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Macroeconomic Fundamentals, Price Discovery and Volatility Dynamics in Emerging Markets

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Abstract

This study characterizes volatility dynamics in external emerging bond markets and examines how prices and volatility respond to news about macroeconomic fundamentals. As in mature bond markets, macroeconomic surprises in external emerging bond markets are found to a¤ect both conditional returns and volatility, with the e¤ects on volatility being more pronounced and longer lasting than those on prices. Yet the process of information absorption tends to be more drawn out than in mature bond markets. International and regional macroeconomic news is at least as important as local news for both asset valuations and volatility dynamics in external emerging bond markets.

JEL Classification Numbers: E44, G14

Keywords: emerging markets; bond pricing; macroeconomic news; announcements; survey data; news spillovers; high-frequency data

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I. Introduction

Insights about how financial markets react to news are essential to effective macroeconomic policy-making as well as efficient trading. Policy makers are interested in designing effective policy and communication strategies that are conducive to fundamental price discovery while avoiding excessive volatility owing to uncertainty. Understanding investors' reaction to international and regional news is especially valuable as it indicates how market shocks can spill across borders, possibly putting macroeconomic and financial stability at risk. Equally, greater knowledge of volatility dynamics and the process of price discovery in financial markets helps improve portfolio and risk management by market participants. Profitable trading decisions hinge on the knowledge of market reaction to information about macroeconomic fundamentals, while insights regarding volatility responses help finetune the order flow and manage risks.

The analysis of price discovery and volatility dynamics in financial markets requires using intraday data. The nearly instantaneous reaction of markets to individual pieces of news can be discerned only at such high frequencies. Most studies of daily dynamics in mature markets, for example, find little evidence that asset prices and volatility respond to macroeconomic news (*inter alia* Hakkio and Pearce, 1985; Dwyer and Hafer, 1989; and Cutler, Poterba, and Summers, 1989). This is in contrast to theoretical predictions and the empirical findings based on high-frequency data, which show that asset prices, and even more so volatility, react to macroeconomic news. In the context of emerging markets, however, high-frequency evidence is scant, largely owing to data limitations. Among a few exceptions is the study by Robitaille and Roush (2006) on Brazilian external sovereign bonds, which finds that macroeconomic announcements have significant effects on mean returns, abeit without accounting for return dynamics, which risks biasing its conclusions. It also does not explore the impact of news on volatility and covers only one country. Wongswan (2006) examines high-frequency data for the Korean and Thai stocks and finds that both global and local news affect intraday volatility.

This paper provides a broader and more systematic analysis of high-frequency price and volatility dynamics in emerging markets. We examine the impact of local, regional and international macroeconomic news on asset valuation and trading activity on the most liquid external emerging sovereign bonds. The focus on these markets is motivated by their relatively underexplored status in the literature, particularly given their growing importance in recent years due to the increased activity of so-called "cross-over investors" who maintain diversified portfolios of assets, including both emerging and mature sovereign bonds. These two types of assets serve as natural comparators.

We compare our findings for emerging sovereign bonds to those in the literature on mature sovereign bonds, using U.S. bonds as a benchmark. Both U.S. treasury bonds and emerging U.S. dollar-denominated bonds are interdealer-traded in over-the-counter (OTC) markets with significant foreign investor participation. The valuation of both types of sovereign bonds is determined by a similar information set of macroeconomic fundamentals. The U.S. treasury bond market is the most liquid market in the world, with U.S. primary dealers making continuous markets via global trading desks and setting a global benchmark of efficient price formation. Emerging sovereign bonds in our sample also represent the most actively traded (and most standardized) segment of emerging market credit. Thus, the choice of U.S. treasury bonds as a benchmark ensures that we compare assets that are most liquid in their respective classes.[1]

How would prices and volatility of external emerging market bonds be expected to react to macroeconomic news? In line with the literature on comparable mature markets, local data releases are expected to have a direct and consistent effect on prices and volatility. News from systemically and regionally important economies should also have a strong impact on prices and volatility of foreign currency-denominated bonds—such news not only directly affect the predominantly international investor base, but they also have bearing

[1] Using U.S. corporate bonds as a benchmark is appropriate for the purposes of this study. While emerging sovereign bonds and U.S. high-yield corporate bonds tend to converge on risk-return profiles, the information sets underlying pricing and investor behavior in these markets differ significantly. Moreover, the universe of high-yield corporate bonds is far more fragmented and heterogenous in terms of issuers, security characteristics and investor base. Corporate issues are rarely open series, in contrast to sovereign bonds, which implies that they usually do not have standardize payment terms and the pricing of multiple issues is not compatible.

on perceptions about emerging sovereigns' repayment capacity. As for the duration of the adjustment, information absorption may take longer in external emerging markets than in mature bond markets, given their lower liquidity and greater information asymmetries.

When examining market reaction to news, we distinguish two types of adjustment: repricing (the price impact) and repositioning (the volatility impact). Repricing involves shifts in asset prices as traders discern the implications of public news for the fair value of a bond. Within the theoretical framework suggested by Kim and Verrecchia (1991b), investors form their expectations before the release of news about macroeconomic fundamentals and trade accordingly. Following an announcement, traders revise their beliefs and trade only if there is a surprise component in the news, i.e., the released data differ from market expectations. Good-news surprises cause an increase in prices, whereas bad-news surprises result in a decrease. The recommencement of trading following an announcement is further reflected in an increase in trading activity, as investors rebalance their portfolios in light of new information to fit their risk preferences (Andersson, 2007).

The market microstructure literature posits that any repositioning stems from information asymmetry between informed and liquidity traders (Admati and Pfleiderer, 1988), as well as the heterogeneous interpretation of public information by investors (Kim and Verrecchia, 1997). In Admati and Pfleiderer (1988), informed traders concentrate their trades during periods of high market activity, such as around public announcement times, to ensure that their informed trading has little effect on prices and that they can benefit from the liquidity externalities generated by other traders. This, in turn, promotes concentration of liquidity trades and generates even greater trade volume and more volatility. Similarly, Kim and Verrecchia (1997) argue that public announcements increase information asymmetry because investors have varying degrees of skill in interpreting news. This implies that the news impact on volatility dominates the effect on prices, with volatility remaining at elevated levels long after prices have adjusted. In addition, responses to macroeconomic announcements may also vary depending on the overall level of volatility in the market. In our sample, volatility increased sharply with the onset of the financial crisis in the United States in the summer of 2007. In line with the findings in Andritzky, Bannister, and Tamirisa (2007), we would expect the news effect to recede during financial turbulence, because investors are likely to engage in more active and frequent repositioning of their portfolios amid declining trading volumes and greater price uncertainty.

These hypotheses are largely confirmed by the analysis, although some caveats apply. As in studies of mature markets, we find that the initial price adjustment upon the arrival of new information is weak and dissipates within minutes of the announcement. The direction and magnitude of the response is broadly similar for external emerging and U.S. treasury bonds at very high frequencies. Yet, as expected, the volatility response is much more pronounced than the price response. Volatility remains at elevated levels, at up to six times the preannouncement level, for up to one and a half hours after the announcement—about three times as long as in mature bond markets, which suggests greater uncertainty about the implications of new information and the time required for it to be fully absorbed. Although responses to news vary to some extent across countries and types of indicators, international news (from systemically and regionally important countries) is generally at least as important as domestic news for both asset valuations and volatility dynamics in emerging markets. Moreover, we find evidence of asymmetric effects (stronger responses to negative news than to positive news) and observe a disproportionately large impact of news releases that contain large surprises. As average volatility has increased with the onset of the subprime crisis, the impact of international (U.S.) macroeconomic news has become more muted, possibly reflecting an increased importance other news, such as announcements on financial sector performance, or a perception - prevalent in the early stage of the financial crisis - that emerging economies are likely to be resilient to the U.S. downturn.

The rest of the paper is organized as follows. After reviewing the literature in Section II., Section III. describes the high-frequency data on bond prices and macroeconomic announcements and also explains how the surprise content of news was measured. Section IV. discusses the methodological approach, based on a two-stage model of returns and volatility. Section V. explains the modifications that were introduced into the traditional two-stage model to reflect price and volatility dynamics of emerging markets. It also characterizes price and volatility dynamics in emerging markets. The empirical findings concerning the effect of macroeconomic news on prices and volatility are presented in Section VI.. Section VII. concludes.

II. Literature Review

The literature on mature markets provides a useful benchmark for the analysis of the market microstructure of emerging market bonds. Mature markets appear to respond to public information in a multi-stage process. Prices do not always react to announcements, but, when they do, the adjustment occurs within one minute of the announcement, implying a high information efficiency of mature financial markets. Trading activity, as reflected in the volatility of prices, rises within 10 to 15 minutes of the announcement and remains elevated for about an hour. Bid-ask spreads widen in tandem with the increase in trading activity but narrow before trading activity subsides, suggesting that the initial stages of adjustment are dominated by informed trading, whereas the last stages are driven by liquidity trading (Fleming and Remolona, 1999; and Balduzzi, Elton, and Green, 2001).

In one of the most comprehensive studies on the topic, Andersen et al. (2003) examine the role of fundamentals in high-frequency movements in the U.S. dollar spot exchange rates. They find that surprises in macroeconomic data releases have a significant effect on five-minute returns. This finding implies, in line with theoretical models of market microstructure (see O'Hara, 1995, and the references therein), that news about fundamentals is quickly incorporated into asset prices. Market reactions are asymmetric: that is, bad news has a greater impact on markets than good news. Bauwens, Omrane, and Giot (2005) confirm the latter finding, using headlines released on Reuters screens as a measure of news. They also examine how news affects volatility, but do not detect any significant post-announcement effects. In contrast, earlier studies by Ederington and Lee (1993) and Fleming and Remolona (1999) reported strong bond market volatility in response to macroeconomic releases. For stock markets, Andersen, Bollerslev, and Cai (2000) also find that macroeconomic announcements have an instantaneous impact on the volatility of five-minute returns on the Nikkei 225 index.

Regarding the type of fundamentals that markets focus on, the literature on mature markets suggests that news about local macroeconomic indicators that are considered to be good predictors of the cyclical position of the economy and policy actions matters most, although news about fundamentals in systemically important foreign countries also affects prices and volatility. The timeliness and incremental information content of news also matters. In a study of 10-minute returns in U.S. futures markets, Veredas (2006) finds that traders show less interest in macroeconomic indicators that are released with a long delay—for example, gross domestic product (GDP) data—than more frequent releases—such as those of the consumer price index (CPI), employment, industrial production, and factory orders.

