed, which is related to the change in its balance sheets, had the dominant effect on investors reactions. We explore the volatility spillover from the increase in the ECB and Fed's balance sheet to bilateral exchange rates, stock and bond markets

and macroeconomic variables such as inflation and industrial production. Our goal is to assess the impact of unconventional monetary policies on the volatility of economic and financial variables in emerging market economies. We also attempt to make some inferences regarding the impact of an exit from unconventional policies.

The rest of the paper is structured as follows. Section 2 reviews the related literature that guides the analysis. Section 3 specifies the data used and the empirical methodology. Section 4 provides some policy implications and Section 5 concludes.

2 Related literature

Bernanke and Reinhart (2004) discuss the policy options for Central Banks, when the zero lower bound is reached. They advocate three main responses to the zero lower bound, starting with forward guidance for low interest rates. Secondly, they propose changing the Central Bank balance sheet composition. Thirdly, they recommend expanding the Central Bank's balance sheet or quantitative easing. Bernanke and Reinhart (2004), wrote this back in 2004 but soon Bernanke became Chairman of the Fed and had to move beyond the academic discussion about unconventional monetary policies and implement all of these policies to stimulate the economy, as the Fed quickly reached the zero lower bound. These policies however, are likely to have unintended consequences beyond the domestic economy, and spillover into other economies.

We build on the findings of Fratzscher, Lo Duca and Straub (2013), who find that the Fed's unconventionally monetary policy announcements had a smaller effect than the actual operations of the Fed. They find that the actual operations of the Fed, which increase its balance sheet, affect the portfolio decisions and asset prices outside the U.S. in emerging market economies. Their finding suggests that foreign investors have not fully priced the Fed's announcements but it is its operations that had the dominant effect on investors reactions. They argue that their finding announcements are not enough to repair dysfunctional markets and that the Fed's actual operations could have new information. The same they argue in the unconventional monetary policy measures the ECB's 3-year longterm refinancing operations (LTROs) in 2011 and 2012, where the amount borrowed by the banks was the determinant of the success of the LTRO. We build on Fratzscher, Lo Duca and Straub

(2013) and take the balance sheet of the Fed and the ECB as the main instrument for unconventional monetary policy.

The recent theoretical literature has developed models on the interconnectedness of countries financial assets such as the model developed by Devereux and Yetman (2010). Their paper proposes a model of the international transmission of shocks due to interdependent portfolio holdings among leverage-constrained investors. When the leverage constraints bind, the diversified portfolios of investors create a financial transmission channel that results in a positive comovement of production, independently of the size of international trade linkages. Related to the recent crisis Bacchetta, Tille and Van Wincoop (2012), proposed an explanation for risk panics based on self-fulfilling shifts in risk made possible by a negative link between current asset prices and risks for future asset prices. The theoretical strand of the unconventional monetary policy literature, such as Gertler and Karadi (2011), finds that indeed there are welfare benefits from unconventional monetary policies. Gertler and Karadi (2011) show that during a crisis, when private balance sheets are constrained, the intervention of the Central Banks, using its unconstrained balance sheet can deliver welfare benefits.

This literature is closely related to the spillovers from unconventional monetary policy interventions because interventions reduce the risk of future asset prices and thus tend to increase the price of assets today. Regarding asset pricing the CAPM has provided the theoretical background for pricing risky assets. The basis of most asset pricing methods is the papers by Sharpe (1964), Lintner (1965) and Merton (1973). However, the reduction in the volatility of economic fundamentals can affect asset prices negatively or positively. Hence, there is no clear direction of how asset prices will move given the interventions by Central Banks. This remains to be explored by our research project.

Relevant empirical literature includes a paper by Izquierdo, Romero-Aguilar and Talvi (2008), which investigates the role of external factors using a VAR/VECM econometric methodology, on the economic performance of Latin America. The authors investigate how external factors contributed to the economic situation in Latin America. More recent literature related to the crisis has focused mainly on event studies looking at the immediate impact of unconventional monetary policy announcements on financial variables. One such paper is by Ait-Sahalia et al. (2012), which utilises an event study approach to explore the market responses to policy initiatives. Moreover, Fratzscher, Lo Duca and

Straub (2013), demonstrate how monetary policies pursued by the Federal Reserve, have contributed to portfolio rebalancing and to changing the price of risk in global financial markets.

A closely related paper by Chen et al. (2013), explores the international spillover of Central Banks balance sheet policies. The paper performs an event study as a first step and then uses a Global VAR and a GVECM estimation to assess the international transmission of the expansion of Central Banks balance sheets on the financial and real variables of several countries. However, it is not clear if the VECM is the appropriate or the best methodology to utilize, given the criticism of the tests for co-integration by Elliott (1998). Perhaps several econometric techniques should be used to assess their fitness with the data in order to be more confident of their results. Moreover, the dataset used covers the period until 2010 before the crisis had developed in Europe. Additionally, a policy paper by Cecioni, Ferrero and Secchi (2011), provide a useful review of the literature on unconventional monetary policy developed during the recent crisis.

