MAGKS

Joint Discussion Paper
Series in Economics

by the Universities of

Aachen · Gießen · Göttingen
Kassel · Marburg · Siegen

ISSN 1867-3678

No. 30-2017

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When the Fed sneezes - Spillovers from U.S. Monetary Policy to Emerging Markets

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When the Fed sneezes - Spillovers from U.S. Monetary Policy to Emerging Markets

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July 11, 2017

Abstract

This paper aims to shed light on the role mean and volatility spillovers of U.S. monetary policy played for asset markets of several emerging market economies in a period from January 2000 to October 2014. We employ multivariate GARCH models in which we distinguish between a conventional and an unconventional monetary policy phase to account for possible heterogeneity in spillover effects. Our results suggest that the anticipation of loose U.S. monetary policy has diverse effects across monetary policy regimes. While spillovers have little impact on equity returns, they put pressure on local currencies. However, they increase conditional volatilities of both stock and exchange rate returns considerably in most emerging economies within the conventional monetary policy period. These effects can be stronger during unconventional monetary policy times. In accordance with these findings, we observe a tighter link between U.S. monetary policy and foreign asset markets during the unconventional monetary policy phase. Volatility impulse responses show that conditional volatilities of foreign asset markets mainly decrease in response to historical shocks. Particularly during unconventional monetary policy times, U.S. shocks gain importance in explaining the change in conditional volatilities especially for countries with less geographical distance to the United States.

Keywords: emerging markets, monetary policy spillovers, multivariate GARCH, unconventional monetary policy, quantitative easing

JEL classification: E43, E44, E52

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1 Introduction

'*When Paris sneezes, Europe catches a cold*' is a metaphor originally coined by Klemens von Metternich (1773-1859) to describe France's impact on all of Europe. As over the past decades the deck has been reshuffled in world politics, the U.S. became the most influential country in our modern world. The question then arises whether von Metternichs' statement can equally be applied to the U.S. and, in the light of the recent financial crisis, to its monetary policy decisions. Since spray from a sneeze typically is limited to a five-foot radius, which obviously constitutes a much shorter distance than the one between the U.S. and most emerging countries, do emerging countries get away with merely a sore throat or does this saying hold and things get feverish instead?

The systemic importance of U.S. monetary policy decisions for global markets should not be regarded as negligible. Since 2009, emerging market economies (EMEs) experienced massive capital inflows induced by the Fed's quantitative easing programs QE1, QE2, and QE3 leading to somewhat unwelcome upward pressure on local currencies and equity markets. Since loose monetary policy in the U.S. invites carry trades in which traders borrow capital at cheap interest rates from the U.S. in order to invest into high-yielding assets in emerging markets, exploding demand for emerging market investments inflates prices in these countries' equities and leads to an appreciation of EME's currencies against the U.S. dollar (USD).

While much effort has been put into research on level spillovers of monetary policy, potential spillover effects through volatilities have been more or less neglected. It is conceivable that the propagating effects of the Fed's unconventional monetary policy decisions will not be regarded as a major cause of increasing volatility in EMEs. However, these measures might trigger two opposing effects on asset market volatility. On the one hand lower levels of risk, caused by the Fed's expansionary policies, may effectively reduce panic among risk managers and thus decrease volatility on asset markets. On the other hand massive capital inflows and higher levels of trading volume may push up volatility on asset markets. The latter relationship can be traced back to the early work of Osborne (1959).

Due to these events, this paper offers first and foremost an empirical analysis of mean and volatility spillovers arising from U.S. monetary policy decisions proxied by U.S. short-term interest rate expectations to bilateral exchange rates and major stock market returns of four emerging countries, namely Brazil, Chile, South Korea and South Africa. In doing so, we aim to draw reliable conclusions on the vulnerability of emerging markets to changes in the Fed's expected monetary policy. As generalized autoregressive conditional heteroskedasticity (GARCH) models account for two transmission channels, i.e., spillovers in mean returns and spillovers in volatility, we employ bivariate GARCH models as in Sun et al. (2009). This analysis attempts to throw light on whether the expected U.S. monetary policy stance tamed volatility and thus led to stabilizing effects on foreign financial markets or rather jacked up volatility and entailed destabilizing effects.

Secondly, since it is crucial to distinguish phases of conventional monetary policy from those of unconventional monetary policy, we have set ourselves the task of assessing how spillovers within these two phases differ. We modify bivariate GARCH models by including dummy variables which allow for shifts in the parameters capturing spillovers emanating from the U.S. during different monetary policy phases. Considering that there is still no consensus on the potential asymmetric impact of monetary policy measures, we contribute to the growing literature that compares pre-crisis spillovers to those in post-crisis times.

Thirdly, multivariate GARCH models are suited to analyze correlation coefficients in the covariance equation and thus allow to examine implications for conditional correlations between U.S. monetary policy and foreign asset markets. Again, the implementation of dummy variables enables us to explore whether the link between the U.S. and foreign countries changed over time due to shifts in the monetary policy stance of the Fed.

Lastly, the analysis of volatility impulse response functions (VIRFs) allows us to analyze changes of conditional exchange rate and stock market volatility on specific days where accomodative monetary policy decisions were implemented or announced or when potential tapering was postponed. In particular, we are able to study how observable U.S. and local shocks feed through into the conditional volatility of future periods. The concept of volatility impulse response functions is particularly convenient because orthogonalization and ordering issues known from the identification process of vector autoregressive models can be neglected.

Our results suggest that U.S. monetary policy spillovers have little impact on equity returns but lead to an appreciation of emerging market currencies. In terms of volatility spillovers we observe stronger effects. Conditional volatilities of both, stock and exchange rate returns increase considerably in most emerging economies within the conventional monetary policy period. These spillovers may be even stronger in times of unconventional monetary policy. Volatility impulse responses show that conditional variances decrease considerably due to historical events. Yet, it is worth noting that local shocks play a crucial role within the conventional monetary policy regime. The opposite is true for the unconventional monetary policy phase.

Here, U.S. shocks become more important, in particular for countries with a smaller geographical distance to the United States.

Overall, our findings bear a number of implications for regulators and portfolio managers. Rising volatilities that impede trade and investment decisions are events that investors fear and that they are constantly seeking to hedge against. Thus, a better understanding of the nature of spillover effects might be beneficial for investors. Further, since it improves the knowledge of how EME's stock markets relate to U.S. monetary policy decisions, it can also help guide policymakers in EME's to limit volatility spillovers arising from U.S. monetary policy decisions. Several measures such as close monitoring of stock markets, capital controls, macroprudential policies, or official exchange rate interventions might be possible tools to protect these countries from volatility spillovers.

This paper is organized as follows. Section 2 provides an overview about the relevant literature on international monetary policy spillovers while in section 3 and 4 the estimated model and the calculation of VIRFs are presented. A discussion of the empirical results can be found in section 5. Section 6 concludes and draws some policy implications.

2 Literature on Monetary Policy Spillovers

Since the Fed initiated a whole string of new and unconventional forms of monetary stimulus responding to the financial crisis that escalated in the summer of 2008, monetary policy spillovers have acquired new popularity among researchers. The Fed's unconventional toolkit included a target federal funds rate of effectively zero accompanied by a series of unconventional monetary policy measures aiming at calming markets (QE1), and propping up the sluggish economy (QE2 and QE3). Apart from the literature that focuses on the domestic effects of these unconventional monetary policy measures[1] there exists a growing range of publications that is specifically concerned with the cross-border impact of the Fed's unconventional monetary policy.

In particular, this paper contributes to four strands of the literature. Firstly, it is related to the existing literature on the international transmission of the Fed's unconventional monetary policy announcements and operations on global financial markets. Neely (2015) shows that in 2008 - 2009 QE announcements considerably lowered foreign long-term bond yields and led to a notable depreciation of the U.S.

[1] See for example Krishnamurthy and Vissing-Jorgensen (2011), Wright (2012), Baumeister and Benati (2013), Gilchrist and Zakrajsek (2013), Neely (2014).

dollar by 4 - 11%. Using high frequency data Bowman et al. (2015) find within an event study framework that especially sovereign bond yields of 17 EMEs responded strongly to U.S. unconventional monetary policy announcements. They point out that for some countries, these reactions on long-term bonds dwarfed those on U.S. sovereign yields upon announcement. Similarly, Chen et al. (2016) affirm that U.S. monetary policy spillovers had a greater impact on many EMEs than on U.S. financial markets. In contrast, Fratzscher et al. (2013) conclude that relative to other countries especially QE1 lowers sovereign yields and increases equity prices in the U.S. effectively. Lim et al. (2014) document that the Fed's policy measures increase gross capital inflows to developing countries and find that this effect is pronounced in the early phase of QE while it diminishes over time. Further research on the financial market impact of unconventional monetary policy decisions provides similar results, indicating a rise in equities worldwide, increasing capital inflows to developing countries, and substantial upward pressure on local emerging market currencies, see for example Berge and Cao (2014) and Tillmann (2016). In a very recent paper Dedola et al. (2017) formulate a two step approach in which a series of macroeconomic and financial variables from 18 advanced and 18 emerging economies is regressed on previously identified U.S. monetary policy shocks. They show that a surprise U.S. monetary tightening leads to heterogeneous effects on asset prices, portfolios as well as on banking cross-border flows. Apart from that it induces a drop in inflation rates, a depreciation of local currencies against the U.S. dollar, a decline in industrial production and real GDP, as well as an increase in unemployment.

Additionally, this paper adds to the literature that aims to assess if and to what extend spillovers from unconventional monetary policies differ from those measures introduced in the pre-crisis period. In order to quantify the effectiveness of both sorts of policies on the USD, Glick and Leduc (2015) identify monetary policy surprises from changes in interest rate futures prices in a 30-minute window around policy announcements. They deduce that surprise loose monetary policy during the financial crisis has a much greater impact on the USD than a monetary easing conducted through the federal funds rate.

In accordance with these findings, Chen et al. (2014) demonstrate that unconventional monetary measures cause larger spillovers per unit of surprise than conventional policies to EMEs. The authors presume that their findings may result from structural reasons e.g., that the magnitude of spillover effects may be either linked to the respective policy measure implemented during the unconventional monetary policy period, or the liquidity that was generated during that time.

Using a panel data approach, Moore et al. (2013) attempt to quantify the impact of U.S. Large Scale Asset Purchases during the financial crisis on capital flows into EMEs' bond markets and thus on longer-term government bond yields. Their empirical results suggest that a 10-basis-point cutback in long-term U.S. treasury yields raises foreign ownership shares of emerging market debt by 0.4 percentage points. This increase conversely decreases government bond yields in EMEs by about 1.7 basis points. The authors stress out that their results are broadly comparable to the spillover effects of conventional U.S. monetary policy easing.

The vast amount of the literature on monetary policy spillovers measures global externalities emanating from monetary policy in levels. Only a minority of the existing papers account for volatility spillovers as a potential international transmission channel. Thus, this article contributes to the limited number of studies that analyze volatility spillovers which arise from the Fed's policy measures.

Empirical evidence for volatility spillovers coming from the U.S. monetary stance to inflation expectations in Brazil and Colombia between 1999 and 2008 is provided by de Mello and Moccero (2009). Within a multivariate GARCH analysis they show that higher interest rate volatility in the U.S. increased volatility in inflation expectations of Latin American countries. Related literature on conditional interest rate volatility is the work of Connolly and Kohler (2004) in which the impact of news relating to the expected path of monetary policy of several central banks on interest rate futures is analyzed.

The papers closest to our work are the ones from Apostolou and Beirne (2016) and Ghosh and Saggar (2016). Both studies use GARCH models to examine the transmission of U.S. monetary policy decisions to EMEs in recent times. Apostolou and Beirne (2016) estimate a univariate GARCH model in which volatility spillovers arise from the monthly expansion of the Fed's and European Central Bank's (ECB) balance sheets for the period 2003 - 2014. From their results, the authors conclude that especially volatility spillovers due to the Feds' balance sheet expansion played a crucial role in explaining increasing volatility in EMEs while spillovers due to the ECB's balance sheet expansion had a less perceivable and less sweeping impact.