III. Intraday Price Data and Announcements

The core of our emerging market data set consists of intraday price data for the benchmark external bonds issued by Brazil, Mexico, Russia and Turkey. Together with Argentina and Venezuela (which we exclude because of data problems), these countries account for most sovereign issuance in emerging markets. These bonds are also among the most liquid and actively traded fixed income instruments in the asset class (JP-Morgan, 2008). In the last quarter of 2008, sovereign eurobonds accounted for 18 percent of trading[2] in emerging market debt instruments (or $2.3 billion daily).[3]

Data on expectations and announcements of local macroeconomic data and interest rate decisions are used as a proxy for public information about macroeconomic fundamentals. For international macroeconomic data, we use announcements for the United States; for Russian and Turkish bonds we also control for news

[2] Emerging market debt trading was about $13 billion a day at end-2008 (down from $19 billion in the same quarter of 2007 as a result of higher risk premia and a plunge of new sales and offerings). The decline in trading together with an increase of trading frequency suggests lot sizes fell with the onset of the U.S. subprime crisis. Brazilian sovereign bonds were the most actively traded asset among emerging market debt with an average daily volume of more than $500 million ($193 billion on the annual basis), followed by Russia, Mexico, Argentina, and Turkey.

[3] This is roughly a quarter of trading in U.S. treasuries (or $10 billion daily average at end-2008) according to primary dealer estimates (Emerging Market Traders Association, 2008a and 2008b).

on German macroeconomic developments. The sample period is from October 1, 2006, to February 20, 2008 (297-340 trading days during 17 months, depending on the bond), split into two subperiods: before and during global financial turmoil triggered by the U.S. subprime market crisis, whose onset is identified as June 5, 2007 (see below).

Intraday bond prices. We focus on the benchmark bonds for each of the four countries. The Brazilian 11 percent 2040 bond with an outstanding volume of $4.2 billion is by far the most liquid emerging market bond. The high liquidity of this bond is also reflected in its average bid-ask spread of $0.12 per $100 face value—the lowest among all *Emerging Markets Bond Index Global* (EMBIG) constituents. Mexico's external sovereign issuance comprises several liquid instruments. Among those, we choose the 5.625 percent 2017 as the largest issue, with an outstanding amount of about $3.5 billion and showing the lowest bid-ask spread ($0.22). Russia's 2030 bond is the largest Russian global issue, with an outstanding amount of $20 billion; it marks a significant weight of close to 8 percent in the EMBIG. It is also the second-most traded eurobond in the emerging market asset class, trading at an average bid-ask spread of about $0.23. Turkey's 11.875 percent 2030, the third-most traded emerging market eurobond, enjoys an annual trading volume of about $80 billion. Its outstanding value is $1.5 billion, making it the largest bond issued by Turkey, and the average bid-ask spread is reported to be $0.42. For comparisons with mature markets' behavior, this data set for emerging market bonds is complemented by tick-by-tick data for the corresponding on-the-run 10-year U.S. treasury note provided by Tullett Prebon, an interdealer broker. These intraday data are comparable to GovPx data, which are often used in the literature on government bond trading in mature markets.

The primary price data on emerging market bonds are 10-minute mid-quotes, where the mid-quote is an average of the bid and ask prices available on Bloomberg, the most widely used information system for bond trading. Most trading in the emerging market bonds takes place over-the-counter, and bid-ask quotes from Bloomberg are considered reliable, and most importantly, tradable. Further, evidence from other OTC markets, such as foreign exchange markets, indicates that returns constructed from quotes and trade data closely follow each other, especially when sampled every 10 minutes (see Goodhart, Ito, and Payne, 1996; and Danielsson and Payne, 2002). Ten-minute intervals are also preferred because trading activity is limited at shorter time intervals. However, we also construct a secondary dataset that consists of 1-minute return series from quotes posted between 8.00 a.m. and 9.00 a.m. Eastern Standard Time (EST), to study the impact of surprises in U.S. macroeconomic news on emerging and mature bond returns. To get the data into a form suitable for analysis, we remove observations during non-trading hours (assumed to be 3.00 a.m. and 5.00 p.m. EST for Mexican and Brazilian bonds and 2.00 a.m. and 5.00 p.m. EST for Turkish and Russian bonds), on weekends, on major U.S. and U.K. public holidays, and on days when 95 percent or more of returns are zero. To minimize data errors, we exclude non-positive bid and ask quotes, observations for which the absolute bid/ask price change is greater than 10% of the previous bid/ask price (Huang and Stoll, 1994) and the (information-insensitive) technical jumps from the U.S. treasury note data, which characterize about 3 percent of our sample (see Mizrach and Neely, 2007, for a discussion of discontinuities in the U.S. treasury data). Finally, we replace overnight returns with their unconditional means, to remove overnight, weekend and public holiday effects (see Andersen and Bollerslev, 1997, and Engle and Russell, 1998).

Table 1 provides information on the sample sizes, liquidity (defined here as the average number of bid/ask quotes arriving per trading day, see for example Andersen et al., 2007) and data summary statistics for the 1- and 10-minute return series. Within our sample, the Russian and Turkish bonds are the most liquid emerging market bonds, with the average number of bid/ask quotes arriving per trading day equal to 236 and 230 over the full sample period. However, the liquidity in the Latin American bonds increased two- to four-fold during the subprime crisis, to levels comparable with the liquidity in the other two bonds. The average returns are, as expected, 0 for both 1- and 10-minute series, with the standard deviation ranging from 0.3 basis points for 1-minute U.S. returns to 2.3 basis points for 10-minute Mexican returns. Generally, the Latin American returns are the most variable. Apart from the 10-minute Brazilian series, the return distributions are negatively skewed, and all the distributions show excess kurtosis. Moreover, the data display small negative first-order autocorrelation. The summary statistics for the absolute returns also indicate that the U.S. treasury note returns are the least volatile with the average absolute return equal to 0.2 basis points.

Table 1: Summary Statistics for 1- and 10-Minute Bond Returns

	Brazil		**Mexico**		**Russia**		**Turkey**		**U.S.**	
	10min	*1min*	*10min*	*1min*	*10min*	*1min*	*10min*	*1min*	*10min*	*1min*
Sample sizes										
Number of trading days	325		297		324		325		340	
Proportion of 8:00 – 9:00 quotes	9.92%		10.77%		11.06%		10.16%		8.27%	
Number of observations	27,300	19,500	24,948	17,820	29,160	19,440	29,250	19,500	30,600	20,340
Liquidity[a]	166	18	210	25	236	29	230	26	659	55
— before crisis[b]	60	9	129	21	188	27	170	18	561	52
— during crisis[b]	246	25	276	29	272	31	276	32	751	58
Returns										
Mean	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Standard deviation	0.019	0.011	0.023	0.013	0.015	0.007	0.022	0.009	0.006	0.003
Skewness	0.064	-0.070	-0.101	-0.431	-0.743	-2.784	-0.325	-0.818	-0.171	-0.588
Kurtosis	19.662	37.326	19.463	54.091	36.969	110.237	29.096	64.022	14.501	53.033
First-order autocorrelation	-0.171	-0.190	-0.203	-0.095	-0.144	-0.091	-0.084	-0.088	-0.053	0.055
Absolute returns										
Mean	0.009	0.003	0.010	0.004	0.007	0.003	0.011	0.003	0.004	0.002
Standard deviation	0.017	0.010	0.021	0.012	0.014	0.007	0.019	0.008	0.004	0.003
Skewness	3.486	5.232	3.648	6.254	4.927	7.271	4.532	6.371	3.320	6.063
Kurtosis	23.503	38.371	21.000	59.196	49.653	152.215	37.039	76.977	25.351	89.928
First-order autocorrelation	0.253	0.224	0.317	0.196	0.265	0.148	0.210	0.218	0.253	0.223

Notes: The table reports sample sizes and summary statistics for the 10-year U.S. treasury note and emerging market external bonds: Brazil 2040, Mexico 2017, Russia 2030, and Turkey 2030. Quotes posted outside trading hours (assumed to be 3.00 a.m. – 5.00 p.m. EST for Mexican and Brazilian bonds and 2.00 a.m.– 5.00 p.m. EST for Turkish and Russian bonds), during weekends, major U.S. and U.K. public holidays, and days with majority of zero 10-minute returns (95 percent or more) are removed from the sample. For the 1-minute sample only quotes posted between 8.00 and 9.00 a.m. EST are retained. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

[a] Average number of bid/ask quotes arriving per trading day (see above) over the period November 6, 2006 – February 20, 2008.

[b] The beginning of the the U.S. subprime market crisis is identified as June 5, 2007. For all assets, the differences in liquidity before and during the subprime crisis are significant at the 5% level.

Macroeconomic announcements and expectations. Releases of macroeconomic data and market expectations for Brazil, Mexico, Russia, and Turkey, as well as for Germany and the United States (as controls for systemic changes in macroeconomic conditions), are also obtained from Bloomberg. Given the large number of data releases, especially for the United States and Germany, the sample is restricted to the most relevant items, in line with other studies, such as that by Andersen et al. (2003). The selection of macroeconomic data is guided by timeliness, economy-wide relevance, and frequency of releases (we require at least four announcements during the sample period), as well as the availability of analyst forecasts ("surveyed announcements"). The selection is confirmed through a survey of the IMF's country desks.

Information on macroeconomic developments in a given period is released in stages: releases of high-frequency data (for example, monthly data on CPI, PPI, industrial production and retail sales) are followed by releases of quarterly data (for example, on GDP). Many data releases follow a pre-announced release schedule, in line with requirements of the IMF Special Data Dissemination Standard (SDDS), to which these countries subscribe.[4] Macroeconomic policy frameworks, as well as historical tradition, also bear on the composition of countries' data releases, as reflected, for example, in the emphasis Brazil and Mexico place on the frequent monitoring of prices, given their histories of hyperinflation. Regularity in the timing of data releases also varies across countries.[5] For example, Turkey and Mexico tend to schedule data releases at specific times, whereas releases in Brazil occur at multiple times during the day, with changing announcement times. Releases in Russia occur at irregular times during the day.

Besides actual macroeconomic releases, we use data on markets' expectations of these releases. Bloomberg conducts surveys of market analysts in the week prior to a release. Analysts' median forecasts provide a measure of market expectations, comparable to those presented in Market Forecasts (formerly MMS).

Measures of surprise. In line with common practice in the literature (see, for example, Balduzzi, Elton, and Green, 2001; and Andersen et al., 2003 and 2007), we calculate the standardized surprise associated with macroeconomic indicator k at time t as

$$S_{k,t} = \frac{\text{Actual}_{k,t} - \text{Expectation}_{k,t}}{\widehat{\sigma}_k}, \tag{1}$$

where $\text{Actual}_{k,t}$ is the announced value of indicator k, $\text{Expectation}_{k,t}$ is the median market's expectation of k, and $\widehat{\sigma}_k$ is the standard deviation of all surprises ($\text{Actual}_{k,t}-\text{Expectation}_{k,t}$) over the sample period. The calculation measures the size and direction of "news," and the standardization allows for meaningful comparisons of the estimated news effects regardless of different units of measurement (Andersen et al., 2003). We use the magnitude of surprises when estimating the impact of news on mean returns, with a prior that, consistent with economic intuition, larger news surprises would trigger larger price movements.