Our paper follows the methodology developed by Ng (2000), who proposed a two step approach to investigating the volatility spillover from the U.S. and Japanese stock markets to the Asia PacificBasin region stock markets. The two step approach starts with the calculation of the volatility in a bivariate GARCH model including the U.S. and Japanese stock markets. In the second step it includes the innovations derived in the first step to calculate the volatility spillover to the Asia Pacific-Basin region. The Ng (2000) is not the first paper to explore the volatility spillovers and previous literature has focused also on volatility spillovers such as the Bekaert and Harvey (1997), which allow for an impact, or spillover, of global shocks to the other countries. More recently, Engle, Gallo and Velucchi (2012) find that a network of interdependencies propagates volatility shocks across Asia, which make the system more unstable during crisis.

Moreover, Hattori, Schrimpf and Sushko (2013) find that perceived risks decrease in response to both announcements and actual unconventional monetary policies by the Fed. More importantly for our estimations, Hattori, Schrimpf and Sushko (2013) find that the effect of the actual purchases of assets, that increase the size of the Fed balance sheet, is strongest when there is an expansion and a duration extension of the balance sheet. Bekaert, Hoerova and Lo Duca (2010) find similar results to Hattori, Schrimpf and Sushko (2013), that loose monetary policy decreases risk aversion

and uncertainty, when they control for business cycle movements. Their results reinforce our empirical strategy, which investigates the volatility of both financial and macro variables, building on the decrease in risk aversion and uncertainty generated by the unconventional monetary policies of the Fed and the ECB.

In addition, Gambacorta, Hofmann and Peersman (2012) using a Panel VAR approach find that the effects of unconventional monetary policies in different countries contribute to a temporary rise in economic activity and the price level. Therefore, the monetary policy tools utilized by the Fed and the ECB are likely to have temporary positive effects on their domestic economies respectively, but are likely to have asymmetric effects on developing countries that do not share the same macroeconomic characteristics. The volatility spillover literature, such Diebold and Yilmaz (2009), has concentrated on stock market returns, and finds that there are bursts to volatility spillovers, that have no trend. This reinforces our findings that the burst in unconventional monetary policies by the Fed and the ECB had an asymmetric impact on the financial and macroeconomic variables in emerging market economies. Yilmaz (2010), calculates an equity volatility spillover index and finds that the interdependence among East Asian equity markets pushed the indices to their highest levels during the current crisis.

The ARCH model was developed by Engle (1982) and Bollerslev (1986) and provide a good fit for financial time series. Several volatility models have been proposed, and the GARCH specification have become an important tool in measuring volatility of various financial and economic variables. We use the GARCH model to estimate the volatility of balance sheet of Central Banks, which has increased significantly since the crisis.

Given the above mentioned literature more rigorous research is needed to evaluate the impact of unconventional monetary policies by assessing their impact on both financial and real variables in emerging market economies. Moreover, more up-to-date data and recent actions by the Fed and the ECB are likely to have impacted emerging market economies in ways unlike previous policies. A suitable methodology is needed to assess the impact of these unconventional monetary policies on the volatility of macroeconomic variables in emerging market economies, such as a GARCH approach. Equally important, the research project will provide some insights into the effects of exit from unconventional measures by performing forecasts of the future volatility of the important

variables.

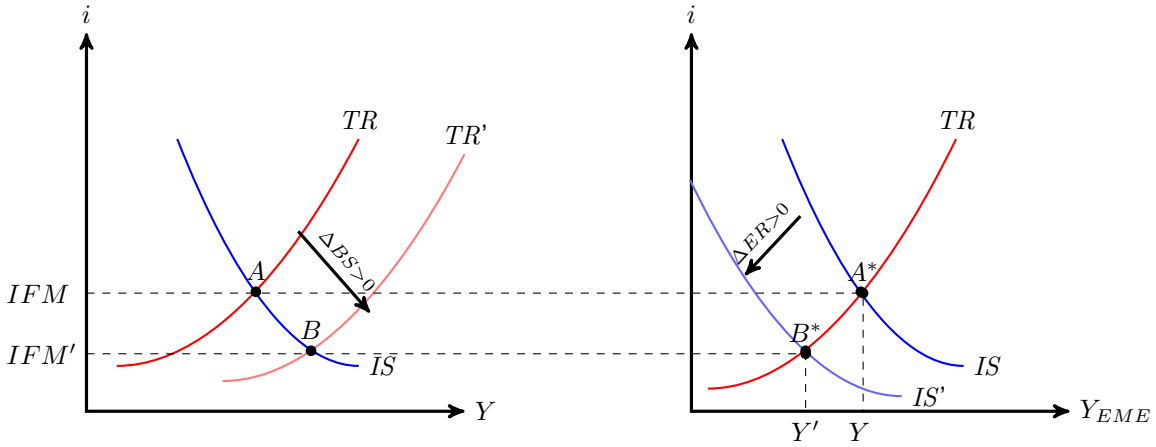
3 Theory

The theoretical underpinnings of our empirical specification are the basic IS/LM model interpreted by Burda and Wyplosz (2012), as the IS/TR (Taylor Rule) model with international market interest rate. TR is the Taylor Rule reaction function of the Central Bank. The world interest rate facing a country is defined as *i* plus expected depreciation of that currency. This is depicted as the International Financial Market (IFM) line. Normally countries cannot affect the world interest rate but that cannot be said for the Fed and the ECB. The response of the Fed and the ECB, which achieve a reduction in interest rates by expanding their balance sheets, is shown by the movement of the TR to the right at TR'.