Ghosh and Saggar (2016) create a bivariate GARCH model to provide empirical evidence of contemporaneous volatility spillovers from returns on U.S. equity to several EMEs stock markets during the Fed's tapering talk, which constitutes the period in the summer 2013, when there was talk about the Fed potentially quitting its loose monetary policy which causes massive capital outflows from emerging markets as well as increasing volatility on financial markets. They find that conditional volatility during taper talk exceeded conditional volatility during actual tapering substantially.[2]

In this paper, we propose to study the effects of conventional and unconventional monetary policies on several financial markets in EMEs by employing the constant conditional correlation GARCH (CCC-GARCH) model as introduced by Sun et al. (2009). This model originally was adopted to study potential changes in the cross-market linkage between China's A-share and China's B-share stocks due to liberalization. The authors modify their model by including two event dummies that account for potential changes in the liberalization process. With respect to our paper this implies that one dummy variable is introduced to our model to distinguish between a conventional monetary policy phase and an unconventional one. In doing so, we aim to add empirical evidence to the general literature on monetary volatility spillovers such as to the question whether monetary policy spillovers may differ in times of conventional and unconventional monetary policy.

3 Empirical Framework

In order to analyze possible contagion effects that spill over from U.S. monetary policy decisions to foreign asset markets, we formulate a bivariate GARCH(1,1) model following Sun et al. (2009) who use a modified version of the constant conditional correlation GARCH model proposed by Bollerslev (1990).

3.1 The Data

In this paper we are interested in whether the international transmission of monetary policy changed during times of conventional and unconventional monetary policy. That is why we include a dummy variable to account for shifts in the parameters capturing spillovers for two monetary policy phases. We define the conventional monetary policy phase reaching from 01/04/2000 to 11/24/2008 right before QE1 was announced while the unconventional monetary policy regime starts from 11/25/2008 and ends on 11/28/2014 when QE was tapered off completely.

Essential for the conduct of monetary policy is the Fed's decision about the accurate level of the federal funds rate. Thus, the stance of monetary policy can simply be proxied by this short-term interest rate. However, in times of unconventional monetary policy in which the federal funds rate is at its zero lower bound, measuring the monetary policy stance is no longer straightforward. Keeping that in mind, we

[2]Other studies like Bala and Takimoto (2017) and Leung et al. (2017) investigate equity and stock return volatility spillovers in emerging and developed markets. They estimate multivariate GARCH models and take structural breaks into account.

tend to use a variable that serves as a proxy for monetary policy decisions in both policy regimes. Eggertsson and Woodford (2003) argue that successful monetary policy is characterized by a proper guidance of expectations. They point out that especially the private sector's anticipation of the future path of short-term rates determine equilibrium long-term interest rates, equilibrium exchange rates and other asset prices which in turn are decisive factors for many current spending decisions. Following their argumentation, we use the one year ahead expectations of average future short-term interest rates provided by Adrian et al. (2013) as a proxy for U.S. monetary policy.[3] In general, these expectations are unobservable and need to be inferred indirectly which is why the authors use a five-factor, no-arbitrage term structure model to decompose Treasury yields into their term premium component that investors charge to buy long-term U.S. government debt and their expectation component of average future short-term interest rates. The underlying assumption is that spillovers stem from the expectations component but not from changes in the term premium.

The selection of emerging countries for our analysis of monetary policy spillovers is based on a number of factors[4]: We include South America's biggest fast-growing economy Brazil, which is also a BRICS member, as it constitutes a central focal point in the debate about U.S. monetary policy spillovers to other countries. Additionally, its relative importance of the U.S., by geographical distance, trade, and flow of capital are decisive reasons for our choice. It is worth noting that Brazil has been one of the leading countries that, since 2010, took actions to offset the detrimental effects of the Fed's quantitative easing programs, including a tax on portfolio inflows.

As a second Latin American country we include Chile which, very similar to Brazil, was under great pressure to stem the considerable appreciation of the Chilean Peso as a response to the quantitative easing programs induced by the Fed.

Other economies such as those in Emerging Asia or Africa may have different responses to an external U.S. monetary policy shock than Latin American countries either due to geographical distance, market capitalization or different trade patterns. Hence, for our analysis we choose South Korea as a country that potentially has been fertile ground for U.S. monetary policy spillovers and synchronized asset price movements due to its open and liberalized capital markets. Lastly, South

[3] For robustness reasons, we also use the ten year ahead expectations of average future short-term interest rates. Our GARCH estimates suggest that for mostly all model specifications explanatory power decreases. However, the results remain somewhat similar to our benchmark model.

[4] We follow the classification of emerging economies by the IMF. Countries that are Eurozone members are excluded since they are expected to be more vulnerable to the ECB's actions than to Fed policies. Further, we refrain from including countries that manage their exchange rates, like China and Russia.

Africa is considered as a member of the BRICS and a country with large market capitalization.

Thus, we obtain the following daily bilateral exchange rates BRL/USD (Brazil), CLP/USD (Chile), KRW/USD (South Korea), XAF/USD (South Africa)[5] and the major local stock market index[6] from DataStream International for the EMEs under consideration. Our data set includes 3729 observations.

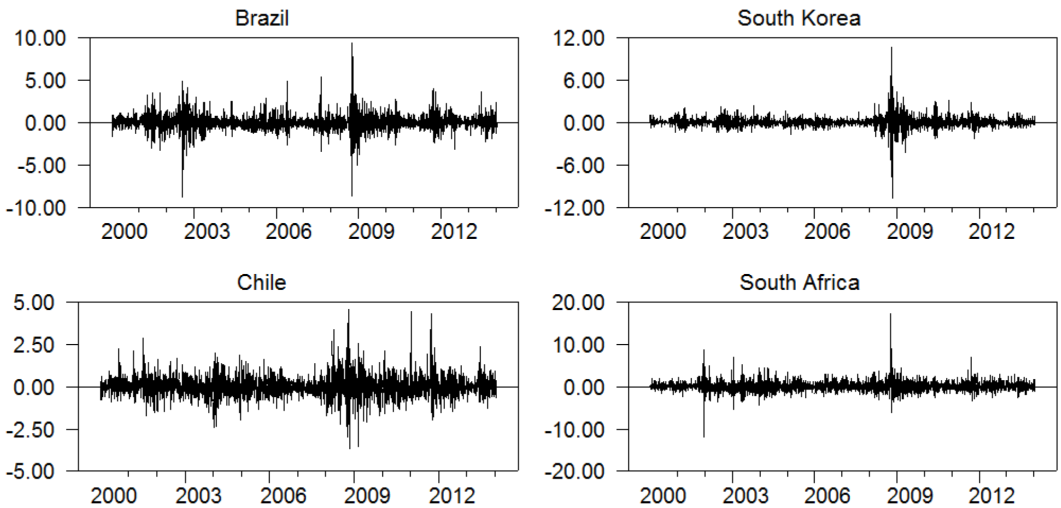

Figure 1: Bilateral exchange rate returns for emerging countries.

Figures 1 and 2 depict the daily exchange rate and equity returns of the four emerging countries in our sample. Peaks and troughs in volatility for exchange rates and equity returns are observable in most countries around major financial market calamities, such as the dot-com bubble burst in the early 2000's including the attacks of September 11, 2001 and especially around the financial crisis in 2008 - 2009 and 2011. In addition, extended periods of high market volatility occur in 2013 when financial markets feared a premature reduction in monetary stimulus. Back then, many emerging market economies experienced a second round of high volatility. However, this reactions where still far below the extreme spikes of 2010. Furthermore, the figures reveal that stock markets appear to be considerably more volatile than exchange rates throughout the sample period.

[5]In order to account for possible time differences between the U.S. and the chosen EMEs we first obtain the nominal bilateral exchange rates in indirect quoting before we transform it to direct quoting for reasons of better interpretation.

[6]As for the major equity indexes we use Bovespa-Index (Brazil), Índice de Precio Selectivo de Acciones (Chile), Korea Composite Stock Price Index (South Korea) and FTSE/JSE All-Share Index (South Africa).

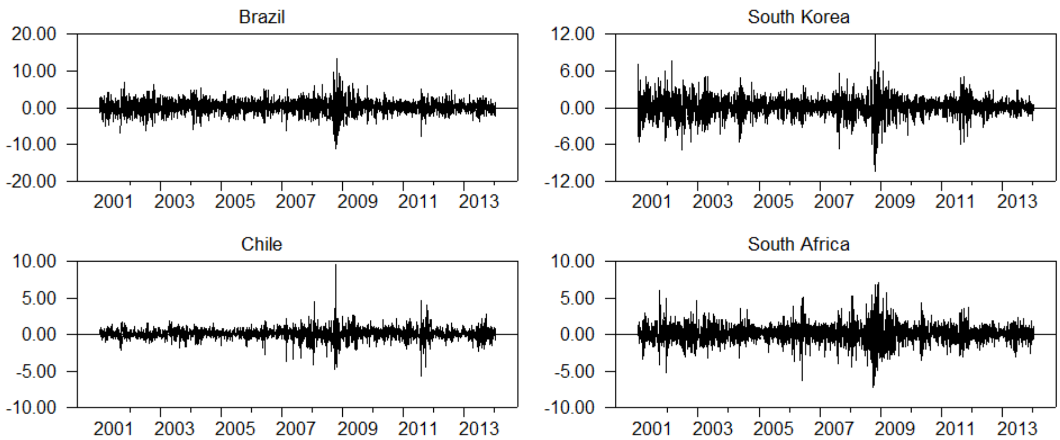

Figure 2: Equity returns for emerging countries.

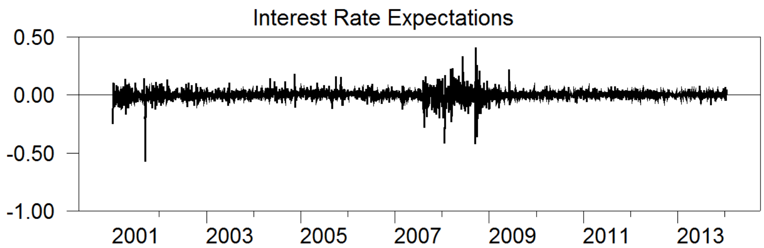

Figure 3: Difference in U.S. short-term interest rate expectations.

Figure 3 shows the difference in U.S. short-term interest rate expectations. Especially in 2001 and during the beginning of the financial crisis, periods of increasing volatility are observable. Yet, volatility remains stable thereafter. We test for stationarity by calculating the augmented Dicky-Fuller test. The results reveal that returns of equities and exchange rates are stationary for all countries of interest. The same is true for monetary policy expectations.

3.2 Spillover GARCH Model

We consider two different transmission channels. Firstly, spillovers in mean returns and secondly, spillovers in variances. Hence, our model comprises the following system of mean equations:

$$\begin{aligned} R_{US,t} &= \alpha_{0,US} + \alpha_{1,US} R_{US,t-1} + \alpha_{2,US} R_{C,t-1} + \alpha_{3,US} D_{QE} R_{C,t-1} + \epsilon_{US,t} \\ R_{C,t} &= \alpha_{0,C} + \alpha_{1,C} R_{C,t-1} + \alpha_{2,C} R_{US,t-1} + \alpha_{3,C} D_{QE} R_{US,t-1} + \epsilon_{C,t} \end{aligned} \tag{1}$$

$$\epsilon_{US,t} \sim N(0, h_{US,t})$$
$$\epsilon_{C,t} \sim N(0, h_{C,t}) \tag{2}$$

with $R_{US,t} = \Delta r_{US,t} = r_{US,t} - r_{US,t-1}$ as the difference in the U.S. monetary policy variable $r_{US,t}$ at time t. The variable $R_{C,t}$ describes the daily major asset return for each country, respectively. D_{QE} represents the dummy variable that takes the value of one from 11/25/2008 onwards, and zero otherwise. We are most interested in $\alpha_{2,C}$ and $\alpha_{3,C}$ since these coefficients catch the mean spillovers to EMEs that might arise from changing U.S. monetary policy expectations. The error terms $\epsilon_{US,t}$ and $\epsilon_{C,t}$ are normally distributed with a mean equal to zero and conditional variances $h_{US,t}$ and $h_{C,t}$, respectively.