We also consider release time indicators $A_{k,t}$ as a measure of information arrival. The motivation for including the news arrival dummies is twofold. Firstly, Andersen et al. (2003 and 2007) report that volatility response is more consistently induced by the arrival of information rather than by the magnitude of surprises and that including news announcement dummies in the volatility equation rather than the absolute values of the news surprise components improves model fit.[6] Secondly, this approach facilities the analysis of the effects of macroeconomic releases for which few analysts' forecasts are available. For example, there are no market expectations for consumer credit in Brazil or the current account balance in Russia, and only 12 out of 16 Turkish unemployment statistics are accompanied by relevant market forecasts. Table 2 provides a summary of the macroeconomic news announcements included in the study and the total number of releases and market expectations. The number of considered releases varies between 152 for Turkey to 529 for Brazil, which provides a range of inflation statistics. Market expectations are available for at least 80 percent of the

[4] The Special Data Dissemination Standard (SDDS) was established in 1996 as a guide for the provision of economic and financial market data. It requires subscribers to observe good practices for data coverage, periodicity, quality, integrity and timeliness and to provide the public with access to the data.

[5] Spot checks of news ticker items provide confidence that release times, as saved by Bloomberg, are sufficiently precise to be usable for the analysis of 10-minute bond returns.

[6] As a robustness check, we repeat estimations for all models with scaled surprises, absolute scaled surprises, and release periods, and we compare alternative model specifications using balanced data sets. The results are broadly consistent.

releases (Turkey), with virtually all German, Mexican and U.S. announcements being accompanied by the corresponding survey data.

IV. Two-Stage Modeling of Returns and Volatility

Following Andersen and Bollerslev (1998) and Andersen et al. (2003 and 2007), we use a two-step weighted least-squares (WLS) approach to simultaneously model the dynamic effects of a broad range of macroeconomic announcements on the returns and volatility of emerging market bonds.[7,8] The approach can be summarized as follows. Let R_t be a 10-minute logarithmic return, $t = 1, \ldots, T \cdot N$, where T is the number of calendar days in the sample and N is the number of 10-minute returns within each trading day. We model the conditional mean as

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \sum_{k=1}^{K} \sum_{j=0}^{J} \beta_{kj} S_{k,t-j} + \varepsilon_t, \tag{2}$$

where $\varepsilon_t \sim f\left(0, \sigma_t^2\right)$. The lag length I and the response length J are determined using model selection criteria, and we also test whether coefficients change during the financial crisis period (see below). The ordinary least squares (OLS) estimation of equation (2) would yield asymptotically consistent but inefficient estimates, because the variance of return innovations, $\widehat{\varepsilon}_t$, is time-varying.[9] To deal with this inefficiency, we model time-varying volatility of return innovations and then use the estimated volatility to obtain the correct standard errors of the parameters in equation (2) with the WLS technique. Absolute return innovations $|\widehat{\varepsilon}_t|$ are used as a proxy for the volatility process; a theoretical motivation for using absolute returns instead of squared returns is provided by Forsberg and Ghysels (2007).

We assume that intraday volatility follows the following multiplicative process:

$$\sigma_t = h\,(\text{deterministic volatility}) \cdot g\,(\text{stochastic volatility}) \cdot u_t, \tag{3}$$

where u_t is independent, identically distributed (i.i.d.) with unit mean and unit variance. The deterministic volatility is the seasonal component of intraday and week effects that we allow to vary during the financial crisis. This behavior is modeled using cubic splines $\phi\,(t)$—piecewise polynomial smoothing functions that are often used to model intraday seasonality in high-frequency financial data (see De Boor, 1978, and Eubank, 1988, for a general treatment of splines). The stochastic volatility $\sigma_{d(t)}$ is assumed to be a function of the short- and long-run persistence effects, and announcements effects. More specifically, the functional form of equation (3) is

$$\ln|\widehat{\varepsilon}_t| = \alpha + \phi\,(t) + \psi\sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\widehat{\varepsilon}_{t-i}| + \sum_{k=1}^{K} \sum_{j'=0}^{J'} \beta_{kj'} A_{k,t-j'} + \ln u_t, \tag{4}$$

where the left-hand-side variable, $\ln|\widehat{\varepsilon}_t|$, is the logarithm of the absolute value of the residual of equation (2), and $\sigma_{d(t)}$ is the daily volatility of 10-minute returns t over the day, which captures the long-run persistence effects (Andersen and Bollerslev, 1998). We compare two estimators of $\sigma_{d(t)}$, namely one-day-ahead generalized autoregressive, conditionally heteroskedastic GARCH(2,2) predictions from a model fitted to a longer sample of daily data (Andersen et al., 2003), and the average of 10-minute absolute return innovations

[7] For other applications of this approach, see Andersen, Bollerslev, and Cai (2000); Bollerslev, Cai, and Song (2000); Dominguez (2006); and Wongswan (2006).

[8] The alternative, one-stage approach requires estimating a large set of GARCH parameters in a simultaneous model of intraday returns and volatility. That approach has been used in studies that focus on the impact of a narrow set of announcements or news intensity. The latter is often proxied by the number of headlines arriving on Bloomberg or Reuters screens. For examples of the one-stage approach, see Chang and Taylor (1998 and 2003), Gau and Hua (2007), DeGennaro and Shrieves (1997) and Melvin and Yin (2000).

[9] See Mandelbrot (1963) for an early discussion of volatility clustering, i.e. the tendency for large (small) return innovations to be followed by other large (small) return innovations, Bollerslev (2001) for an overview of the time-varying volatility studies.

Table 2: Macroeconomic News Announcements

	Brazil		Mexico		Russia		Turkey		U.S.		Germany	
	Obs.	*Exp.*	*Obs.*	*Exp.*	*Obs.*	*Exp.*	*Obs.*	*Exp.*	*Obs.*	*Exp.*	*Obs.*	*Exp.*
GDP	5	5	5	5	7	7	5	5	11	11	6	6
Industrial production	16	16	14	14	16	16	15	15	16	16	17	17
Personal consumption									16	16		
Investment			16	16	14	14						
Current account	14	13			5	0	14	14	5	5	17	17
Trade balance	67	16	24	22	42	33	15	15	17	17	51	51
Public budget balance	15	15	14	14	15	0			17	17		
Net debt & reserves	15	15			15	15						
Durable goods orders									16	16		
Factory orders									17	17	17	17
Capacity utilization							16	15	16	16		
Inventories									17	17		
Retail sales	14	14	13	13	14	14	13	0	17	17	16	16
Personal spending									16	16		
Personal income					14	14			16	16		
Consumer credit	11	0							16	16		
Construction									17	17		
Housing indicators									60	55		
Economic indicator			13	13					16	16	16	16
Industry indices									51	51	51	51
Consumer confidence			14	14			13	0	16	16		
CPI	336	288	23	23	64	55	15	15	32	32	32	32
PPI					14	14	15	15	15	15	33	30
Real wages					14	13						
Unemployment	12	12	13	13	14	14	16	12	88	88	16	16
Interest rate	9	9	13	13			15	15	8	7	17	17

Notes: The table provides a summary of the macroeconomic news announcements included in the study and the total number of releases (*Obs.*) and market expectations (*Exp.*). For Brazil, trade balance includes separate series of weekly and monthly releases; CPI: Getúlio Vargas Foundation (FGV) Market General Price Index (final and preliminary), FGV Prices General Index–Internal Availability, FGV Consumer Price Index, Foundation Institute for Economic Research (FIPE) Consumer Price Index (weekly and monthly), Brazilian Institute of Geography and Statistics (IBGE) National Consumer Price Index, and IBGE Amplified Consumer Price Index. Private bank lending is used instead of consumer credit. Net debt & reserves report the net debt. For Mexico, trade balance and CPI include separate series of preliminary and final releases. For Russia, CPI includes separate series of month-on-month, year-on-year, and year-to-date CPI, and core CPI; trade balance: imports, exports, and trade balance. Disposable income is used instead of personal income. Net debt & reserves report the reserves. For Turkey, tourist arrivals are used instead of retails sales. For the U.S., GDP includes separate series of advance and preliminary releases; personal consumption: advance, preliminary, and final releases; housing indicators: building permits, housing starts, new home sales, and the S&P/ Case-Shiller index; industry indices: the ISM Manufacturing and Non-Manufacturing indices; CPI: consumer and core consumer price indices; unemployment: initial jobless claims and nonfarm payroll. The interest rate is the Federal Open Market Committee target interest rate. For Germany, PPI includes separate series of producer and wholesale price index releases; trade balance: imports, exports, and trade balance; industry indices: the Purchasing Manager Manufacturing and Services indices, and the ZEW Financial Expert Survey. The interest rate is the European Central Bank interest rate. *Sample period:* October 1, 2006 – February 20, 2008. *Data source:* Bloomberg.

over the previous day. We choose the latter estimator because it fits the data better, as judged by the AIC and BIC statistics. Finally, the short-run persistence effects, or autoregressive, conditionally heteroskedastic (ARCH) effects, are estimated using the lags of $\ln|\widehat{\varepsilon}_t|$. As above, the ARCH lag length $I^{'}$ and the response length $J^{'}$ are determined using model selection criteria. The key in estimating equation (4) is to ensure that the fitted volatility innovations $\widehat{u}_t$ are i.i.d. random variables, that is, without any autocorrelation or heteroskedasticity. As discussed below, these assumptions are satisfied in our data set in the multiplicative model. Also, we use the heteroskedasticity- and autocorrelation-consistent (HAC) standard errors to ensure robustness of the standard errors. The HAC standard errors are obtained using the Newey-West procedure (Newey and West, 1987), with the Newey-West lag truncation $L = trun\left(\frac{1}{2}\left(T \cdot N\right)^{\frac{1}{3}}\right)$. Finally, we use the reciprocal of the fitted volatility series as weights for the WLS estimation of the conditional mean equation (2). This allows us to use the correct standard errors when testing for the significance of news, and plotting the confidence intervals of the impulse-response functions.