During the crisis, these the Fed and the ECB lowered their interest rates and embarked on unconventional monetary policies, which in turn lowered the world interest. However, the ECB and the Fed can only lower the world interest rate less than their domestic interest rates and as a results their currencies weakened as well. As a result capital flight from the Eurozone and the U.S. ensued, and capital was directed towards emerging market economies that had a higher interest rate but also in expectation of higher exchange rates. In reaction, emerging market economies Central Banks' should have lowered their domestic interest rates, however due to various reasons they were not able to reduce their interest rates as fast as the Fed and the ECB. Therefore, to accommodate this influx of capital their economies will have to adjust. IS will shift to IS', unless governments embarked in ambitious fiscal stimulus programs, and their economies were suppressed.

Figure 3 demonstrates that unconventional monetary policies emanating from developed countries Central Banks, which have an effect on the world interest rate, can affect both the financial and real variables in emerging market economies. The effects of these unconventional monetary policies are asymmetrical and are likely to affect the volatility of variables in emerging market economies, and it is exactly the magnitude of the volatility spillovers, which we aim to quantify in this paper.

Figure 3: Spillover when Central Banks become more accommodative



4 Methodology and Data

4.1 Data Description

We gather monthly data from the Fed and the ECB regarding the total size of their balance sheets from 2003M1 to 2013M6. For developing countries we gather monthly data for Brazil, Russia, India, China and South Africa regarding their bilateral exchange rate against the U.S. dollar and the Euro, the main stock market index, EMBI spreads, industrial production and the consumer price index. We use monthly data to be able to capture volatility spillover because over longer periods it is harder to decipher the volatility spillovers.

We have gathered the data using Haver analytics, which provides seasonal adjustments to the variables of the BRICS countries and the Fed and ECB. We calculate the percentage change in the Fed and the ECB balance sheet using data provided by the respective Central Banks. We also calculate the percentage change in the variables of the BRICS countries.

4.2 Methodology

We use a two-step GARCH specification to assess the impact of unconventional monetary policies in developed countries, on emerging market economies. We start with the specification of GARCH(1,1)

model for the Central Bank:

$$r_t = \sqrt{\sigma_t^2} z_t \quad z_t \sim D(0,1) \tag{1}$$

where r_t is the percentage change in the Central Bank's balance sheet and D is a distribution with mean 0 and variance 1 and:

$$\sigma_t^2 = \omega + \alpha r_{t-1}^2 + \beta \sigma_{t-1}^2 + \epsilon_t \tag{2}$$

where $\omega > 0$, $\alpha \geq 0$, $\beta > 0$ and $\alpha + \beta < 1$

We use the GARCH (1,1) model as defined by Bollerslev (1987), since the period of unconventional monetary policy was characterized by periods of calm followed by periods of volatility.[1]

In the second step we take the innovations from our first GARCH (1,1) regression and add it as an explanatory variable in the second GARCH(1,1) regression for the variables in developing countries. The specification is as:[2]

$$R_{i,t} = \beta_{i,0} + \beta_i R_{i,t-1} + \gamma_{i,t-1} r_{CB,t-1} + \varepsilon_{i,t} \tag{3}$$

and the variance is defined as:

$$\sigma_t^2 = \omega + \alpha r_{t-1}^2 + \beta \sigma_{t-1}^2 + \epsilon_t \tag{4}$$

where $\omega > 0$, $\alpha \geq 0$, $\beta > 0$ and $\alpha + \beta < 1$, where

$$\varepsilon_{i,t} = e_{i,t} + \phi_{i,t-1} e_{CB,t} \tag{5}$$

The above specification means that we include the innovations from our first step, the Central Bank GARCH(1,1), to capture its explanatory power with regards to the volatility in the variables of developing countries. The above specification is the general specification but we test each time for

[1] We use GARCH(1,1) for both the Fed and ECB but with slightly different specifications
[2] Following Ng (2000)

the significance of the coefficient of the innovations from the step 1 regression. We use the Wald test to test if the coefficient on the innovations or lagged value of the Central Bank's change in balance sheet is different from zero. Where we find that these coefficients are not different from zero, then we conclude that there are no volatility spillovers.[3]

Then we find the ratio of the volatility of the variables in the developing countries that is explained by the volatility in the developed countries Central Banks' balance sheet. We calculate this ratio as:[4]

$$VR_{i,t}^{CB} = \frac{\phi_{i,t}^2 \sigma_{CB,t}^2}{h_{i,t}} \tag{6}$$

The ratio of VR measure the proportion of conditional variance of the developing countries variables is accounted for the change in the Central Banks' balance sheet. This measure will be our volatility spillover measurement from developed countries Central Bank's balance sheet volatility to variables in BRICS countries. We will demonstrate this volatility spillover using graphs to illustrate our results.

5 Results

The results confirm our intuition regarding the ECB's balance sheet volatility. We find that the volatility in the ECB's balance sheet mainly affects the bilateral exchange rate, between the Euro and the BRICS countries' currencies as well as the volatility of the stock market in some of the BRICS countries.