In order to complete the CCC-GARCH model we define the system of conditional variances as described in equation 3

$$\begin{aligned} h_{US,t} =& \beta_{0,US} + \beta_{1,US} h_{US,t-1} + \beta_{2,US}\epsilon^2_{US,t-1} + \beta_{3,US}\epsilon^2_{C,t-1} + \beta_{4,US} D_{QE}\epsilon^2_{US,t-1} + \\ & \beta_{5,US} D_{QE}\epsilon^2_{C,t-1} \\ h_{C,t} =& \beta_{0,C} + \beta_{1,C} h_{C,t-1} + \beta_{2,C}\epsilon^2_{C,t-1} + \beta_{3,C}\epsilon^2_{US,t-1} + \beta_{4,C} D_{QE}\epsilon^2_{C,t-1} + \\ & \beta_{5,C} D_{QE}\epsilon^2_{US,t-1} \end{aligned} \tag{3}$$

We allow idiosyncratic monetary policy shocks, proxied by the unconditional volatility in the variance equations, $\epsilon^2_{US,t-1}$, to affect the EMEs' conditional variance in both monetary policy regimes. These effects are captured by the coefficients $\beta_{3,C}$ and $\beta_{5,C}$, respectively. Likewise, the symmetric nature of the model allows for potential feedback effects arising from shocks in emerging market economies to the U.S. monetary policy stance which are measured by $\alpha_{2,US}$ and $\alpha_{3,US}$ in the case of mean spillovers and $\beta_{3,US}$ and $\beta_{5,US}$ in the case of volatility spillovers.

The conditional covariance of the model can be calculated by multiplying the estimated conditional correlations $\rho_{US,C}$ and $\rho^{QE}_{US,C}$ to the square roots of the conditional variances

$$h_{US,C,t} = \left[\rho_{US,C} + \rho^{QE}_{US,C} D_{QE}\right] \sqrt{(h_{US,t} h_{C,t})}\,. \tag{4}$$

These time-invariant conditional correlations quantify the degree of co-movement between U.S. short-term interest expectations R_{US} and a single emerging country's exchange rate or equity return R_C in the conventional monetary policy regime and the unconventional monetary policy regime, respectively.

We test whether the estimation of a CCC-GARCH model is appropriate by employing a Lagrange Multiplier test based on Tse (2000). In three out of eight models the test statistic suggests time varying correlations. Thus, we feel confident in limiting ourselves to CCC-GARCH models. Yet, the implementation of a time dummy enables to account for time variation to a certain extent. In order to test for our predefined structural break on 11/24/2008[7], we firstly estimate a bivariate GARCH model with variance spillovers but without dummies. We then plot the accumulated gradients of the estimated correlation coefficient and identify striking gradient change points. In all model specifications these can be detected for the $2007 - 2009$ period. Varying the structural break point within the period $2007 - 2009$ leads to no crucial changes in the estimation results. Thus, we are confident in the choice of the monetary policy regimes.

4 Volatility Impulse Response Functions

Since the volatility of most assets might fluctuate strongly over time, multivariate GARCH models are a convenient way to trace the evolution of the conditional covariance matrix in a higher dimensional time series setting. For our analysis, it might be reasonable to uncover the volatility dynamics operating between the variables of interest in more detail.

Based on our results from the previous section, we follow Hafner and Herwartz (2006) and provide an impulse response analysis to independent shocks on volatility. Basically, we investigate the potential effects of spillovers on conditional volatility obtained from historically observed shocks coming from the CCC-GARCH model. To put it more simply, we analyze how an observable shock to the conditional variance evolves over time. The concept of volatility impulse response functions is especially appealing because it neglects orthogonalization and ordering issues that typically arise in the identification process of vector autoregressive models. Further, we examine pre and post event average volatility impulse response functions. Those are calculated for 10 days before a certain monetary policy announcement to depict the dynamics of conditional volatilities prior to this event as well as for 10 days after this event.

Volatility impulse response functions are calculated recursively in the following way

[7] One might argue that the unconventional monetary policy phase already started in 2007 when the adjustment of the federal funds rate was still feasibly and the Fed cut interest rates drastically.

$$
\begin{aligned}
VIRF_{t+1} &= \mathbf{A_i}(\epsilon_\mathbf{t}\epsilon_\mathbf{t}{}' - \mathbf{H_t}) \\
VIRF_{t+k} &= (\mathbf{A_i} + \mathbf{B})\,(VIRF_{t+k-1}),
\end{aligned} \tag{5}
$$

with $i = 1, 2$.

Matrix $\mathbf{H_t} = (h_{US,t}, h_{C,t})'$ constitutes the diagonal of the GARCH covariance matrix, $\epsilon_\mathbf{t} = (\epsilon_\mathbf{US,t}, \epsilon_\mathbf{C,t})'$ is the observable residual vector in period t and $\mathbf{B} = (\beta_{1,US}, \beta_{1,C})'$ represents the matrix of GARCH-coefficients.

$$
\mathbf{A_1} = \begin{pmatrix} \beta_{2,US} & \beta_{3,US} \\ \beta_{3,C} & \beta_{2,C} \end{pmatrix}, \qquad \mathbf{A_2} = \begin{pmatrix} \beta_{2,US} + \beta_{4,US} & \beta_{3,US} + \beta_{5,US} \\ \beta_{3,C} + \beta_{5,C} & \beta_{2,C} + \beta_{4,C} \end{pmatrix},
$$

are matrices that contain the ARCH-coefficients from the variance equations. For the conventional monetary policy regime (regime 1) we use $\mathbf{A_1}$ to calculate VIRFs while we use $\mathbf{A_2}$ for the calculation of VIRFs within the unconventional monetary policy regime (regime 2). Thus, the spillover coefficients $\beta_{4,US}$, $\beta_{5,US}$ and $\beta_{4,C}$, $\beta_{5,C}$ are added for historical dates in regime 2 whereas we refrain from using them for interest rate cuts in regime 1.

The volatility impulse response functions depend on the actual data through the covariance matrix $\mathbf{H_t}$. On that note, a 'shock' to the conditional variance constitutes the amount by which the squared residuals $\epsilon_\mathbf{t}\epsilon_\mathbf{t}{}'$ exceed their expected value $\mathbf{H_t}$. Thus an initial impulse can either be positive or negative and should affect asset prices only to the extent that have not been anticipated.

5 Empirical Results

The results of the bivariate GARCH estimation are presented in two steps. We first discuss the implications of spillovers from short-term interest rate expectations to bilateral exchange rates as well as spillovers to local EME stock markets. In a next step we analyze volatility impulse response functions as in Hafner and Herwartz (2006) in order to discuss the effects of several historical shocks, i.e. shocks on the announcement day of several monetary policy decisions on EME's conditional variances.[8]

5.1 Spillovers to EMEs

In the following, we present empirical results of our specified GARCH model described in section 3.2 for several emerging market countries. Our sample includes

[8]The GARCH models and VIRFs were estimated with modified Estima RATS programs.

a number of emerging market economies like Brazil, Chile, South Korea and South Africa which are considered economies that were affected by the Fed's decisions considerably. In table 1 and table 2, R_{US} indicates the change in the U.S. short term interest rate expectations and R_C represents either the exchange rate calculated as the return of the foreign currency to the USD or a major local stock market index return. The first four rows in each column display the estimated coefficients from the mean equations shown in equation 1, followed by six coefficients from the conditional variance equations in equation 3. The last two rows show the correlation coefficients ρ for each monetary policy regime.

Spillovers to bilateral exchange rates

Our estimates illustrate that for any country of interest, the effect of the spillover coefficients α_2 and α_3 on R_{US} is either insignificant or significant but very close to zero. These findings are consistent with the fact that U.S. short-term expectations typically do not respond to movements in the exchange rate.

	BRA/USD		CHL/USD		KRW/USD		XAF/USD	
	R_{US}	R_C	R_{US}	R_C	R_{US}	R_C	R_{US}	R_C
α_0	0.00	-0.02***	0.00	0.00	0.00	-0.01	0.00	0.02*
α_1	-0.08***	0.10***	-0.09***	0.14***	-0.09***	-0.22***	-0.08***	0.00
α_2	0.00	-0.38	0.00	0.03	0.00	-0.46*	0.00	1.03**
α_3	0.00	0.92	0.00***	1.40**	0.00	2.23***	0.00	-2.68**
β_0	0.00***	0.01***	0.00***	0.00***	0.00***	0.01***	0.00***	0.01***
β_1	0.90***	0.84***	0.91***	0.87***	0.88***	0.91***	0.91***	0.91***
β_2	0.10***	0.16***	0.09***	0.11***	0.11***	0.07***	0.10***	0.08***
β_3	0.00	1.16*	0.00	0.92**	0.00***	0.33	0.00	2.30**
β_4	-0.07***	-0.01	-0.05***	-0.05***	-0.07***	-0.01*	-0.06***	0.00
β_5	0.00***	33.96***	0.00	34.22***	0.00	11.95**	0.00***	4.02
$\rho_{US,C}$	-0.06***		-0.05*		-0.06***		0.02	
$\rho^{QE}_{US,C}$	0.11***		0.05		0.17***		0.06*	

Table 1: Bivariate GARCH estimation results: Exchange Rate.

Notes: Statistical significance is as follows: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.
The GARCH estimation exhibits no convergence problems. However, we find the stationary condition $\beta_1 + \beta_2 < 1$ to be not fulfilled in the conventional monetary policy phase for R_{US} in the Brazilian, Chilean and South African case.

In contrast, we illustrate that a decline in the expected short-term interest rates might lead to significant mean spillovers on exchange rates R_C, as represented by the coefficients α_2 and α_3. Regarding Latin American countries, we find that for the conventional monetary policy period the spillover parameter α_2 appears to be insignificant. However, the Korean Won depreciates by 0.46 percent. This effect is reverted within the unconventional policy regime since a positive coefficient α_3 of

2.23 leads to an overall appreciation of this currency. We find the opposite results for the South African Rand which appreciates significantly by 1.03 percent. Again, this effect is mitigated by 2.68 percent in the unconventional monetary policy regime leading to an overall depreciation of the South African Rand. We find a significantly positive spillover coefficient α_3 of 1.40 for the Chilean Peso in the unconventional policy phase indicating that accomodative monetary policy leads to upward pressure on the local currency in unconventional monetary policy times. For Brazil, the mean spillover coefficient α_3 exhibits the expected positive sign, but lacks significance. In brief, our results show that the exchange rate movements prove to be moderate in response to monetary policy spillovers.

The most salient question is not whether monetary policy spillovers are positive or negative, but whether they are stabilizing or destabilizing for EMEs. In that sense, our focus lies on the analysis of volatility spillovers instead of mean spillovers. As can be seen from the results in table 1, we observe an increase in the conditional volatility due to shocks in the U.S. interest rate expectations during normal monetary policy times captured by parameter β_3. For the majority of countries in our data set, this effect is significant albeit moderately positive. Interestingly, we can state that a shock during the unconventional monetary policy period increases the conditional volatility notably further, as can be seen from coefficient β_5. We find that conditional volatilities across countries respond heterogeneously to shocks in policy expectations. Particularly the Latin American countries Brazil and Chile appear to be highly vulnerable to shocks in expectations. A shock of one percent within the unconventional monetary policy regime boosts conditional volatility further by 33.96 and 34.22 percent, respectively. For all countries, we find that back spills in means and volatilities, arising from EMEs to the U.S. can be neglected.

In terms of correlation coefficients in the covariance equation, we receive, somewhat surprisingly, either non-significant or extremely low values for our first regime. This finding indicates that the linkage between U.S. short-term interest rate expectations and EMEs was non-existent. However, the correlation increases to a great extent during unconventional monetary policy times. Particularly in the case of Brazil and South Korea it augments up to 0.11 and 0.17 respectively, which emphasizes the inverse relationship between U.S. short-term interest expectations and foreign currencies i.e., lower interest rate expectations are in line with a decrease of the exchange rate and thus with a depreciation of the USD. A tighter link between U.S. short term rate expectations and foreign currencies is consistent with the idea that, in response to the global financial crisis and low interest rates, investors searched for decent returns abroad. As a consequence, massive capital inflows pushed local asset prices and put appreciation pressure on local currencies.

Spillovers to equity markets

Table 2 summarizes the results of the CCC-GARCH model for all countries of interest. Once more, we can state that mean spillovers played a minor role in the transmission of potential spillovers from the U.S. to EMEs. Within the conventional monetary policy regime, expectations of loose monetary policy entail no significant effects on local asset markets. Only in the case of South Korea we obtain a positive coefficient α_2 that is significantly different from zero at the one percent level. This implies that a drop in monetary policy expectations by one percent entails a lowering of asset prices by 3.42 percent. Since the spillover coefficient β_5 takes the value -6.36 for the unconventional policy phase, we observe an overall increase of equity prices due to a drop in monetary policy expectations by one percent.