To distinguish responses to news before and after the start of the financial crisis, we employ a Markov-switching vector autoregression model, MS(M)-VAR(K, p), to endogenously identify a structural change at the first two moments, i.e., to date the structural breaks in the returns and volatility of emerging market bonds. The general idea behind regime-switching models, introduced by Hamilton (1989), is that the parameters of the K-dimensional vector of return series $\mathbf{R}_t = (R_{1t}, \ldots, R_{Kt})^{'}$ depend upon a stochastic, unobservable regime variable $\theta_t = \{1, \ldots, M\}$, which defines the regime prevailing at time t. Since we assume a singular jump in the time series (i.e., no smooth adjustment via the intercept) at the start of the financial crisis (Hamilton, 1994), we specify the mean-adjusted MS(2)-VAR(4,2) process of lag order $p = 2$ and $M = 2$ regimes for $K = 4$ bond return series as

$$\mathbf{R}_t - \boldsymbol{\mu}\left(\theta_t\right) = \sum_{k=1}^{p} \mathbf{B}_k\left(\theta_t\right)\left(\mathbf{R}_{t-k} - \boldsymbol{\mu}\left(\theta_{t-k}\right)\right) + \boldsymbol{\nu}_t$$

where $\theta_t = \{1, 2\}$. In this setting, the vector of the selected sample bond returns $\mathbf{R}_t$ is conditional upon its own past values $\{\mathbf{R}_{t-j}\}_{j=1}^{\infty}$ and the (unobserved) regime variable $\theta_t = \{1, 2\}$, with $\mathbf{B}_k\left(\theta_t\right)$ denoting the matrices of the autoregressive parameters in each state θ_t and lag k. The innovation process $\boldsymbol{\nu}_t \mid \theta_t$ is assumed to be i.i.d. Gaussian with variance-covariance matrix $\Sigma\left(\theta_t\right)$. The model is linear in each regime defined by the "switching mechanism" θ_t.

A complete description of this data-generating mechanism requires specifying θ_t and its effect on $\mathbf{R}_t$. Following Hamilton (1989), we parameterize θ_t as a discrete-state, first-order Markov process with a (2×2) transition matrix $\mathbf{P} = \begin{pmatrix} p_{11} & p_{21} \\ p_{12} & p_{22} \end{pmatrix}$, $p_{i1} + p_{i2} = 1$ for each state. The transition probabilities are defined as

$$p_{ij} = \Pr\left(\theta_t = i \mid \theta_{t-1} = j, \mathbf{R}_{t-1}, \mathbf{X}_{t-1}\right) \quad \forall i, j \in \{1, 2\}$$

where $\mathbf{X}_{t-1}$ denotes a $(K \times R)$ matrix of strongly exogenous variables. We estimate θ_t by controlling for lagged changes in the U.S. government bond yield as exogenous variable. We apply our model to the standardized, daily logarithmic returns of all bonds in our sample over a time period from January 2006 to February 2008 (544 observations). We estimate a joint transition probability matrix $\mathbf{P} = \begin{pmatrix} 0.8104 & 0.7041 \\ 0.1896 & 0.2959 \end{pmatrix}$ and identify June 5, 2007 as a statistically significant date of the structural break. We find that this date coincides with first signs of rising uncertainty about asset prices and rising risk aversion as indicated by a rise in the implied volatility of equity options on several financial institutions and a brief episode of further weakening of the U.S. dollar against the most prominent "carry trade" currencies, such as the Japanese Yen and the Australian Dollar.

V. Price Dynamics in Emerging Markets

One of the key contributions of this paper is that it modifies the traditional two-stage model of returns and volatility that has been widely used for mature markets to fit the unique features of emerging bond markets by identifying the deterministic patterns in intraday returns and volatility. The deterministic component (seasonality) of volatility in equation (4), in particular, accommodates weekly and daily patterns by controlling for them through dummy variables and interaction terms while allowing for a structural break at the onset of the financial crisis. Stripping the data of the deterministic volatility pattern is methodologically superior to relying on unconditional event studies, which can lead to biased results. We find, in particular, that the additive volatility model that is common in the literature on mature markets does not fit the behavior of emerging markets as well as the multiplicative volatility model. Below, we describe in detail how we select emerging market model specification and provide a characterization of volatility patterns in these markets.

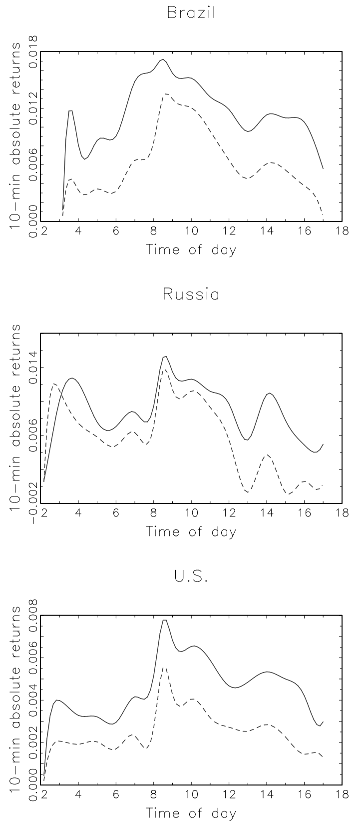
A visual inspection of volatility patterns points to some evidence of systematic weekly and daily patterns, with volatility rising during the opening hours of the U.S. markets and on Fridays. This behavior is robust to using alternative intervals (for example, five-minute returns). We thus model the intraday behavior in return volatility using cubic splines with hourly knots, adding an extra knot at 8.30 a.m. to control for the opening of the U.S. market. Separate splines are used for Mondays and Fridays to control for weekly patterns, with the largest volatility on Fridays and the least on Mondays. The mean of intraday absolute returns peaks during the U.S. market opening (see Figure 1).

Intraday volatility follows an inverse U-shaped pattern, which is characteristic of mature markets as well (see Andersen and Bollerslev, 1998, and the references therein). Given the concentration of OTC trading in New York and London, intraday patterns are comparable to those in foreign exchange markets, with spikes occurring during the U.S. and U.K. openings, particularly for euro-denominated Russian and Turkish bonds. An inspection of intraday patterns in the higher statistical moments of the data reveals that skewness and kurtosis also exhibit intraday seasonality. For example, for the Russian bond, the closing returns are negatively skewed and leptokurtic, whereas for the Turkish bond, strong positive skewness and large kurtosis are observed around closing time. The time-of-day seasonality in higher moments could reflect different liquidity levels prevalent in the financial centers, in which the bulk of trading takes place. In contrasts, in mature foreign exchange markets, trading occurs nearly continuously around the clock. The implication of diurnality in higher moments is that the additive volatility model, which works well for highly liquid mature assets (see, for example, Andersen et al., 2003), does not capture well the deterministic behavior of the emerging asset class. We use the multiplicative volatility specification instead, as per equation (4).

Intraday volatility behavior also differs before and during financial crisis (see Figure 1). Before the crisis, the U.S. market opening was associated with an increase in volatility, but differences in volatility during the openings of the U.K. and U.S. markets diminish during the crisis. Average daily volatility increased across all emerging markets during the financial crisis, pointing to increased market activity,[10] heightened uncertainty, and, possibly, weaker information efficiency. To control for differences in volatility, we include crisis interaction terms in the model.

[10] Despite falling aggregate trade volumes, as measured by the Trade Association for the Emerging Markets.

Figure 1: Intraday Volatility Patterns Before and During The Subprime Crisis



Notes: The figure graphs the intraday patterns of return volatility (defined as absolute ten-minute returns) for the U.S. ten-year Treasury note and emerging market external bonds: Brazil 2040, Mexico 2017, Russia 2030 and Turkey 2030. The dashed lines represent the intraday volatility patterns pre-crisis, and the solid lines—during the crisis. Both estimates are obtained using cubic splines with hourly knots, with an extra knot at 8.30. The beginning of the the U.S. subprime market crisis is identified as June 5, 2007. The time of the day is measured in hours since midnight, Eastern Standard Time. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

We determine the lag structure in the conditional mean equation by testing for up to six hours of autoregressive (AR) effects and for different coefficients during the financial crisis. The best model specifications are chosen based on Akaike (AIC) and Bayesian (BIC) information criteria. Whenever there is a conflict between the selection criteria, we use the F-test to decide between the two models. The ARCH structure of the stochastic volatility is determined in a similar manner as the AR structure. The best models that emerge following the tests are presented in Table 3. Further, we allow the data to determine both the length of the response to news for the conditional mean and volatility equations and any differences in the response during financial turbulence. In line with Andersen et al. (2003), we test for periods from zero minutes (i.e., without lagged response) to three hours. Guided by the AIC and BIC criteria, we uniformly choose to model the impact of news on the returns without lagged response, but allow for 30 minutes of lagged news effects in the volatility equations (i.e. $J = 0$ and $J' = 3$ for each asset). We also do not allow the individual news coefficients to change during the period of financial turbulence.

Table 3: AR-ARCH Specification

	Brazil	Mexico	Russia	Turkey	U.S.
AR	AR(9)	AR(16)*	AR(7)*	AR(8)*	AR(1)*
ARCH	ARCH(13)*	ARCH(18)*	ARCH(8)*	ARCH(18)*	ARCH(9)*

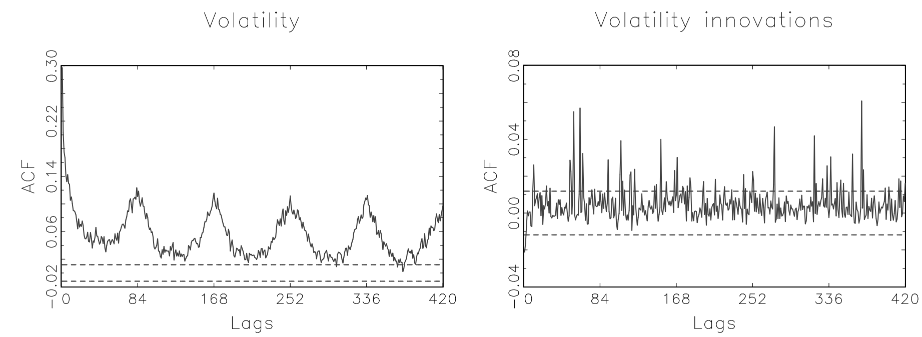
Notes: The lag structure of the conditional mean and variance equations for emerging market external bonds and the 10-year U.S. treasury note is determined within the following framework:

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \varepsilon_t,$$

$$\ln|\hat{\varepsilon}_t| = \alpha + \phi(t) + \psi\sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\hat{\varepsilon}_{t-i}| + \ln u_t,$$

where R_t is the 10-minute log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the 10-minute return t, and $\phi(t)$ is the seasonal component of intradaily and weekly effects that we allow to vary during the period of the subprime crisis. This behavior is modeled using cubic splines with hourly knots (and an extra knot for 8.30 a.m. EST). We test for up to six hours (i.e. 60 lags) of autoregressive (AR/ARCH) effects for indicators I and I' in the conditional return and volatility equations, and for different coefficients during the subprime crisis. The best model is chosen by AIC and BIC criteria. Whenever there is a conflict between these two criteria, we use the F-test to decide between the two models. This table reports the AR-ARCH specification of the models, with $*$ denoting that coefficients are allowed to change during the crisis period. *Sample period:* October 1, 2006 – February 20, 2008. The beginning of the U.S. subprime market crisis is identified as June 5, 2007. *Data sources:* Bloomberg, Tullett Prebon.