Figure 3 summarizes the coefficients of the spillover from the unconventional monetary policies of the Fed and the ECB and their significance levels. We observe that the volatility spillover from the Fed affects more variables in the BRICS countries than the ECB's volatility spillovers.

Figure 5 shows that a significant portion of the volatility of the bilateral exchange rate between the Russian Ruble, the Chinese Renminbi and the Euro is explained by the volatility in the ECB's balance sheet. The portion of the bilateral exchange rate volatility accounted by the ECB's balance sheet volatility for the other BRICS countries is however much lower. However, observe that in 2013 there is a significant volatility spillover from the ECB to the Euro bilateral exchange rate with the South

[3] We use various specifications using the Wald to determine if there are volatility spillovers

[4] Again from Ng (2000)

Figure 4: Spillover coefficient and significance

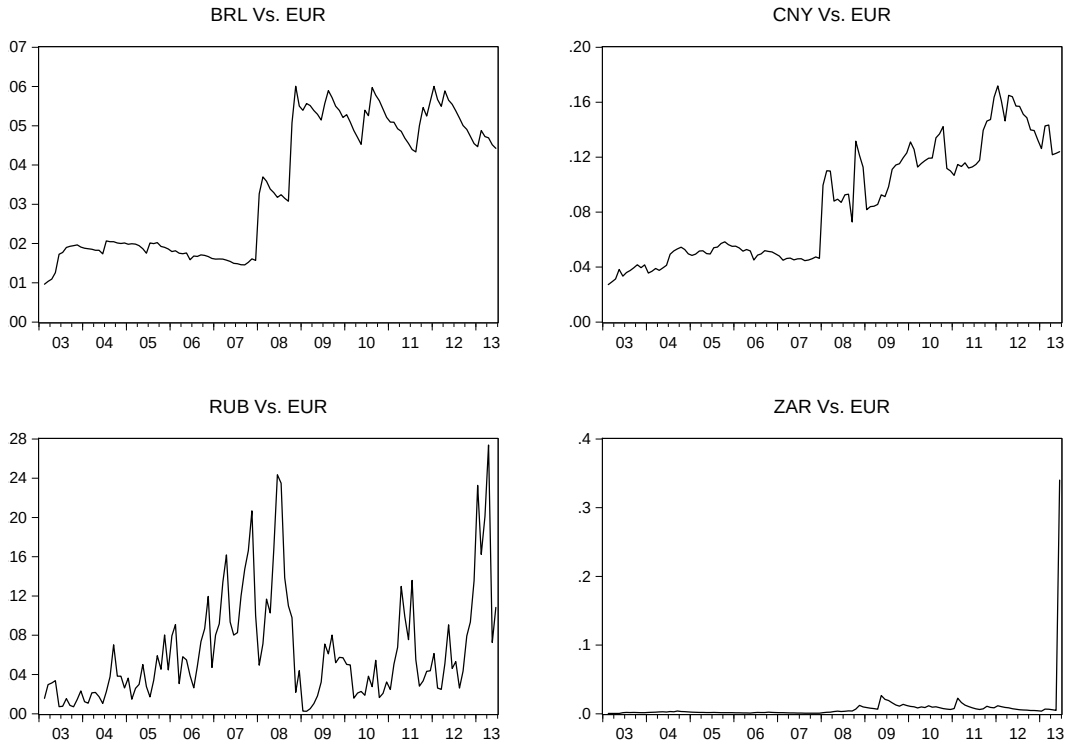
FED Coefficient

	ER	STOCK	EMBI	IP
BRAZIL	0.230993*	-0.381501*	-15.49712*	0.025985*
RUSSIA	-0.061035*	-0.349664*	5.910268	0.047331*
INDIA	0.104957*	-0.359999*	-0.207347*	-0.014871
CHINA	-0.000561	-0.372367	-1.568501	-0.009231*
S. AFRICA	0.281307*	-0.232456*	-18.50562*	-0.073161*

ECB Coefficient

	ER	STOCK	EMBI	IP
BRAZIL	0.171038*	-0.428231*	-15.68627*	-0.034303
RUSSIA	0.131122*	-0.576674*	5.303911	0.018246
INDIA	-0.035402	-0.363983	-0.210433	-0.015725
CHINA	-0.147878*	-0.638132*	-3.027506	-0.007183
S. AFRICA	0.059852*	-0.314157*	-16.2156	0.015814

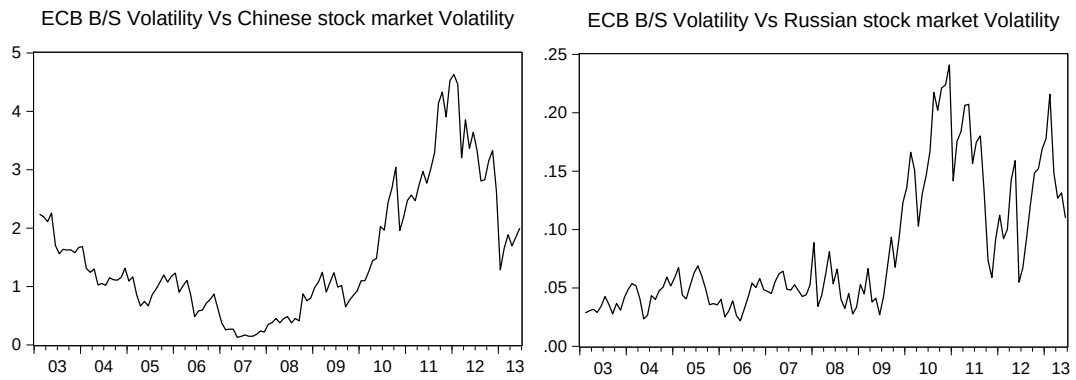
Figure 5: ECB Balance Sheet volatility spillover to BRICS Bilateral Exchange Rate



African Rand.