	Brazil		**Chile**		**South Korea**		**South Africa**	
	R_{US}	R_C	R_{US}	R_C	R_{US}	R_C	R_{US}	R_C
α_0	0.00	0.08***	0.00	0.05***	0.00	0.06***	0.00	0.08***
α_1	-0.09***	0.04***	-0.09***	0.23***	-0.09***	0.00	-0.09***	0.04**
α_2	0.00	0.28	0.01***	-0.11	0.00	3.42***	0.00*	-0.31
α_3	0.00	0.15	-0.01***	0.11	0.00	-6.36***	0.00**	0.16
β_0	0.00***	0.07***	0.00***	0.07***	0.00***	0.01***	0.00***	0.02***
β_1	0.88***	0.90***	0.89***	0.85***	0.89***	0.93***	0.86***	0.89***
β_2	0.11***	0.06***	0.10***	0.13***	0.11***	0.07***	0.12***	0.10***
β_3	0.00**	9.96**	0.00*	1.32*	0.00	2.96*	0.00***	5.34***
β_4	-0.06***	-0.01*	-0.05***	-0.01	-0.07***	-0.01	-0.06***	0.00
β_5	0.00	9.52	0.00	15.48**	0.00***	-10.01	0.00	-8.53
$\rho_{US,C}$	0.15***		0.02		0.07***		0.03	
$\rho_{US,C}^{QE}$	-0.22***		-0.03		-0.14***		0.01	

Table 2: Bivariate GARCH estimation results: Major Equity Index.

Notes: Statistical significance is as follows: $*p < 0.1$, $**p < 0.05$, $***p < 0.01$.
The GARCH estimation exhibits no convergence problems. However, we find the stationary condition $\beta_1 + \beta_2 < 1$ to be not fulfilled in the conventional monetary policy phase for R_{US} in the South Korean case.

As for spillovers that are transmitted via volatilities, our results show that for all EMEs a shock to U.S. policy expectations increases the conditional volatility of major equity indexes in conventional monetary policy times. Additionally, we find that conditional volatilities across countries respond heterogeneously to shocks in policy expectations. Particularly Brazil and South Africa appear to be highly vulnerable to shocks in expectations since a shock of one percent boosts conditional volatility by 9.96 and 5.34 percent, respectively. Chile's equity market occurs to be the least affected as the spillover coefficient β_3 takes a value of 1.32.

In contrast to our previous results for bilateral exchange rates, volatility spillovers in the unconventional monetary policy regime exhibit no essential differences to spillovers in the conventional monetary policy regime. For Brazil we obtain a non-significant positive value for β_5 while for South Korea and South Africa we obtain negative coefficients that have not reached statistical significance. However, our results suggest that shocks to monetary policy expectations increase the conditional volatility of the Chilean equity market considerably further by 15.48 percent after the implementation of the Fed's unconventional monetary policy measures. Thus, especially Chilean equity markets suffered from increasing volatility due to the massive expansion of the open market operations by the Fed. Once more, spill backs from EMEs to the U.S. remain negligibly small.

Within the conventional monetary policy regime the correlation coefficients $\rho_{US,C}$ for the whole country set take positive values. This result implies a counterintuitive co-movement of equity prices in EMEs and U.S. monetary policy expectations since the anticipation of a tighter U.S. monetary policy stance typically induces capital flows into the U.S. and thus a drop in foreign equity markets. For the unconventional monetary policy regime however, the correlation coefficients take higher values with the expected negative sign. Thus they indicate a tighter link between foreign equity markets and U.S. policy expectations.

5.2 VIRFs to historical shocks

In this section we present the results from the calculation of volatility impulse response functions for historical shocks derived from days on which accomodative monetary policy was conducted in the United States. As opposed to standard impulse response analysis for vector autoregressive models we cannot provide a discussion of their significance level.

Within each regime our analysis focuses on a set of historically observed shocks including four federal funds rate target cuts for which the target change was greater than 0.25 percentage points, three important 'buy' announcements of QE1, QE2 and QE3 as well as one taper announcement. In particular, we use federal funds rate target cuts starting from April 18, 2001 until the outburst of the financial crisis in the summer of 2007.[9] Regarding QE announcements, we follow Gagnon et al. (2011), Wright (2012), and Fawly and Neely (2013) by using event dates that are associated with a significant decline in bond yields. With respect to tapering, we focus on the postponed taper announcement during the FOMC meeting in September 2013.

Table 3 summarizes all days for which shocks to the conditional volatility are ana-

[9] The majority of these interest rate cuts occured in 2001.

Conventional Monetary Policy Regime (Regime 1)

Date	Target Before	Target Change	Target After
04/18/2001	5.0	-0.5	4.5
05/15/2001	4.5	-0.5	4.0
11/06/2001	2.5	-0.5	2.0
11/06/2002	1.75	-0.5	1.25

Unconventional Monetary Policy Regime (Regime 2)

Date	Program	Event
11/25/2008	QE1	LSAP initially announced
11/03/2010	QE2	QE2 announced
09/13/2012	QE3	QE3 announced
09/18/2013	Taper	tapering postponed

Table 3: Accomodative Monetary Policy and Tapering Events.

lyzed. Although there were two interest rate cuts on 09/17/2001 and on 10/02/2001 that we should have accounted for in our analysis, we decided to not include them, because of their proximity to the 9/11 attacks. We will compare VIRFs for all events in the first regime with those VIRFs resulting within the second regime. In doing so, we are able to assess the impact of events within our conventional monetary policy regime as well as the effects of events within the unconventional monetary policy regime on volatility. Figure A1 to figure A16 in the Appendix depict the volatility impulse response functions for the bilateral exchange rates and major equity indexes for all countries in both policy phases. We illustrate the volatility impulse response function on a specific date as a solid line while the 10-day average impulse response *before* this event is represented as a dashed line and the 10-day average impulse response function *after* this event is shown as a dotted line.

VIRFs of bilateral exchange rates

Figure A1 to figure A4 illustrate the volatility impulse responses of bilateral exchange rate volatilities for all event dates of interest rate cuts within our first regime. In general, we observe a decrease in conditional volatility across countries in response to historical shocks (both, U.S. and domestic shocks) on most of these events. The strongest drop in conditional volatilities of about 0.29 percent is observable on 11/06/2002 for the Brazilian real to U.S. dollar exchange rate whereas for Chile, South Korea and South Africa we only observe a slight decrease in conditional exchange rate volatilities on this day. An exception to this is the interest rate cut on 05/15/2001 which leads to an increase in conditional volatilities of about 0.26 percent of BRL/USD and the interest cut on 11/06/2001 which increases the conditional volatility of KRW/USD by 0.17 percent. Altogether, exchange rate volatility of the Brazilian exchange rate seems to be affected by historical shocks the strongest whereas for the other countries changes in conditional volatilities remain moderate.

It is worth noting that the VIRFs depict the impact of a U.S. shock as well as of a country specific shock on conditional variances. Yet, for a detailed analysis it is crucial to distinguish between the impact of these two shocks. We calculate the impact of each shock by multiplying the initial historical shock with its corresponding estimated ARCH-coefficient(s) coming from the variance equation 3.[10] Interestingly, we find that the U.S. shock has a damping effect on conditional volatilities for all countries and all events in the conventional monetary policy regime. However, our results show that U.S. shocks have relatively little importance in explaining the change in volatilities. Regarding the Brazilian and Korean exchange rate, U.S. shocks account for merely 5 percent of the change in conditional volatilities. For CLP/USD and XAF/USD we find slightly different results. Again, domestic shocks play the crucial role in explaining the change in conditional volatilities, albeit their importance recedes. For these bilateral exchange rates, U.S. shocks account for up to 22 percent in the change in conditional volatilities. As mentioned before, there are two events on which conditional volatilities increase in total i.e., on 05/15/2001 for BRL/USD as well as on 11/07/2001 for KRW/USD. This result can be explained by the positive impact on volatility arising from the country specific shock, which dominates the damping impact due to the U.S. shock.

Our results suggest further that, on average, 10 days before each interest rate cut conditional volatilities of the BRL/USD exchange rate increase. On three out of four events the dashed VIRFs lay above the zero line indicating a rise in volatilities. In contrast, we find that for the CLP/USD exchange rate the dashed VIRFs signify a slight decrease in volatility which is enforced by the specific event itself. For KRW/USD and XAF/USD the results are mixed. These findings allow us to conclude that firstly, given high volatility environments before specific accomodative monetary policy events, historical shocks on event days contribute to a sizable reduction in conditional volatilities and secondly, given an already low volatility environment, historical shocks on event days lead to a further calming in conditional volatilities. While the damping effect on conditional volatility on event days is observable for all exchange rates in our sample, we find that, on average, 10 days after this event conditional volatilities might both, decrease and increase across countries.

[10]For the conventional monetary policy regime we calculate the impact of each shock on the conditional variance of returns as in the following: $impact_{US} = \beta_{3,C}\left(\epsilon^2_{US,t} - h_{US,t}\right)$ and $impact_C = \beta_{2,C}\left(\epsilon^2_{C,t} - h_{C,t}\right)$. For the unconventional monetary policy regime we calculate: $impact^{QE}_{US} = (\beta_{3,C} + \beta_{5,C})\left(\epsilon^2_{US,t} - h_{US,t}\right)$ and $impact^{QE}_{C} = (\beta_{2,C} + \beta_{4,C})\left(\epsilon^2_{C,t} - h_{C,t}\right)$.

The estimated volatility response functions for our second policy regime in which unconventional monetary policy was introduced by the Fed are depicted in figures A5 to A8. By and large, conditional variances of exchange rates decrease sustainedly due to historical shocks. Solely the South African rand to U.S. dollar exchange rate appears to be an exception. For QE1, QE3 and the postponed taper announcement the calculated VIRFs are located above the zero line implying an increase in conditional volatilities. The decomposition of the overall effect into the fraction that can be explained by the U.S. shock and the fraction that is due to the domestic South African shock adds further insight. It follows that within the unconventional monetary policy regime local shocks are dominant and positive while U.S. shocks, even though negative, are negligibly small. On average, 10 day after the taper postponed announcement in September 2013, we find a slight increase in conditional volatilities for BRL/USD and XAF/USD as well. Although Ben Bernanke's testimony to the Joint Economic Committee about a premature reduction in the pace of bond purchases took financial markets by surprise, financial market volatility did not rise before summer 2013. Thus, a strong increase in the conditional volatility on 09/18/2013 is in line with what we would expect as well as with the findings of e.g. Meinusch and Tillmann (2017) who show that especially around the September FOMC meeting uncertainty and disagreement about the timing of tapering increased. Taking a closer look at the relative importance of the U.S. and the domestic shock we find that the rise in conditional volatility is due to country specific shocks instead of U.S. shocks. Though, for the other exchange rates we find that U.S. shocks gain importance in explaining the change in the conditional variance. In particular they account for on average 49 percent (BRL/USD), 52 percent (CLP/USD) and 17 percent (KRW/USD) in the toal change in conditional volatilities.

Further, very similar to our previous results, on average 10 days before a certain event conditional volatility, depicted by the dashed VIRFs, either increases or is close to the zero line. On event days, however, conditional volatility decreases substantially. For most events and countries, 10 days after the event the decrease in conditional volatility continues as depicted by the dotted line. Yet, there are some exceptions. Our results show an increase in conditional volatility by about 5.5 percent for BRL/USD, 0.5 percent for KRW/USD, and 1.2 percent for XAF/USD after the QE1 announcement.

To sum up, a volatility shock in the conventional monetary policy regime decreases the conditional volatility for the majority of events and countries predominantly due to negative country specific shocks. These shocks are dominant within the conventional monetary policy regime and explain the increases in conditional volatilities mentioned above. In contrast, we find that U.S. shocks become more influential (in some cases even dominant) within the unconventional monetary policy regime. In terms of geographical distance, we can state that all countries are affected by U.S. shocks within the conventional monetary policy regime in a similar way. However, for the unconventional policy regime, we find that U.S. shocks contribute to a greater fraction in the change in volatility for Latin American countries than for countries with a larger geographical distance to the United States.

VIRFs of equity returns

Volatility impulse response functions for foreign equity markets to historical shocks are depicted in figure A9 to figure A12 for the conventional monetary policy phase and in figure A13 to figure A16 for the unconventional monetary policy phase. Clearly, it can be established that for the most part stock market volatility reacts either similar or even stronger in magnitude to historical shocks than exchange rate volatility. In addition, we observe that while conditional exchange rate volatility typically decreases in response to historical shocks on event days, condition volatility of stock markets decreases less frequently. Having stated this, we now go into more detail by discussing VIRFs for each individual country.