Figure 2: Autocorrelation of Ten-Minute Return Volatility and Volatility Innovations



Notes: The solid lines represent the autocorrelation function for ten-minute return volatility (left panel) and volatility innovations $\hat{u}_t = |\hat{\varepsilon}_t| / \hat{\sigma}_t^2$ (right panel) for a sample bond (Brazilian 2040 Bond). The dashed lines represent 95% confidence intervals. 84 lags correspond to one trading day and 420 lags correspond to one trading week. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

The resulting model appears well specified. On average, the correlation between the observed and the fitted volatility series is 0.35. The volatility innovation u_t is i.i.d. (see Figure 2 for an example of autocorrelation patterns in observed volatility and innovations). There is some remaining autocorrelation in residuals from equation (4), but we ensure the validity of hypothesis testing by using the heteroskedasticity- and autocorrelation-consistent standard errors.

VI. News Effects in Emerging Bond Markets

The empirical findings relate to various aspects of information absorption in emerging bond markets. We start by examining how investors reprice and reposition their investments in response to macroeconomic news as reflected in conditional mean and volatility equations. We then discuss the many nonlinearities and asymmetries in these responses, as well as evidence of cross-border spillovers—a reaction to international and regional macroeconomic news.

A. Repricing and Repositioning

Overall, we find distinctive patterns of price discovery and volatility dynamics when we compare the impulse responses for U.S. and emerging sovereign bonds. In both markets, the response of returns to U.S. news is similar in terms of magnitude and duration. However, the repricing effect is less evident for emerging bonds than the U.S. treasury bond, possibly because a consistent absorption of U.S. news is complicated by lower liquidity of emerging bond markets. The volatility response of mature and emerging markets is also similar. The only difference seems to be a more sustained effect of news on volatility in emerging markets.

There is little systematic evidence in 10-minute return data that macroeconomic surprises are causing distinctive price shifts. Moreover, there are few indicators that significantly contribute to explaining the conditional mean, and even these effects are not consistent across countries. One possible reason for this finding is that the economic interpretation of macroeconomic news is not straightforward for sovereign bond markets and, particularly, for emerging bond markets. For example, a negative surprise about a country's trade balance (i.e., a trade deficit is larger than expected) can be a sign of either strength or weakness in macroeconomic fundamentals, depending on the factors driving the deficit and the degree of external vulnerability of the country in question. Macroeconomic announcements for emerging economies also carry a larger margin of error because of the poorer quality and coverage of their statistics, as well as the more significant ongoing changes in the structure of emerging economies. At the same time, the magnitude of surprise is driven by the accuracy of macroeconomic forecasts, which tends to be weaker in an emerging market context due to less comprehensive survey coverage. In addition, short-term arbitrage trading may be less prominent in emerging bond markets than in mature bond markets due to greater price uncertainty. The response of long-term investors also could be more protracted in emerging markets, where cross-over investors holding a broad range of asset classes account for a more significant share of the investor pool than dedicated investors.

Yet it cannot be precluded that there is no evidence of price shifts in response to news simply because of the low frequency of data. Studies on mature markets show that returns react sharply to news for only the first few minutes (see Fleming and Remolona, 1999; and Andersen et al., 2007). Such an immediate and short-lived effect would not be picked up in 10-minute interval data. We therefore follow Green (2004) and undertake a simple event study with 1-minute returns, focusing on U.S. releases occurring between 8.00 and 9.00 a.m. EST. Table 4 reports the contemporaneous and total impact of surprises in U.S. news, obtained by estimating the following model:

$$R_t = \beta_0 + \beta_1 R_{t-1} + \sum_{k=1}^{K} \sum_{j=0}^{3} \beta_{kj} S_{k,t-j} + \varepsilon_t. \tag{5}$$

The contemporaneous effect denotes the percentage change in return when data about a macroeconomic indicator k is released (β_{k0}), while the total effect is calculated as the percentage change in return during four minutes ($\sum_{j=0}^{3} \beta_{kj}$)—the most significant impact of news is observed within three minutes of the announcement. Positive surprises in announcements of real activity indicators trigger price declines, as expected during a period near the peak of the economic cycle and rising price pressures. The magnitude of contemporaneous effects on returns varies between 8 and 108 basis points, in line with the empirical results of Almeida, Goodhart, and Payne (1998), who study the impact of macroeconomic announcements on deutsche mark/U.S. dollar exchange rate returns and report that payroll employment figures produce the strongest response of 30 basis points. Moreover, the direction and magnitude of responses are broadly similar for emerging and U.S. bonds (see Figure 3 for plots of the average median response of 1-minute returns to arrivals of U.S. GDP Advance statistics, core inflation reports and current account news[11]).

[11] The estimates of the impulse-response functions are obtained using Monte Carlo simulations and account for the parameter estimation uncertainty. In cases where AR and ARCH parameters are different before and during the subprime crisis period,

The effect of macroeconomic news on volatility, which reflects investors' repositioning in response to new information, is much more significant than its impact on price levels. Like Li and Engle (1998), who conclude that macroeconomic announcements are "the major source of price volatility," we find that volatility is affected by a broad range of local and global (U.S.) macroeconomic announcements. Figure 4 shows impulse-response functions for the overall impact of news, whereas Figure 5 shows the impact of local and U.S. inflation and interest rate changes. As predicted by the Admati and Pfleiderer (1988) model of intraday trading, releases of domestic and U.S. macroeconomic data increase volatility by one and a half times on average, with responses lasting for up to one and a half hours (and even longer for some types of news).

Given that the effect of macroeconomic news on bond prices, even at 10-minute returns, is negligible in both mature and emerging markets, the prolonged effect on volatility in emerging bond markets does not testify to market inefficiency, but rather to a longer (and more expensive) portfolio reallocation process owing to lower liquidity. The reaction to U.S. news is large and mostly homogeneous, notwithstanding a smaller volatility reaction in Brazilian bonds. This is explained by the fact that the U.S. dollar-denominated bonds in our sample are priced relative to the U.S. treasury bonds with similar maturities. Thus, a higher volatility impact of general news on emerging market bonds would imply a positive marginal contribution of local news to the volatility response (while the impact on conditional returns would require controlling for excess returns, measured as the difference between returns on emerging market bonds and U.S. treasuries). Indeed, domestic news triggers a more muted and more differentiated response. The volatility impact on Brazilian bonds is moderate and dissipates quickly, similar to the impact on the U.S. treasury note, whereas Turkish bonds show a protracted pickup in volatility. Interestingly, in contrast to predictions from the Admati and Pfleiderer (1988) model, Mexican and Russian markets exhibit volatility reversals. This finding is in line with the empirical results reported by DeGennaro and Shrieves (1997) that unscheduled policy news announcements (possibly in combination with lower precision of forecasts) — characteristic, in particular, for Russia in our sample—cause a decrease in volatility. The reverse effect on volatility is also reported by Li and Engle (1998) in a study of asymmetric effects of scheduled U.S. macroeconomic announcements on the treasury futures markets.

The pattern of markets' response to news is consistent across different types of indicators, for example, inflation releases. Federal Open Market Committee (FOMC) interest rate actions are uniformly inducing high volatility in U.S. dollar–denominated bonds of Brazil and Mexico, with volatility spiking two to three times higher in the first 10 minutes, even though changes in the federal funds rate are perfectly predicted over the sample period and are known to be well anticipated by market participants in general (Bernanke and Kuttner, 2005). The response of Russia's and Turkey's euro-denominated bonds to the European Central Bank's interest rate changes is visible but less pronounced. By contrast, local interest rate changes have a large, albeit delayed, effect only on Brazil's external bond. Two caveats to this finding, however, are that monetary policy rate changes in Mexico were largely absent during the observation period, and, in Russia, interest rates are not a policy instrument.

Table 5 provides a cross-sectional comparison of the average increases in volatility in response to domestic, global (U.S.), and—for Russia and Turkey—regional (German) news, controlling for other effects. The table provides the estimates of contemporaneous and total (accumulative) volatility news effects in response to key macroeconomic indicators and on average to all domestic, international and regional news. The contemporaneous effect denotes the percentage change in volatility when a fundamental k is released (β_{k0}). The total effect denotes the total percentage change in volatility over the entire observation window (40 minutes) and is calculated as $\sum_{j'=0}^{3} \beta_{kj'}$. All coefficient estimates provided in bold are significant at the 5 percent level.

The magnitudes and signs of coefficients are consistent with impulse response functions. The volatility response to domestic news is the weakest in Russia, with most coefficients being insignificant and, at times,

the dynamics of the response change. However, the differences are negligible, and thus we plot the impulse response functions using the coefficient estimates and standard errors for the crisis period only.