Next we looked at the effect of the volatility in the ECB's balance sheet and the volatility spillover to the stock markets in developing countries. Figure 6 shows significant spillovers to the Chinese and Russian stock markets. The spillover to the Chinese stock market is higher than the actual volatility of the stock market. This means that the stock market in China reacted to other factors apart from the volatility of the ECB's balance sheet, which had an effect of lowering the actual volatility. These factors include are likely to be related to the closed capital account of China.

Figure 6: ECB Balance Sheet volatility spillover to BRICS Stock Markets



We performed the same exercise for the Fed's balance sheet expansion. We find that volatility of the Fed's balance sheet had a larger spillover effect on the volatility of many variable in the BRICS countries than the ECB's balance sheet expansion. This finding is related to the effect of the role of the U.S. dollar as the global reserve and invoicing currency. Most likely, the influence of the Fed on the world interest rate is the single most important factor in the volatility spillover from the Fed's balance sheet to BRICS' countries variables.

However, regarding the bilateral exchange rate we find that the volatility spillover from the Fed's balance sheet to the exchange rate are less pronounced than the ECB's volatility spillover on the bilateral exchange rate of the Euro. This can be explained by the BRICS countries management of their currencies against the U.S. dollars. Since most invoicing is done in terms of U.S. dollars, countries tend to manage their currencies to remain competitive vis-a-vis their competitors, because exports are priced in U.S. dollars.

Figure 7: FED Balance Sheet volatility spillover to bilateral exchange rate

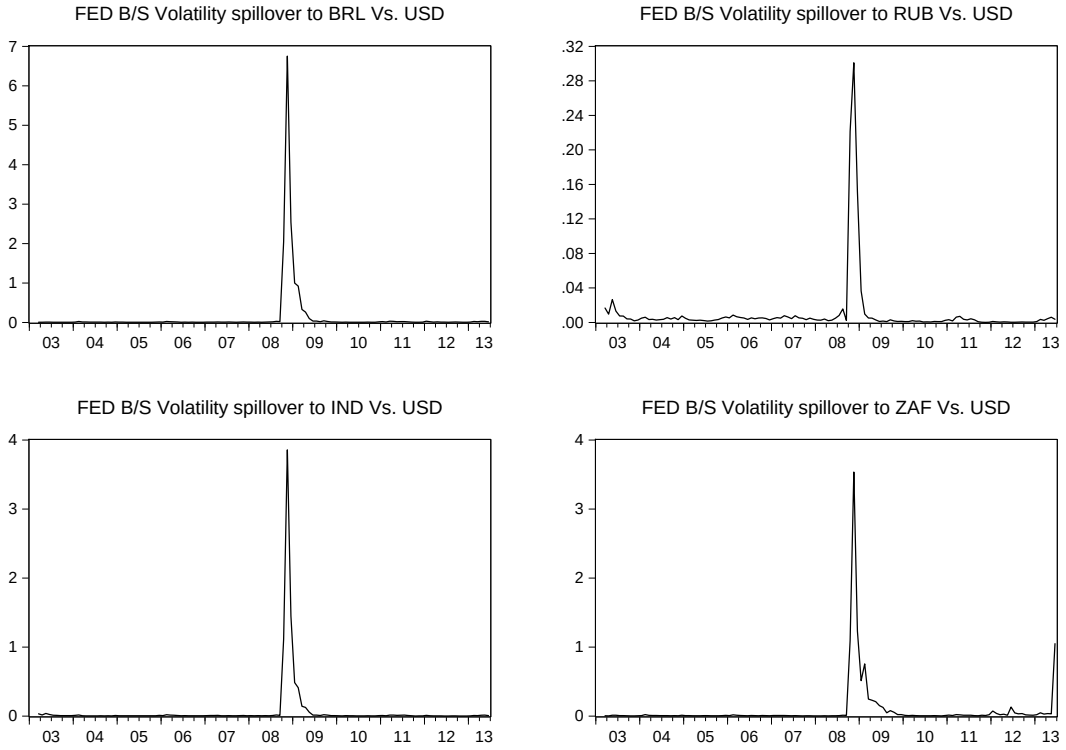
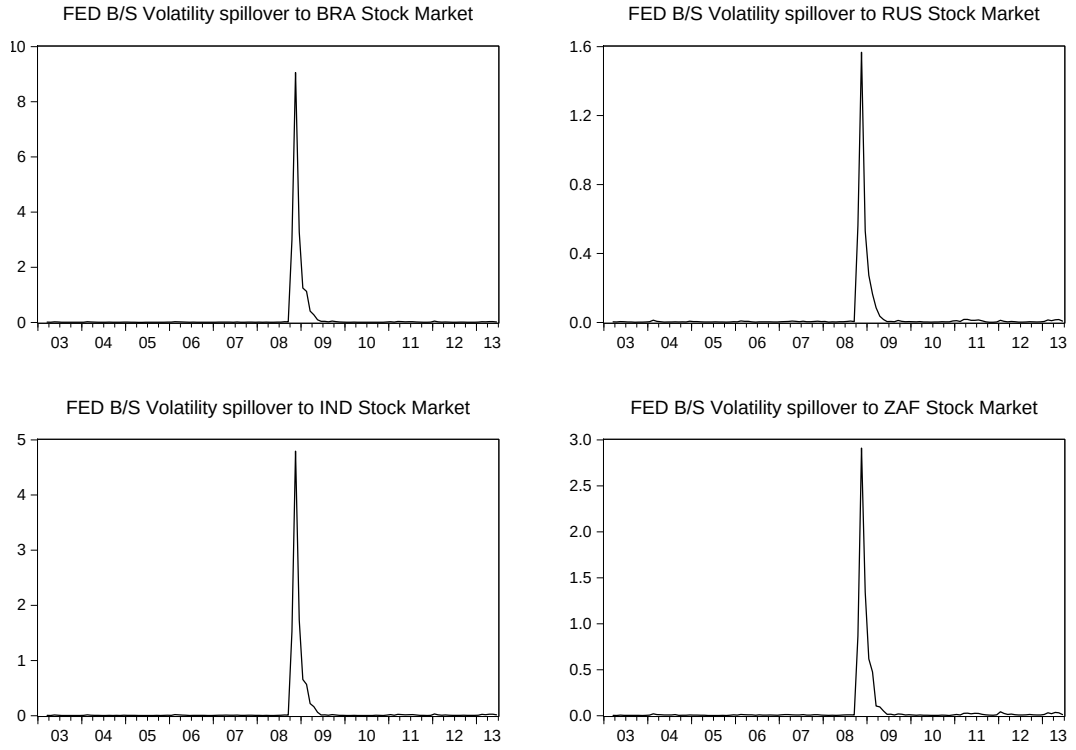