For Brazil's stock market in figure A9 we observe an increase in the conditional volatility on 04/18/2001 of about 22 percent which is driven by a sizable positive domestic shock. 10 day before and after this interest rate cut event conditional volatility increases only moderately, on average. On 05/15/2001 the calculated VIRF implies a reduction in conditional volatility whereas 10 days before and after this event volatilities on average exhibit an increase. Additionally, on 11/06/2001 and on 11/06/2002 we only observe marginal changes in conditional volatilities given a high volatility environment 10 days before the event. In analogy to our results for exchange rates, we find that conditional volatilities of the Brazilian major stock market index are mainly determined by local shocks.

Within the unconventional monetary policy regime conditional volatilities increase substantially for the QE3 and the taper postponed announcement as can be seen in figure A13. On impact, conditional volatilities on this events increase by about 7 and 2.25 percent, respectively. This reaction is once more due to local shocks. However, on average 10 days before and 10 days after these events volatilities show only minor changes. On contrary, QE1 and QE2 lead to a slight decrease in volatilities, as shown in figure A13. We find that on average in both cases, but especially for QE1, 10 days before the announcement conditional stock market volatility increases tremendously. In addition, the importance of U.S. shocks grows within the unconventional monetary policy period up to 10 percent (QE1) and 8 percent (QE2). For Chile, we observe similar effects as depicted by figure A10 and figure A14. Here, interest rate cuts lead to an increase in conditional volatilities in three out of four cases. Again U.S. shocks play only a minor role in explaining the change in conditional volatilities. Conversely, shocks within the unconventional monetary policy regime decrease volatility similar to what can be observed for exchange rates. After all, these reactions exert a stronger effect on stock market volatility as corresponding shocks for exchange rates. Likewise, we find that within the unconventional monetary policy regime U.S. shocks are more important than in the conventional policy regime. For the stock market the relative contribution is about 20 percent.

Opposed to the previous results for bilateral exchange rates, conditional volatility of the Korean and South African stock market index is driven by domestic shocks in both policy regimes, see figures A11 to A12 and figures A15 to A16. This illustrates the importance geographical distance might play for the impact of spillovers arising from the United States. The greater the distance between the U.S. and a certain EME, the less important are U.S. shocks for stock markets and the greater is the influence of domestic shocks. Analogously to our previous findings we can say that increases in conditional volatility have their origin in positive and dominant local shocks.

Thus, we may conclusively state that stock markets show a higher volatility and thus a higher vulnerability to shocks than exchange rates. While in the conventional monetary policy period U.S. shocks are negligibly small for all countries, we observe that for Latin American countries U.S. shocks gain importance within the unconventional monetary policy period.

6 Conclusion

The recent global financial crisis triggered the Fed to experiment with enormous unconventional stimulus packages to revive the sluggish U.S. economy. The cash influx generated by these measures inevitably seeped out to emerging markets in search of returns on capital. This paper has shown that the Fed's policy decisions induce substantial volatility spillovers to EMEs in Latin America and Emerging Asia whereas mean spillovers play a minor role.

In this study we follow Sun et al. (2009) and use a CCC-GARCH framework for modeling the multivariate relationships of volatility among U.S. short-term interest rate expectations and bilateral exchange rates of emerging market currencies (Brazil, Chile, South Korea and South Africa) to the U.S. dollar. In order to differentiate between a conventional and an unconventional monetary policy regime we introduce a dummy variable in the mean and volatility equations.

Our results confirm that mean or volatility spill backs from any country of interest on expected short-term rates are negligibly small i.e., U.S. short-term expectations do not respond to movements in asset returns. The transmission appears to be unidirectional (from the United States to EMEs). Further, we illustrate that a decline in the expected short-term interest rate might lead to significant mean spillovers on exchange rates and equity returns such that foreign currencies appreciate significantly and equity prices rise. However, mean spillovers appear to be of less importance compared to volatility spillovers for all countries in our sample.

In terms of volatility spillovers, we observe an increase in the conditional volatility due to shocks in U.S. interest rate expectations during normal monetary policy times. For the majority of countries studied here this effect is highly significant albeit moderately positive. More importantly, we see that the unconventional monetary policy phase in 2008 - 2014 were associated with a statistically significant rise in conditional volatility.

Especially the exchange rates of Brazil and Chile were hit by these volatility spillovers quite strongly, as were the equity prices in Chile. This result might come as a surprise since these countries were heavily engaged in actions to dampen potential U.S. monetary policy spillovers. Yet, they have proven to be successful in terms of mean spillovers that, based on our results, are rather small for Latin American countries. Additionally, our estimates show that the link between U.S. short-term rate expectations and foreign asset markets tightened since the financial crisis.

The analysis of volatility response functions for bilateral exchange rates and stock market returns illustrates that typically conditional volatilities of asset markets respond stronger to historical shocks than exchange rate volatilities. For most events that are associated with accomodative policy decisions we observe a drop in conditional volatilities. These effects are predominantly driven by country specific shocks in the conventional monetary policy regime. In contrast, our results suggest that U.S. shocks gain importance within the unconventional monetary policy regime. This is especially the case for countries closer to the U.S. such as Brazil and Chile. As a matter of fact, geographical distance appears to play a crucial role in how strong spillovers are transmitted to other countries. The negative relationship between the magnitude of spillovers and geographical distance might be due to trade and financial linkages, institutional stability, as well as due to social distance.

Thus, we conclude that U.S. monetary policy measures might pose a challenge to emerging market economies, as they are transmitted through increasing conditional volatilities to countries outside the U.S. where they might unfold destabilizing effects. However, we find that especially on the day of specific monetary policy decisions or announcements conditional volatilities of exchange rates and equity returns in EMEs might decline which emphasises the stabilizing effects of the Fed's measures in response to the global financial crisis.

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Appendix

Exchange Rates

Regime 1: U.S. interest rate cuts

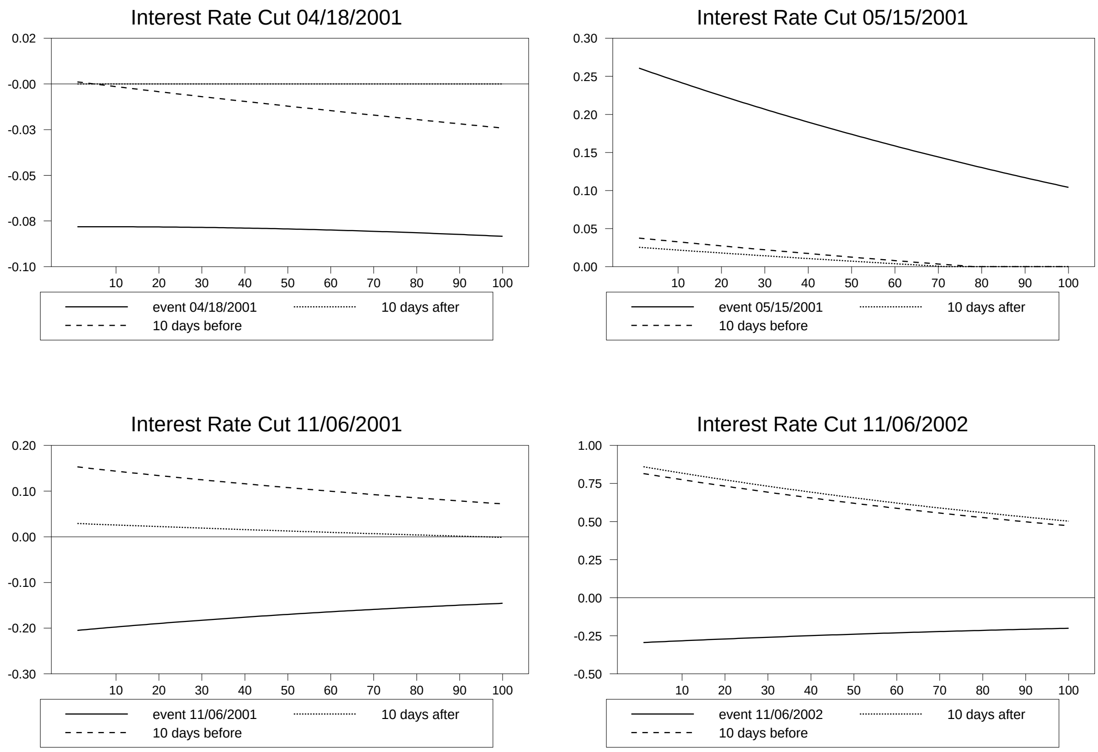

Figure A1: Volatility Impulse Response Functions for Brazil in regime 1: Exchange Rates.

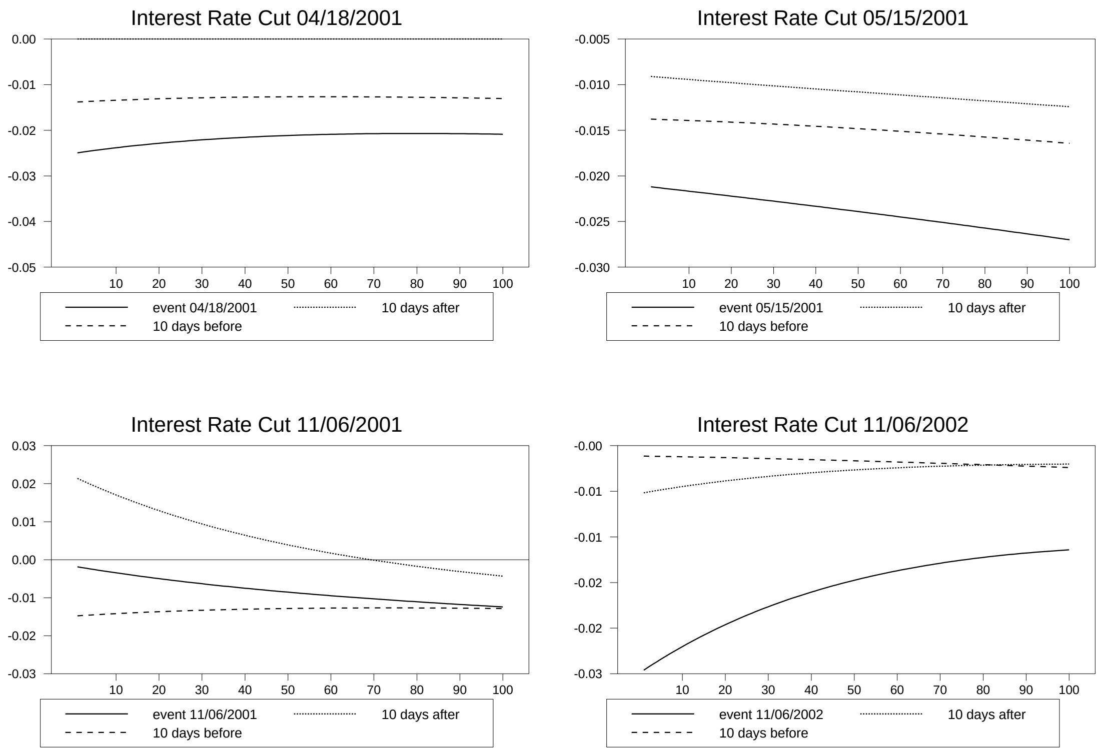

Figure A2: Volatility Impulse Response Functions for Chile in regime 1: Exchange Rates.