Table 4: Impact of Surprises in U.S. Macroeconomic News on 1-Minute Returns

	Brazil		**Mexico**		**Russia**		**Turkey**		**U.S.**	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
GDP (Adv)	-0.160	**-1.517**	-0.040	**-3.367**	-0.051	**-3.674**	0.153	**-2.511**	-0.086	**-1.453**
Personal consumption (Adv)	**-0.085**	0.135	-0.140	0.015	-0.089	-0.039	0.045	-0.441	**-0.194**	-0.047
GDP (Pre)	0.609	0.481	-0.180	1.134	**0.780**	**-1.233**	-0.191	-0.041	-0.096	0.079
Personal consumption (Pre)	0.654	0.678	-0.580	-1.202	0.251	-0.247	-0.364	-0.506	-0.091	0.130
Current account	0.639	**3.391**	0.130	1.071	-0.062	0.491	0.217	**1.267**	-0.049	-0.141
Trade balance	0.136	0.448	0.040	**-1.157**	-0.124	-0.366	0.321	-0.344	-0.022	**-0.569**
Durable goods orders	0.085	-0.269	-0.320	-1.465	**-0.157**	-1.118	-0.508	**-1.316**	-0.078	**-0.938**
Retail sales	0.117	**-2.180**	-0.490	**-3.785**	-0.171	-1.172	-0.046	**-2.368**	-0.115	**-0.869**
Personal spending	-0.405	-0.671	0.040	-0.384	-0.076	**-0.949**	0.199	-0.334	-0.044	**-0.447**
Personal income	-0.164	**-1.861**	0.210	-0.471	0.139	0.014	-0.047	0.140	0.037	-0.013
Housing starts	**0.620**	-0.627	0.690	-0.829	**0.696**	-0.074	0.044	-0.625	0.118	**-0.748**
Building permits	0.247	0.223	**-1.040**	-0.473	-0.237	-0.093	0.039	0.304	**-0.187**	0.207
CPI	0.638	**-1.181**	**-1.030**	**-1.876**	0.030	0.638	-0.219	**-1.101**	-0.111	-0.457
Core CPI	**-0.735**	**-3.802**	0.060	**-4.893**	0.012	**-3.735**	0.116	**-3.458**	-0.185	**-2.255**
PPI	-0.316	-0.553	0.130	**-4.146**	0.626	-0.243	0.118	**-1.406**	0.035	**-0.960**
Unemployment	0.030	0.523	-0.200	0.266	-0.004	**0.760**	-0.176	0.454	-0.025	**0.596**

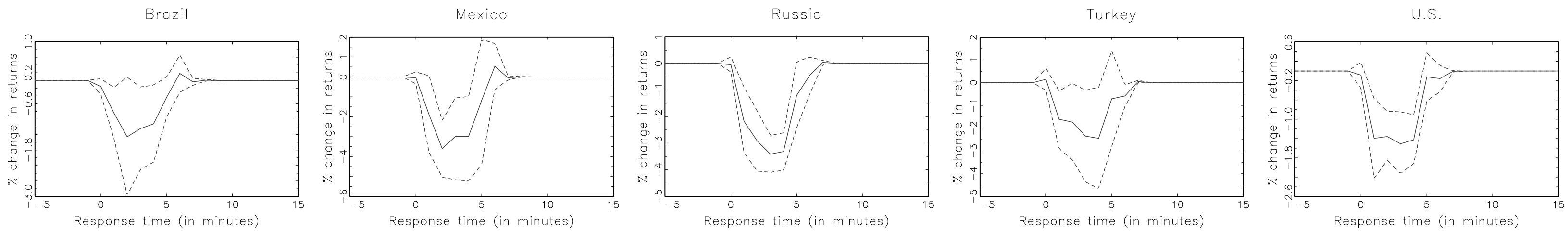
Notes: We estimate the news response model for emerging market external bonds and the 10-year U.S. treasury note,

$$R_t = \beta_0 + \beta_1 R_{t-1} + \sum_{k=1}^{K} \sum_{j=0}^{3} \beta_{kj} S_{k,t-j} + \varepsilon_t,$$

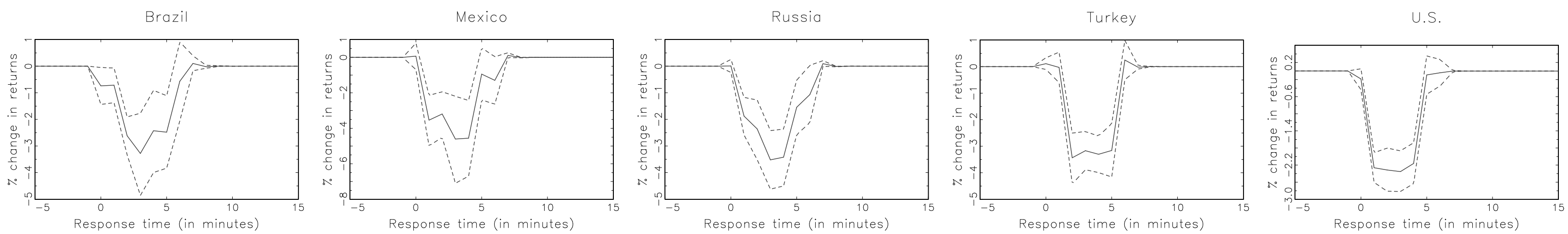
where R_t is the 1-minute log-return on quotes posted between 8.00 and 9.00 a.m. EST, and $S_{k,t}$ is the standardized news corresponding to a U.S. macroeconomic announcement k made at 8.30 a.m. EST. *ContEff* denotes the contemporaneous impact of an announcement (β_{k0}). *TotEff* denotes the total impact of an announcement over the window of 3 minutes, calculated as $\sum_{j=0}^{3} \beta_{kj}$ and tested for significance using the χ^2 Wald statistic. Coefficients provided in **bold** are significant at the 5% level, using heteroskedasticity- and autocorrelation-consistent standard errors. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

Figure 3: Price Response to Surprises in U.S. Macroeconomic News

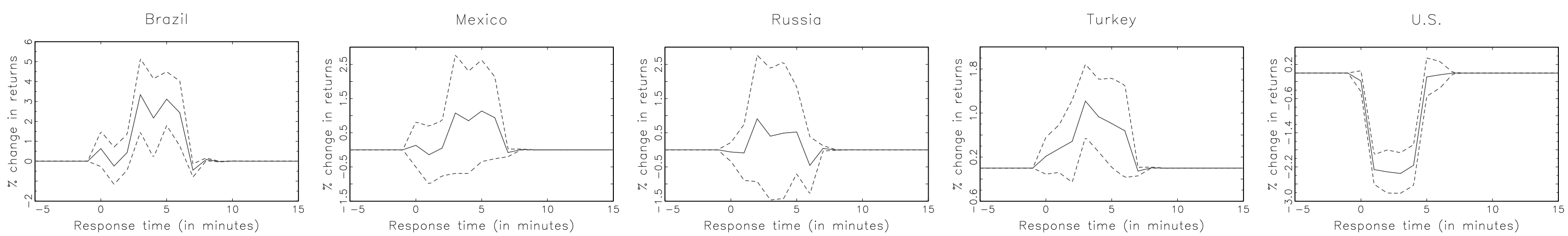
U.S. Gross Domestic Product (Advance)



U.S. Core Inflation reports



U.S. Current Account



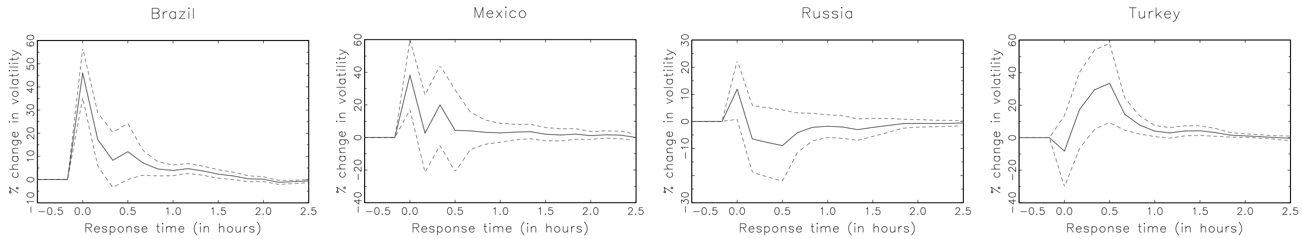
Notes: We estimate the news response model for the emerging market external bonds and U.S. ten-year Treasury note,

$$R_t \quad = \quad \beta_0 + \beta_1 R_{t-1} + \sum_{k=1}^{K} \sum_{j=0}^{3} \beta_{kj} S_{k,t-j} + \varepsilon_t,$$

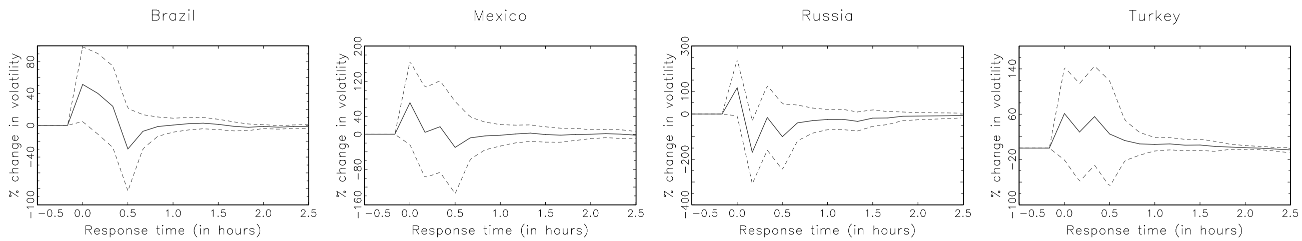
where R_t is the one-minute log-return on quotes posted between 8:00 – 9:00 EST and $S_{k,t}$ is the standardized news corresponding to an U.S. macroeconomic announcement k made at 8:30 EST. The figures present the one-minute return response to arrivals of U.S. GDP Advance statistics (top panel), core inflation reports (centre panel) and current account news (bottom panel). The solid lines represent the median percentage change in returns, and the dashed lines represent the 95% confidence intervals. The estimates are obtained using Monte Carlo simulations and account for the estimation uneceratinty. The x-axis denotes time *in minutes*, with the announcements time fixed at 0. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

Figure 4: Volatility Response to Local News Arrival

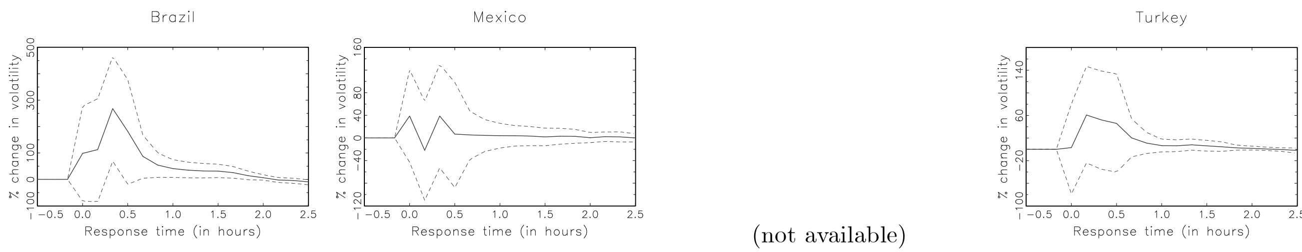
All local news



Inflation releases



Policy interest rate



(not available)