Figure 7 shows that the expansion in the Fed's balance had a significant spillover effect with regards to the bilateral exchange rate. The managed exchange rate against of Russia is probably the main determinant of its low volatility spillover. During the crisis Russia tried to limit the volatility of its exchange rate vis-a-vis the U.S. dollar to enable their exporters to compete in international trade. However, Brazil, India and South Africa that have more flexible exchange rates did experience significant volatility spillovers from the Fed's unconventional monetary policies but this volatility was concentrated during the peak of the crisis in 2008 and 2009. In the case of South Africa, we observe that there is a noticeable increase in the volatility since the announcement of the Fed's intention to taper its bond purchases. Again the openness of the capital account correlates with volatility spillover but it would be interesting to evaluate more recent data from September 2013, when the Fed announced its decision not to taper yet and the volatility observed in the Indian rupee.

Figure 8, shows that there was a significant volatility spillover from the Fed to BRICS countries' stock markets. However, it is clear that during the peak of the crisis in late 2008 and the beginning of 2009 the volatility spillover was much higher. During that time the Fed increased its balance sheet

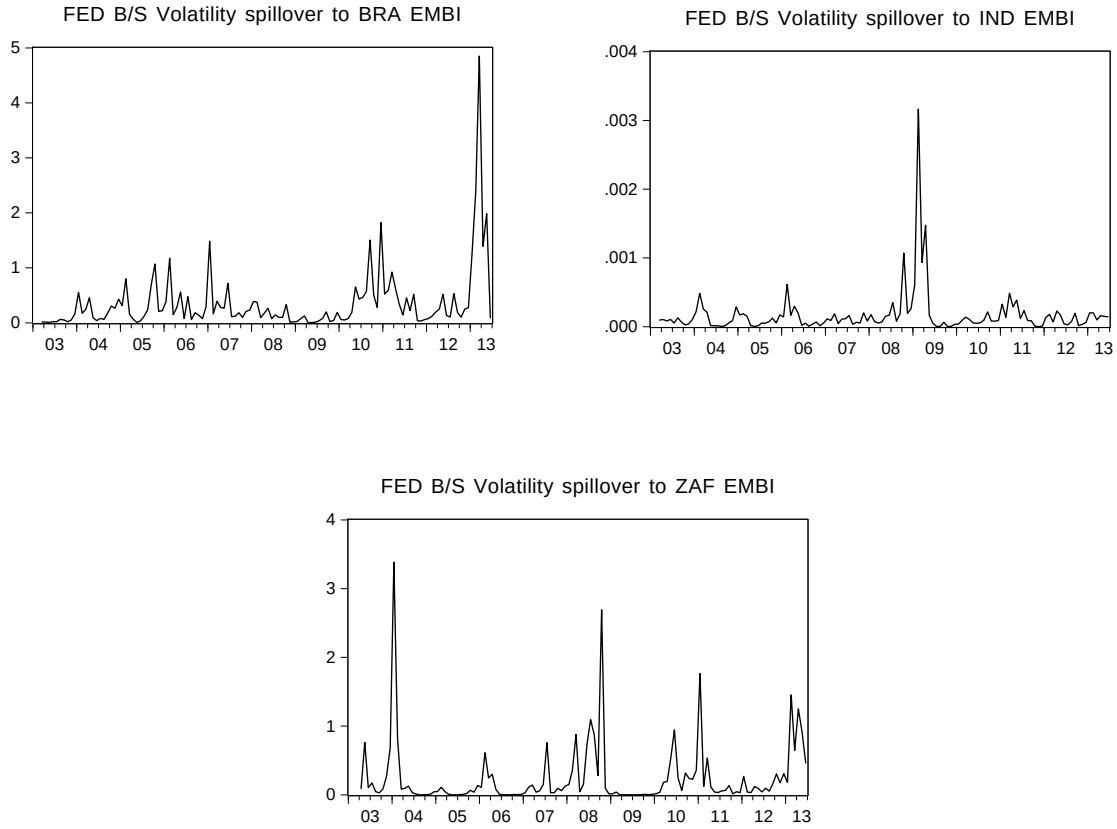
Figure 8: FED Balance Sheet volatility spillover to BRICS stock market