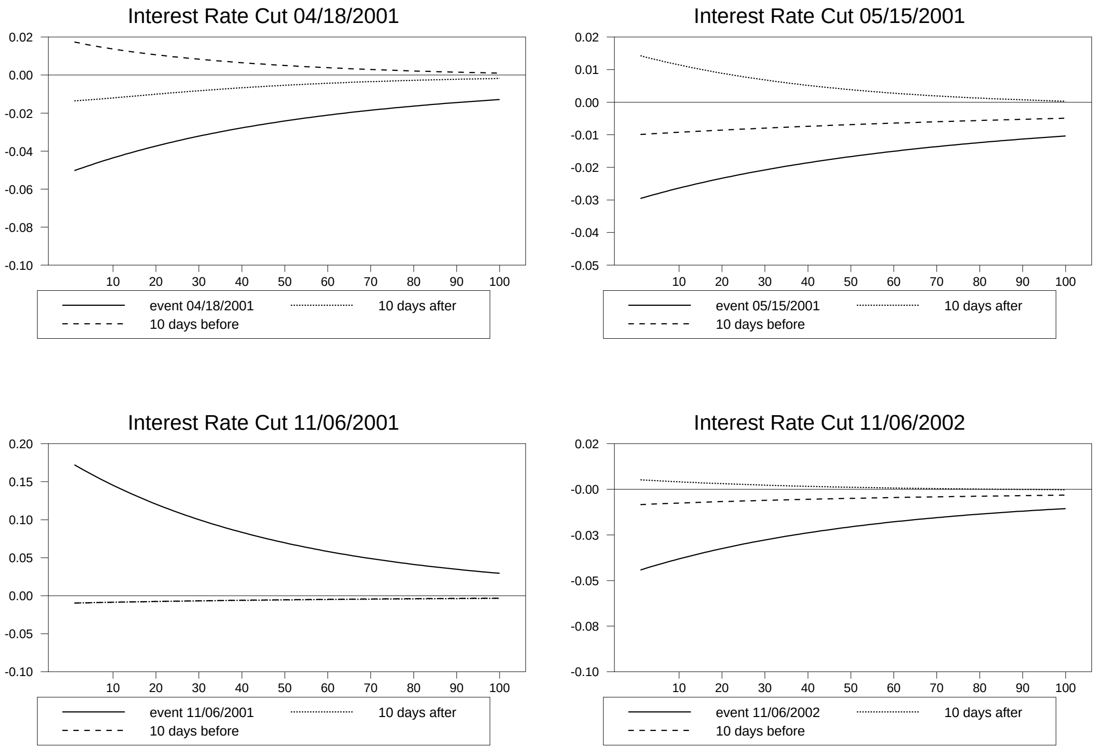

Figure A3: Volatility Impulse Response Functions for South Korea in regime 1: Exchange Rates.

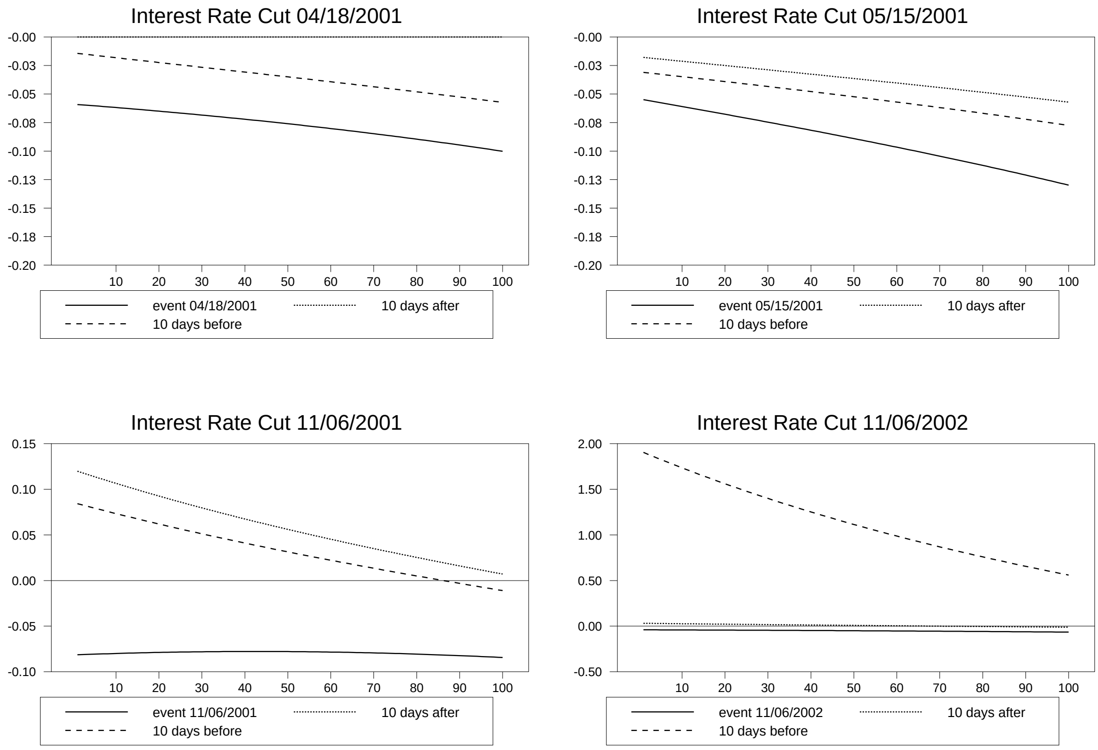

Figure A4: Volatility Impulse Response Functions for South Africa in regime 1: Exchange Rates.

Exchange Rates

Regime 2: QE Announcements and Tapering

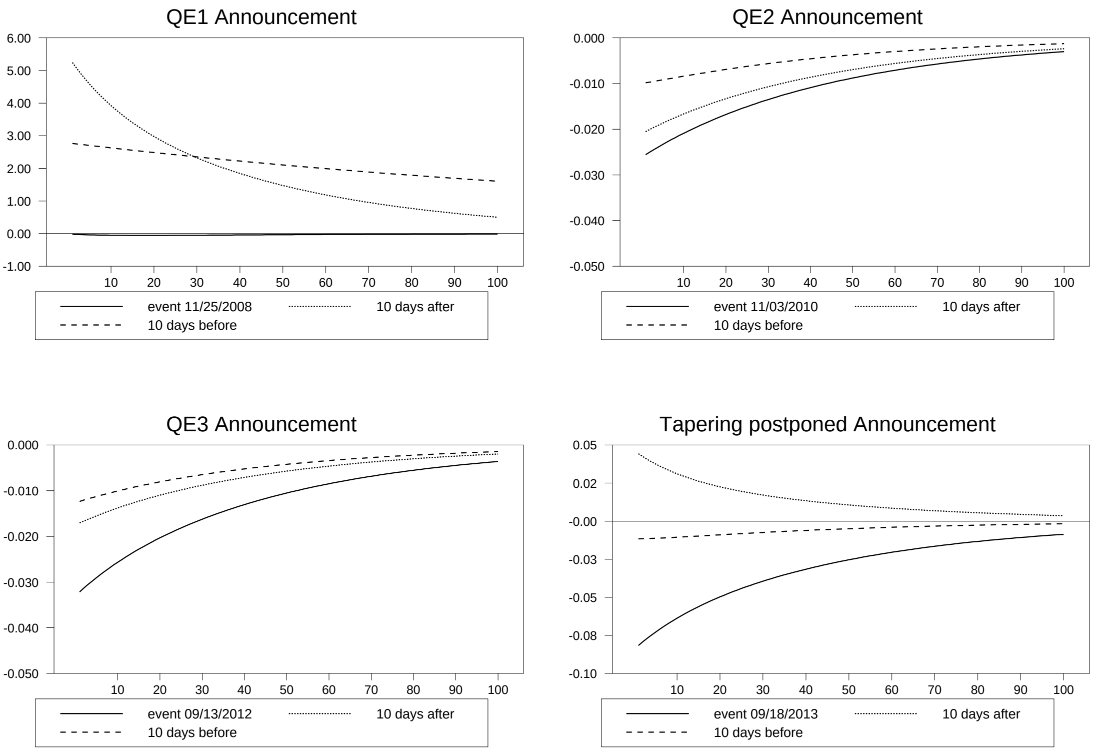

Figure A5: Volatility Impulse Response Functions for Brazil in regime 2: Exchange Rates.

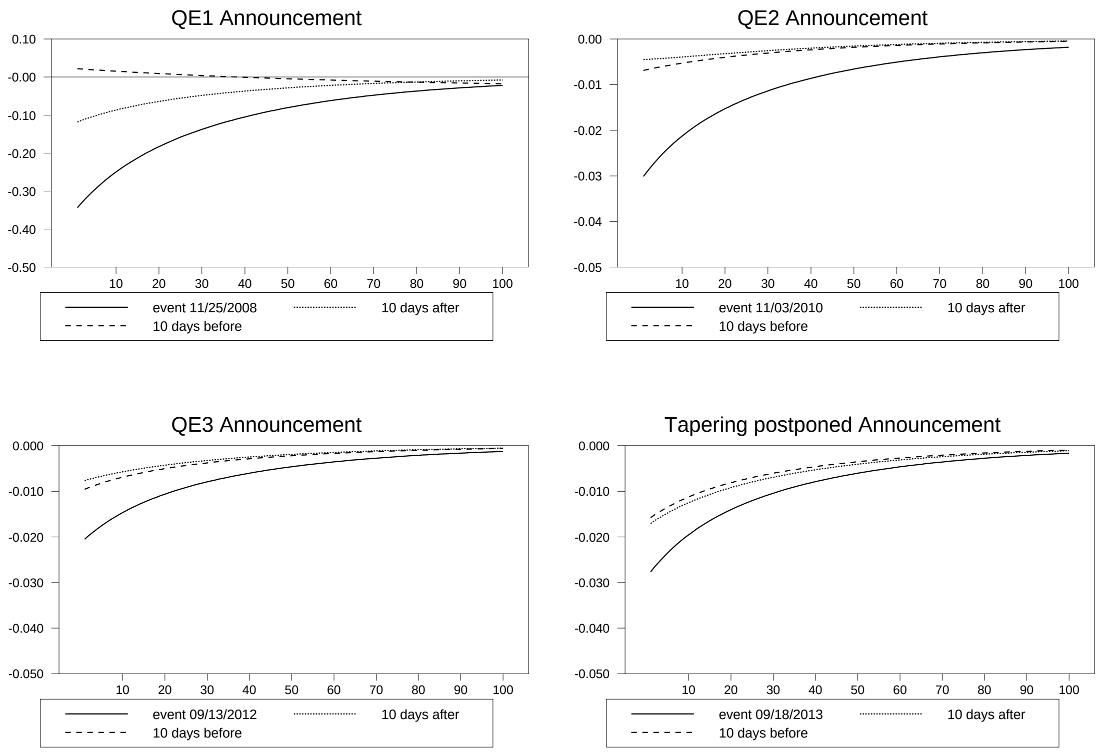

Figure A6: Volatility Impulse Response Functions for Chile in regime 2: Exchange Rates.

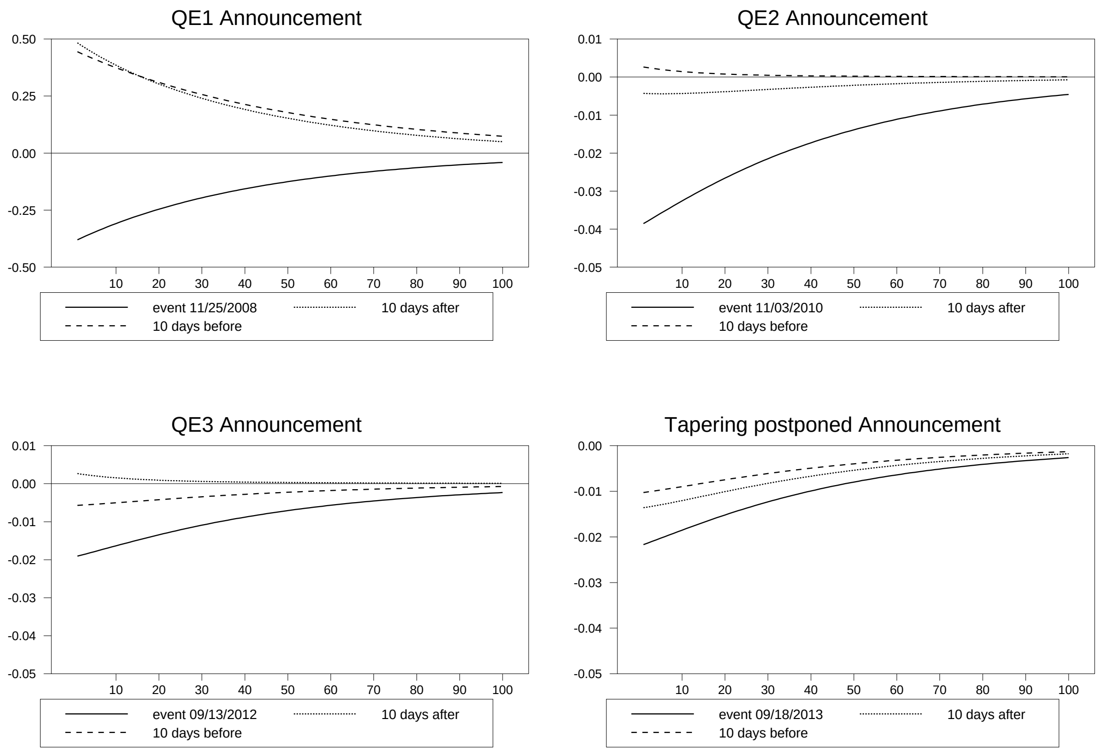

Figure A7: Volatility Impulse Response Functions for South Korea in regime 2: Exchange Rates.