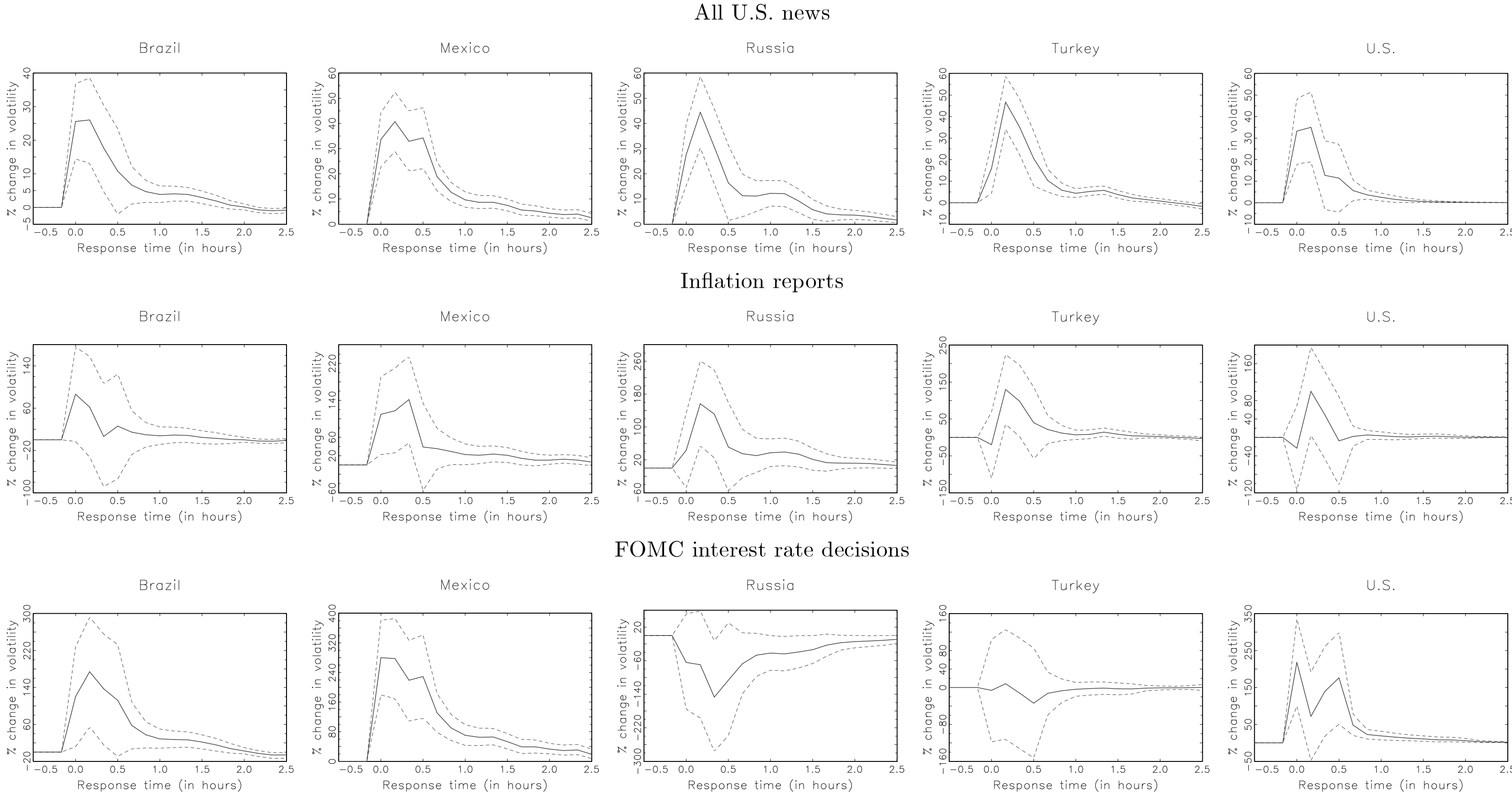
Notes: We estimate the news response model for the emerging market external bonds and U.S. ten-year Treasury note,

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \sum_{k=1}^{K} \beta_k S_{k,t} + \varepsilon_t$$

$$\ln|\hat{\varepsilon}_t| = \alpha + \phi(t) + \psi\sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\hat{\varepsilon}_{t-i}| + \sum_{k=1}^{K}\sum_{j'=0}^{3} \beta_{kj'} A_{k,t-j'} + \ln u_t$$

where R_t is the ten-minute log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the return t, and $\phi(t)$ denotes a cubic spline that estimates the intradaily and weekly seasonality. $S_{k,t}$ is the standardized news corresponding to a macroeconomic fundamental k released at time t and $A_{k,t}$ is a dummy variable indicating the release of this fundamental. The average impact of domestic news arrival on volatility is estimated within a summary model, where $A_{k,t}$ is included in both mean and volatility equations and denotes releases of grouped announcements: (a) domestic and U.S. for BZ40 and MX17 bonds, (b) domestic, U.S. and German for RU30 and TU30 bonds, and (c) U.S. only for U.S. ten-year Treasury note. The figures present the ten-minute volatility response to arrivals of all local macroeconomic news (top panel), inflation reports (centre panel) and policy interest rate decisions (bottom panel, with no meaningful monetary policy interest rates series available for Russia). The solid lines represent the median percentage change in volatility during the subprime crisis (the differences between the dynamics of the response before and during the crisis are negligible, and arise from small variations in the AR and ARCH parameters only) and the dashed lines represent the 95% confidence intervals. The estimates are obtained using Monte Carlo simulations and account for the estimation uncertainty. The x-axis denotes time *in hours*, with the announcements time fixed at 0. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

Figure 5: Volatility Response to U.S. News Arrival



Notes: We estimate the news response model for the emerging market external bonds and U.S. ten-year Treasury note,

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \sum_{k=1}^{K} \beta_k S_{k,t} + \varepsilon_t$$

$$\ln|\hat{\varepsilon}_t| = \alpha + \phi(t) + \psi\sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\hat{\varepsilon}_{t-i}| + \sum_{k=1}^{K}\sum_{j'=0}^{3} \beta_{kj'} A_{k,t-j'} + \ln u_t$$

where R_t is the ten-minute log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the return t, and $\phi(t)$ denotes a cubic spline that estimates the intradaily and weekly seasonality. $S_{k,t}$ is the standardized news corresponding to a macroeconomic fundamental k released at time t and $A_{k,t}$ is a dummy variable indicating the release of this fundamental. The average impact of U.S. news arrival on volatility is estimated within a summary model, where $A_{k,t}$ is included in both mean and volatility equations and denotes releases of grouped announcements: (a) domestic and U.S. for BZ40 and MX17 bonds, (b) domestic, U.S. and German for RU30 and TU30 bonds, and (c) U.S. only for U.S. ten-year Treasury note. The figures present the ten-minute volatility response to arrivals of all U.S. macroeconomic news (top panel), inflation reports (centre panel) and FOMC interest rate decisions (bottom panel). The solid lines represent the median percentage change in volatility during the subprime crisis (the differences between the dynamics of the response before and during the crisis are negligible, and arise from small variations in the AR and ARCH parameters only) and the dashed lines represent the 95% confidence intervals. The estimates are obtained using Monte Carlo simulations and account for the estimation uncertainty. The x-axis denotes time *in hours*, with the announcements time fixed at 0. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

Table 5: Impact of News Arrival on 10-Minute Return Volatility

	Brazil		**Mexico**		**Russia**		**Turkey**		**U.S.**	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
All Domestic News	**46.11**	**51.69**	**38.281**	36.44	11.89	-10.29	-8.20	**56.70**		
GDP	**152.09**	214.70	73.35	83.78	-58.84	-34.04	-31.60	-81.19		
Trade Balance	37.61	41.90	40.98	-155.54	**-111.64**	-252.73	-37.09	15.59		
CPI	**165.19**	**236.41**	**124.19**	**185.53**	163.97	**614.42**	61.09	113.86		
Unemployment	**72.41**	13.80	**150.09**	17.87	24.88	-46.55	**136.24**	**177.7**		
Interest Rate	98.44	**466.52**	39.21	37.34			2.80	**116.16**		
All U.S. News	**25.54**	**49.88**	**33.70**	**92.89**	**27.59**	**62.21**	**15.89**	**77.87**	**33.123**	**68.91**
GDP	**136.08**	36.24	**156.45**	**423.09**	**140.63**	**294.15**	**133.55**	**183.62**	91.43	**161.05**
Trade Balance	39.00	85.82	5.09	146.37	18.10	89.94	1.55	-28.13	-16.98	-0.11
CPI	86.21	113.47	**108.66**	**239.68**	42.66	**202.24**	-20.27	**165.89**	-23.22	92.12
Unemployment	-5.49	55.71	25.76	38.02	20.60	16.39	**40.42**	**120.14**	21.51	83.10
Interest Rate	119.71	**361.92**	**279.94**	**645**	**-63.69**	**-238.14**	-5.77	-41.10	**218.51**	**506.45**
All German News					**48.76**	39.77	-8.79	-8.89		
GDP					**277.23**	-127.58	-18.68	41.00		
Trade Balance					**93.6**	**272.08**	**83.51**	-10.32		
CPI					45.11	70.46	36.36	38.28		
Unemployment					-19.42	**-257.94**	-74.55	-59.35		
Interest Rate					-61.94	-32.24	**88.54**	63.20		

Notes: We estimate the news response model for emerging market external bonds and the 10-year U.S. treasury note:

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \sum_{k=1}^{K} \beta_k S_{k,t} + \varepsilon_t,$$

$$\ln|\hat{\varepsilon}_t| = \alpha + \phi(t) + \psi \sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\hat{\varepsilon}_{t-i}| + \sum_{k=1}^{K} \sum_{j'=0}^{3} \beta_{kj'} A_{k,t-j'} + \ln u_t,$$

where R_t is the ten-minute log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the return t, and $\phi(t)$ denotes a cubic spline that estimates the intradaily and weekly seasonality. $S_{k,t}$ is the standardized news corresponding to a macroeconomic fundamental k released at time t and $A_{k,t}$ is a dummy variable indicating the release of this fundamental. The average impact of domestic, U.S. and German news arrival on volatility is estimated within a summary model, where $A_{k,t}$ is included in both mean and volatility equations and denotes releases of grouped announcements: (a) domestic and U.S. for BZ40 and MX17 bonds, (b) domestic, U.S. and German for RU30 and TU30 bonds, and (c) U.S. only for U.S. ten-year Treasury note. For Brazil, we report the results for Getúlio Vargas Foundation (FGV) Market General Price Index (final) and monthly trade balance; for Mexico: monthly trade balance (preliminary); for U.S. and Germany: preliminary GDP. For Russia, no meaningful monetary policy interest rate series is available, whereas unemployment is simultaneously released with disposable income, investment, PPI, retail sales, and real wages. Details of other macroeconomic statistics are provided in Table 2. *ContEff* denotes the percentage change in volatility when news occurs (β_{k0}). *TotEff* denotes the total percentage change in volatility over the observation window of 40 minutes, calculated as $\sum_{j'=0}^{3} \beta_{kj'}$ and tested for significance using the $\chi^2(4)$ Wald statistic. Coefficients provided in **bold** are significant at the 5% level, using heteroskedasticity- and autocorrelation-consistent standard errors. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

even negative. One possible reason for the muted response to domestic news in Russia is that releases there occur at irregular times of the day, and, furthermore, new macroeconomic data tend to be preannounced in advance of the scheduled release date in speeches by government officials. Another possibility is that investors were less focused on domestic data releases in Russia during the period covered by the study, because at that time they perceived the economy as being resilient to external shocks and having the ability to repay external debt, thanks to high oil and gas prices. In Turkey, the volatility impact is also found to be delayed, perhaps due to a simultaneous release of several macroeconomic indicators.[12] These two results show that investors process unscheduled and/or multiple news releases slowly, in line with the learning model of Kim and Verrecchia (1991a), in which the post-announcement return volatility is lower when announcements are unanticipated or of uncertain quality. The magnitude of volatility effect in Turkey is larger compared to Russia, possibly reflecting investors' perceptions of Turkey's greater vulnerabilities. Unlike the markets for Russian and Turkish bonds, those for Brazilian and Mexican bonds react instantaneously and significantly to a gamut of domestic macroeconomic announcements.