significantly to stop the panic in the U.S. financial system by aggressive expanding its balance. It introduces a portfolio of measures including the, Term Auction Facility (TAF), Dollar Swap Lines, Term Securities Lending Facility (TSLF), Primary Dealer Credit Facility (PDCF), Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF or ABCP MMMF), Commercial Paper Funding Facility (CPFF) and Term Asset-Backed Securities Loan Facility (TALF). The more open capital account countries seemed to have experienced the highest volatility spillover from the unconventional monetary policies of the Fed to their domestic stock markets.

Figure 9 shows that the volatility spillover from the Fed to the EMBI spreads of BRICS countries is large and persistent. However, we find the most significant spillovers for Brazilian and South African spreads. The volatility spillover from the Fed is much higher than the volatility actually observed in the EMBI spreads of Brazil and South Africa. The significant reserves, the actions of the authorities and the fundamentals of these countries had a calming effect on the volatility of the EMBI spreads. Therefore, the shock absorbers, in late 2008 and early 2009 helped these countries weather the volatility much better than they would have otherwise done, given the volatility spillover from the Fed.

Figure 9: FED Balance Sheet volatility spillover to BRICS EMBI Spreads



Nevertheless, for Brazil we observe volatility spillover being amplified in late 2012 and early 2013, when the Fed continued with its significant bond purchases of 85 billion U.S. dollar per month.

Figure 10: FED Balance Sheet volatility spillover to BRICS Industrial Production

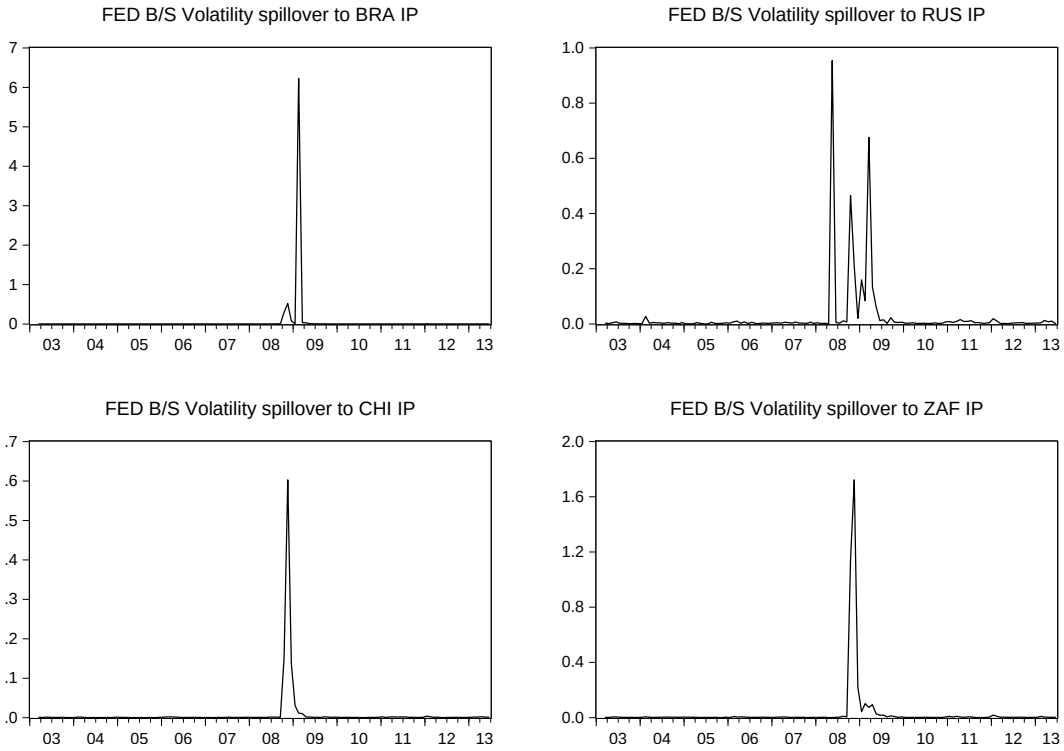
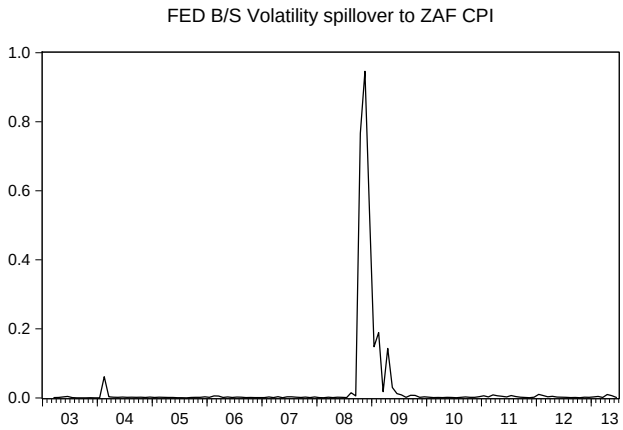