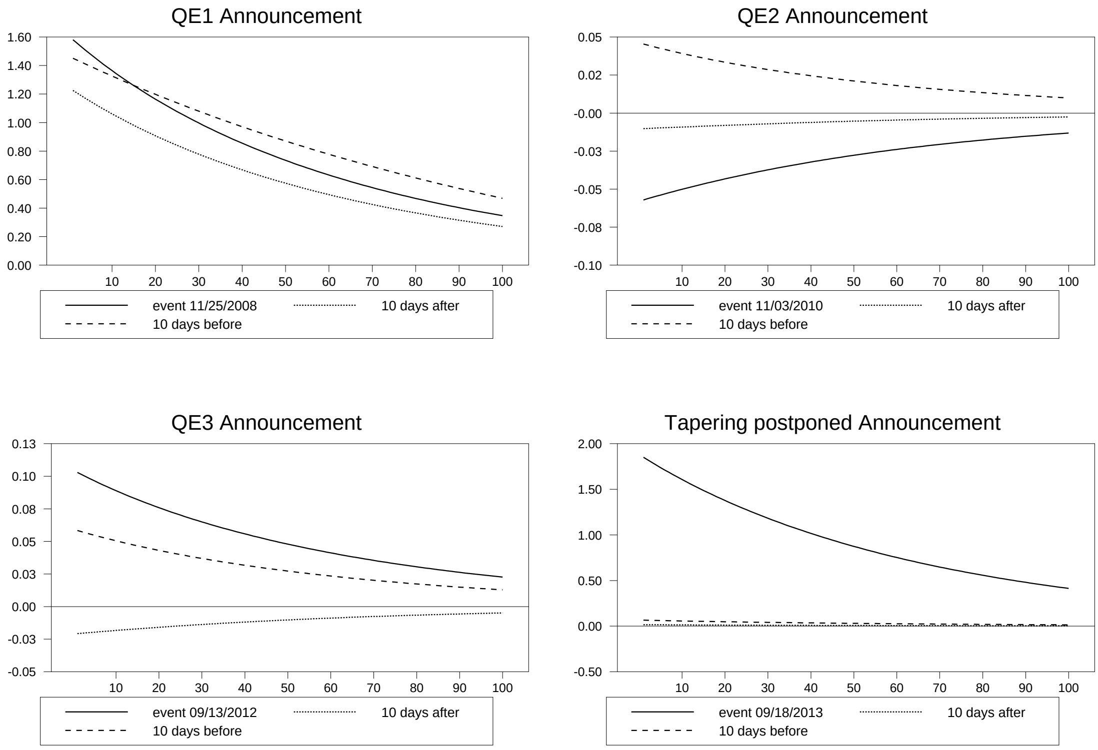

Figure A8: Volatility Impulse Response Functions for South Africa in regime 2: Exchange Rates.

Stock Market Returns

Regime 1: U.S. interest rate cuts

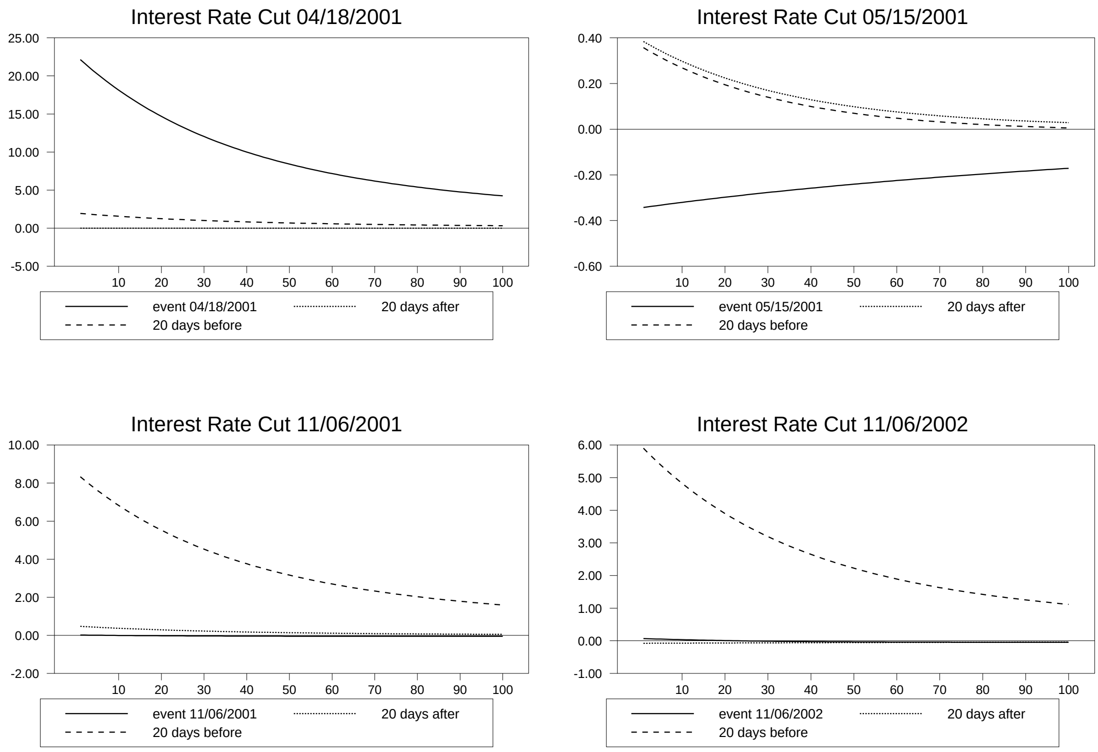

Figure A9: Volatility Impulse Response Functions for Brazil in regime 1: Stock Market Returns.

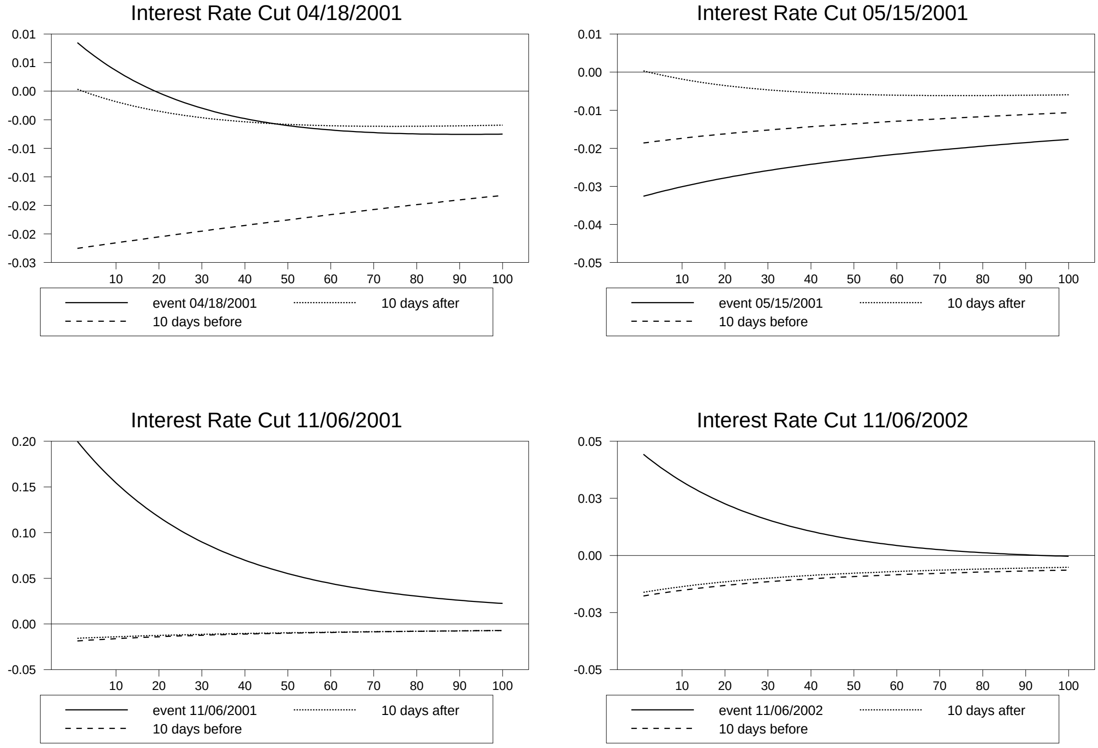

Figure A10: Volatility Impulse Response Functions for Chile in regime 1: Stock Market Returns.

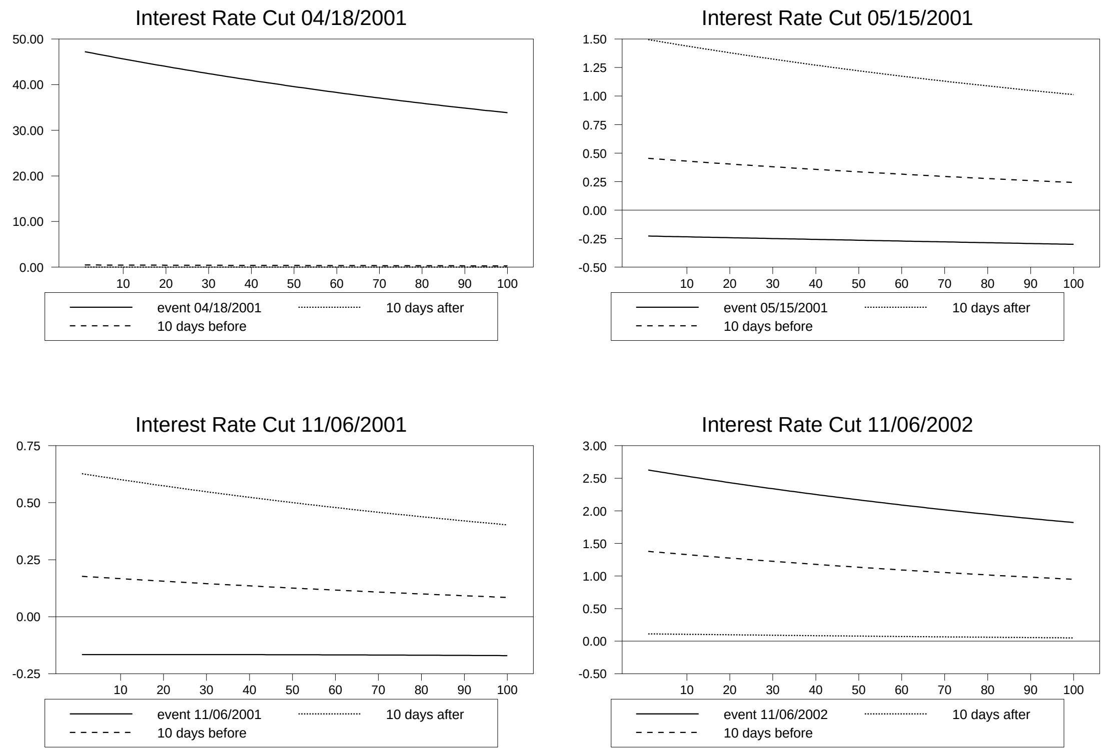

Figure A11: Volatility Impulse Response Functions for South Korea in regime 1: Stock Market Returns.