Figure 10 shows that the Fed's actions in late 2008 and early 2009 had an effect on the volatility of the industrial production in Brazil, China, Russia and South Africa. The volatility spillover was more pronounced in Brazil and South Africa the countries with the most open capital accounts. These countries have strong trade links with the U.S. with open capital accounts and are important commodity exporters priced mainly in U.S. dollars. Any volatility in the balance sheet of the Fed is likely to affect the U.S. dollar exchange rate increasing its volatility, while during the crisis commodity prices decreased significantly. Therefore, it is plausible that the value of commodities priced in U.S. dollars had an effect on industrial production in Brazil and South Africa.

Figure 11 shows that in terms of consumer price index the Fed's volatility spillover is limited to the consumer price index of South Africa. Even for South Africa the impact is concentrated at the during the crisis of late 2008 an early 2009, where the impact of volatility spillover was much higher. Nevertheless, the impact is quite significant, and it lasted for a few months. This results indicates

Figure 11: FED Balance Sheet volatility spillover to BRICS CPI



that the more open the capital account of a country the more spillover from unconventional monetary policy the country experiences.

Our findings have important implications when we consider that the Fed is preparing to exit from its unconventional monetary policy stance.

6 Policy Implications

The policy implications from our paper are three-fold: Firstly the unconventional monetary policies pursued by Central Banks are likely to have had an impact on different variables in the BRICS countries. The volatility spillovers from the Fed have had much far reaching impact on the BRICS countries than the ECB's actions. Secondly, the most affected countries have been the ones who have had a more open capital account. Thirdly the impact of exit from unconventional monetary policies, is likely to have important effect on the volatility of the economies of the BRICS countries. The BRICS have weathered the crisis well, and have been able to absorb the volatility coming from developed countries Central Banks. Given the slowing growth and other problems observed in the BRICS countries the impact from the end of these unconventional monetary policies is likely to be larger.

Therefore, the BRICS countries should stand ready to limit these volatility spillovers that inevitably

would come from the unwinding of the unconventional monetary policies from the Fed and the ECB. These measure should include but not limited to increasing interest rates, minimizing the volatility of exchange rates, the close monitoring of stock market volatility and being able to limit the volatility in the lending and borrowing rates.

7 Conclusion

The main contribution of this paper is to demonstrate that there have been indeed volatility spillovers from the actions of the ECB and the Fed to BRICS countries. On the one hand, the volatility emanating from the ECB is generally less pronounced. On the other hand, the volatility spillovers from the Fed had much more far reaching implications for BRICS countries. We find that the volatility spillover from the developed countries Central Banks has been significant.

Despite, the recent global financial crisis that brought severe recessions in many countries and hurt global growth prospects, BRICS countries have been able to grow impressively. Nevertheless, the BRICS countries growth rates has been sluggish in the past few quarters. If this continues and the withdrawal of stimulus from the Fed comes to fruition then BRICS countries might not be able to weather a renewed volatility spillover to their economies. Caution needs to be taken because if the ECB and the Fed start to decrease the size of their balance, this will have an asymmetric effect on the volatility of economic variables in the BRICS countries. This effect might be capital flight affecting financial variables, but also the lack of confidence in the economy which could lead to more pronounced problems in the economy such as consumption and investment.

Some important caveats remain in the econometric technique such as the limited amount of time about the Fed and the ECB's balance sheet. In the future, when more data are available more robust specification could be carried out in combination with various GARCH specifications. This further work will build more complete picture of the volatility spillover from the ECB and the Fed into BRICS countries.

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8 Appendix

Figure 12: Summary of Spillover from the ECB and FED

FED Spillover

	ER	STOCK	EMBI	IP	CPI
BRAZIL	YES	YES	YES	YES	NO
RUSSIA	YES	YES	NO	YES	NO
INDIA	YES	YES	YES	NO	NO
CHINA	NO	NO	NO	YES	NO
S. AFRICA	YES	YES	YES	YES	NO

ECB Spillover

	ER	STOCK	EMBI	IP	CPI
BRAZIL	YES	YES	YES	NO	NO
RUSSIA	YES	YES	NO	NO	NO
INDIA	NO	NO	NO	NO	YES
CHINA	YES	YES	NO	NO	YES
S. AFRICA	YES	YES	NO	NO	NO