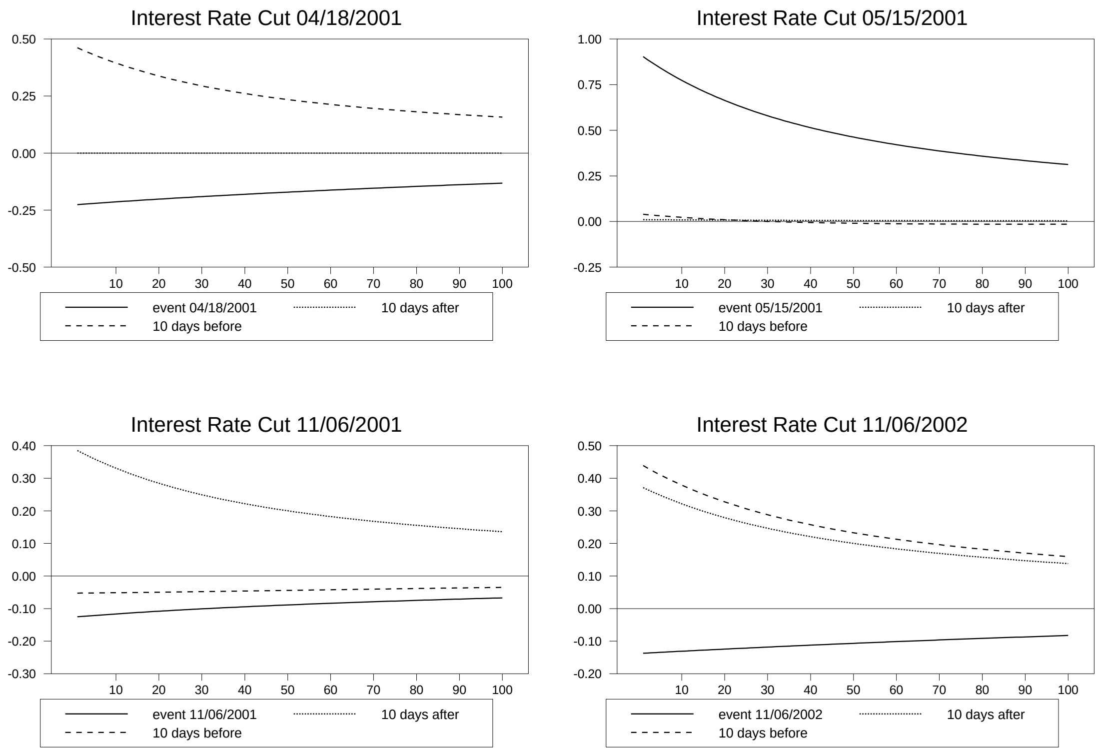

Figure A12: Volatility Impulse Response Functions for South Africa in regime 1: Stock Market Returns.

Stock Market Returns

Regime 2: QE Announcements and Tapering

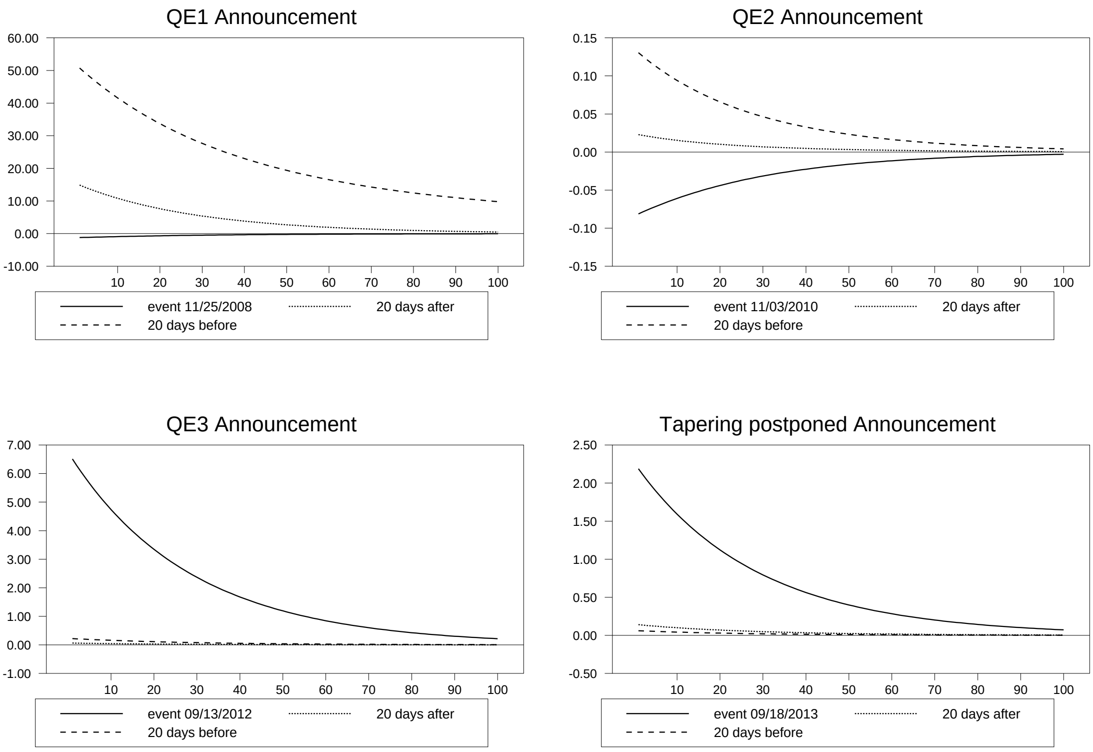

Figure A13: Volatility Impulse Response Functions for Brazil in regime 2: Stock Market Returns.

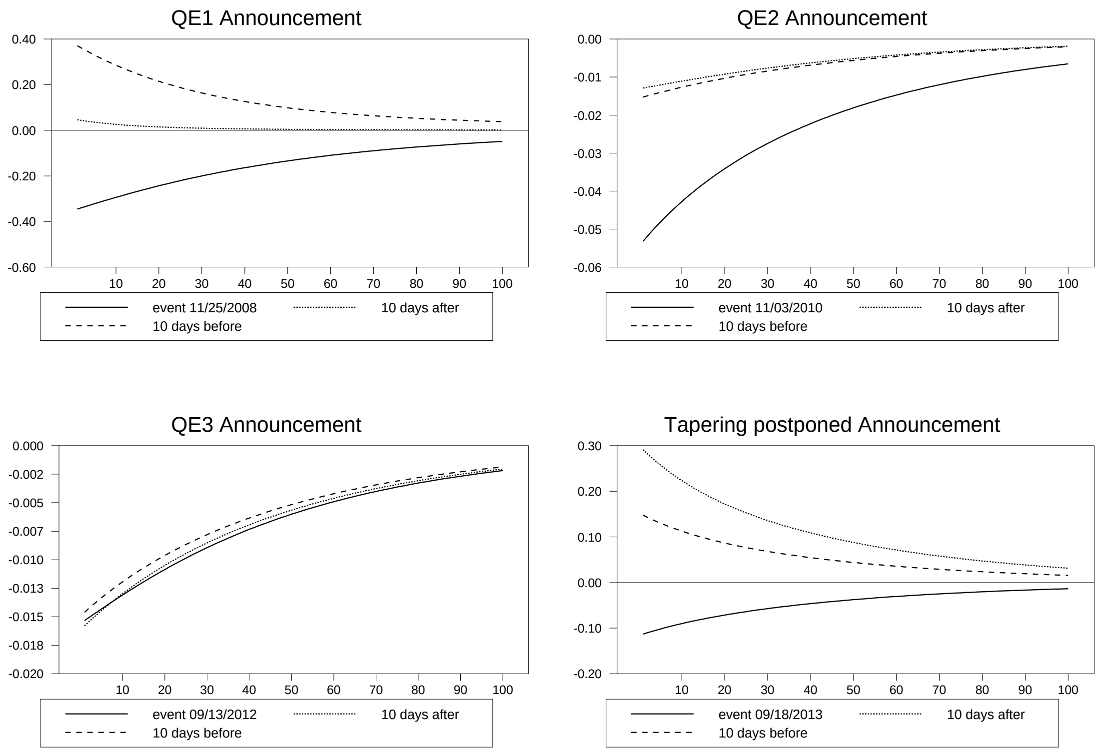

Figure A14: Volatility Impulse Response Functions for Chile in regime 2: Stock Market Returns.

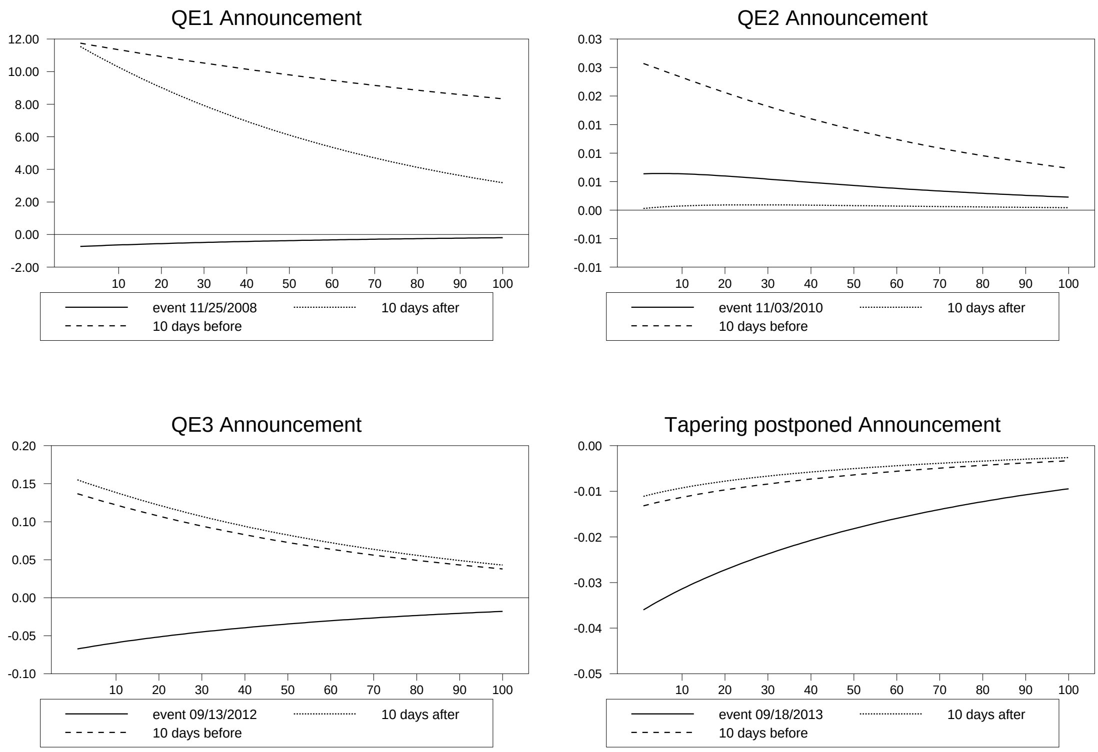

Figure A15: Volatility Impulse Response Functions for South Korea in regime 2: Stock Market Returns.

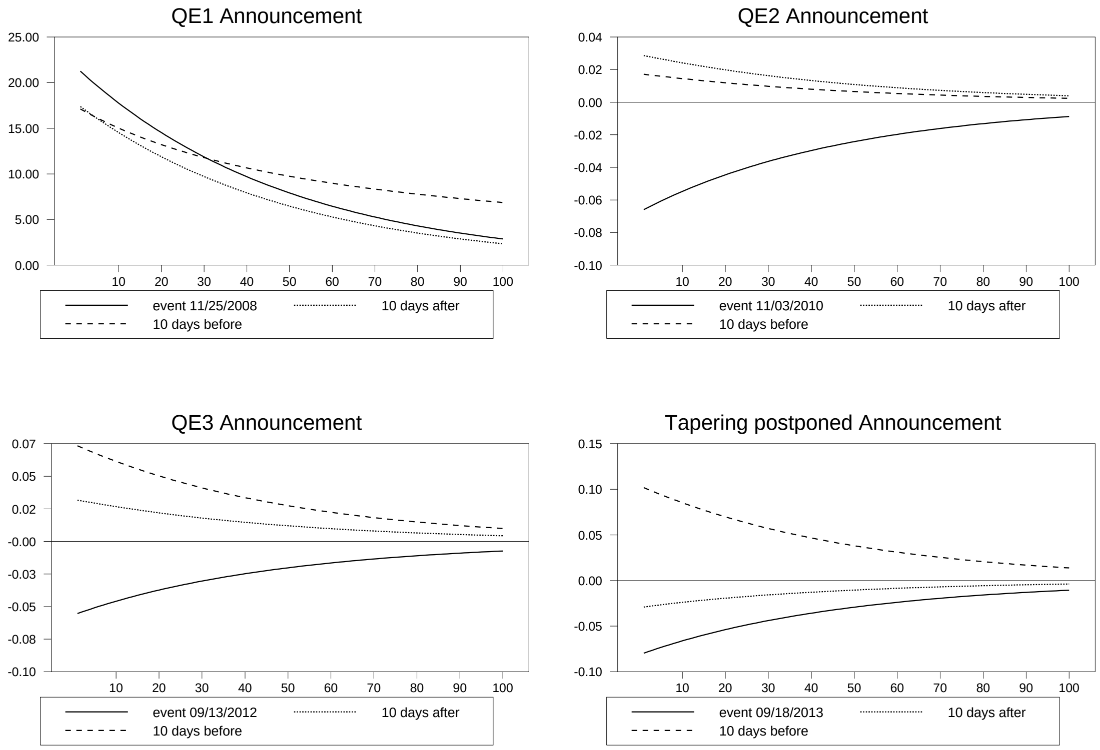

Figure A16: Volatility Impulse Response Functions for South Africa in regime 2: Stock Market Returns.