Besides the country-specific factors discussed above, the relevance of macroeconomic information for investors is likely to depend on its general characteristics: timeliness, marginal information content, and reliability. Indicators released on a more timely, frequent basis could be seen as more relevant, as evidenced, for example, by their much stronger response to weekly releases of trade balance data in Brazil than to monthly data releases and to preview CPI data in Brazil and Mexico than to later releases. However, in some cases, even those indicators that are released late could be highly relevant for markets. For example, despite being released late in the reporting cycle, GDP appears to have a large marginal information content for emerging markets, suggesting that investors' expectations are not well guided by releases of higher-frequency data, such as those on industrial production or retail sales.[13] Perceived data reliability is also an important factor that determines market reaction. Some statistics could be subject to considerable error margins and frequent revisions, dampening market reaction to the original release.[14] In addition, the quality of analysts' forecasts has a bearing on the magnitude of surprises and hence market reaction. Providing early guidance to markets—through the publication of preliminary and advance figures, policy decision rules, and preannouncement of new data in official speeches or informal information leakage—would reduce the magnitude of surprises and market reaction.

B. Asymmetries and Nonlinearities

Finally, we test for the presence of asymmetries and nonlinearities in the process of information absorption in emerging bond markets: (*1*) Does bad news matter more than good news? (*2*) Do big surprises move markets more than small surprises? (*3*) Does macroeconomic news matter more during calm times or during financial turbulence, which, in our sample, follows the onset of the U.S. financial crisis?

Evidence from behavioral studies suggests that negative news tends to trigger a stronger response than positive news (see, for example, Gosnell, Keown, and Pinkerton, 1996; and Andersen et al., 2003). We test for asymmetric responses by regressing the return series on a set of dummy variables that are based on the direction of surprises. We then indicate releases of either positive or negative grouped announcements. We classify the fundamentals as either narrowly defined real activity statistics (GDP, industrial production, investment, and retail sales for local real activity; and GDP, industrial production, construction spending, personal consumption, personal spending, and retail sales for U.S. real activity) or inflation. In line with Bauwens, Omrane, and Giot (2005), we assume that if an announced figure for a real activity variable is larger than the market expectation and the variable contributes to economic growth, the news is classified as

[12] To disentangle individual indicators' responses to releases, we use the surprise content of releases instead of the release times. We find that surprises in PPI tend to have a more immediate impact on volatility than surprises in CPI.

[13] This contrasts with the United States, where advance GDP figures mirror earlier releases of monthly personal spending (consumption accounts for more than 70 percent of GDP in the United States). Jointly released personal income and spending indeed tend to induce significant volatility in emerging market and U.S. bonds. Hence, we do not find strong evidence that advance GDP consistently raises volatility. Yet preliminary GDP (released one month later than advance GDP), which also includes foreign trade data and revisions, does raise volatility.

[14] Examining the role of data revisions is outside the scope of this study, however.

positive; otherwise, it is classified as negative. For inflation, if an announced figure implies lower inflation, the news is classified as positive; otherwise, it is classified as negative.

In line with the previous empirical studies, we find that negative local news on real activity produces more volatility over the total observation window than positive news. Also, negative U.S. real economic shocks met with a stronger response than did positive shocks, in particular, for Mexican, Turkish and U.S. bonds. In contrast, the results for inflation news are more balanced. Positive U.S. inflation news, which may be signalling a loosening of the monetary policy stance, increasing U.S. bond prices in this future (due to lower bond issuance and/or repo activity on U.S. treasuries), and a downward foreign exchange rate pressure on the U.S. dollar, cause greater volatility in all emerging market bonds. This finding suggests that as emerging economies' bonds become more attractive investments (assuming that emerging economies' monetary policy remains unchanged), there is a significant increase in trading activity related to investors' repositioning their portfolios. Given the Mexican government's debt exchange program of peso bonds for U.S. dollar-denominated bonds (which hinges on a tigthening U.S. monetary policy and an appreciation of Mexican bonds, it is not surprising that the strong effect from positive inflation news in the U.S. on volatility is most pronounced for Mexican bonds as uncertainty about the interest rate differential between both countries renders the debt exchange program less lucractive. Negative inflation surprises could also undermine the central bank's inflation-fighting credentials and elevate benchmark interest rates in anticipation of monetary contraction.

Rigobon and Sack (2006) suggest that noisiness and measurement problems explain why the estimated response of macroeconomic announcements on asset prices is rather small. We suspect that this is particularly true for small surprises that do not cause a shift in the macroeconomic outlook in which investors believe. However, large surprises may prompt investors to reconsider their views on the outlook and reshuffle their portfolios, triggering a larger increase in volatility. This hypothesis can be tested by classifying the standardized surprise into two categories (big and small surprises) by absolute magnitude. Judging by model fit, the optimal cutoff lies between the $40th$ percentile (Brazil) and the $80th$ percentile (Mexico). We choose the $70th$ percentile to compare coefficients across countries (see Table 7). Table 7 provides some evidence that larger surprises in the U.S. data trigger a more sizable and more immediate volatility reaction than large surprises in domestic news.

With the onset of financial turbulence in June 2007, the response to U.S. macroeconomic releases has become less pronounced (see Table 8), with domestic news in Brazil and Turkey gaining in importance. Although intraday volatility has increased, the aggregate effect of U.S. surprises on volatility in emerging bond markets has become less consistent and weaker during financial turbulence. The shift in attention away from broad aggregate indicators toward specific and more timely indicators is consistent with the findings in Andritzky, Bannister, and Tamirisa (2007) for periods of emerging market crises. The striking decline in importance of U.S. macroeconomic news could also be viewed as indirect evidence of the perception of divergent growth dynamics in emerging economies and the United States during the first round of financial market turbulence in the wake of the U.S. subprime crisis covered by the study. According to market observers (and recent issues of the IMF's World Economic Outlook (WEO) and Global Financial Stability Report (GFSR) in October 2008, bonds of higher-income emerging economies have served as a safe haven from the dislocations in mature financial markets during the initial stage of the crisis .

Table 6: Impact of Positive and Negative News Arrival on 10-Minute Return Volatility

	Brazil		**Mexico**		**Russia**		**Turkey**		**U.S.**	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
Domestic news										
Positive real activity news	64.38	-36.35	**79.03**	26.95	5.68	-68.73	62.02	185.72		
Negative real activity news	113.56	**185.22**	**41.53**	80.65	**117.3**	60.90	**157.73**	137.49		
Positive inflation news	**88.31**	**74.32**	**168.50**	115.20	14.50	-77.83	13.26	24.33		
Negative inflation news	**54.03**	**80.10**	**165.73**	112.23	90.46	69.08	42.83	125.01		
U.S. news										
Positive real activity news	9.34	57.64	1.71	55.69	1.47	**134.63**	-44.77	**83.59**	23.17	-9.47
Negative real activity news	37.45	30.50	34.96	**183.67**	3.89	74.77	-3.70	**141.47**	**52.62**	**172.95**
Positive inflation news	58.36	**179.03**	**103.68**	**390.86**	66.42	**193.9**	**53.29**	**231.97**	51.02	**171.95**
Negative inflation news	26.18	80.17	**99.78**	**180.58**	-23.15	-7.58	-31.48	43.53	-17.54	83.71

Notes: We estimate the news response model for emerging market external bonds and the 10-year U.S. treasury note:

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \sum_{k \in news^{\diamond}} \beta_k A^*_{k,t} + \varepsilon_t,$$

$$\ln|\hat{\varepsilon}_t| = \alpha + \phi(t) + \psi\sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\hat{\varepsilon}_{t-i}| + \sum_{k \in news^{\diamond}} \sum_{j'=0}^{3} \beta_{kj'} A^*_{k,t-j'} + \ln u_t,$$

where R_t is the 10-minute log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the return t, and $\phi(t)$ denotes a cubic spline that estimates the intradaily and weekly seasonality. $A^*_{k,t}$ is a dummy variable indicating releases of positive or negative grouped announcements; local real activity (GDP, industrial production, investment, and retail sales) and inflation, and U.S. real activity (GDP, industrial production, construction spending, personal consumption, personal spending, and retail sales) and inflation. For real activity, if the announced macroeconomic figures are larger than the market expectations and the variable contributes to economic growth, the news is classified as positive, and negative otherwise. For inflation, if the announced figures imply less inflation, the news is classified as positive, and negative otherwise. *ContEff* denotes the percentage change in volatility when news occurs (β_{k0}). *TotEff* denotes the total percentage change in volatility over the observation window of 40 minutes, calculated as $\sum_{j'=0}^{3} \beta_{kj'}$ and tested for significance using the $\chi^2(4)$ Wald statistic. Coefficients provided in **bold** are significant at the 5% level, using heteroskedasticity- and autocorrelation-consistent standard errors. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

Table 7: Impact of Surprise News in the Upper and Lower 0.70 Quantile on 10-Minute Return Volatility

	Brazil		**Mexico**		**Russia**		**Turkey**		**U.S.**	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
Domestic news										
Lower quantile	**89.86**	**67.32**	**69.92**	**68.23**	17.71	45.67	**66.24**	**112.06**		
Upper quantile	**38.93**	**78.57**	**66.12**	21.52	69.74	-43.18	24.50	70.34		
U.S. news										
Lower quantile	8.05	**55.17**	-3.30	**72.46**	**33.13**	**69.14**	**26.68**	**106.26**	**34.53**	**95.04**
Upper quantile	**32.35**	**51.08**	**64.96**	**121.47**	**53.45**	**131.86**	**35.49**	**143.52**	**52.23**	**92.21**
German news										
Lower quantile					**117.64**	75.34	**66.92**	**89.57**		
Upper quantile					**56.34**	-17.06	**37.7**	-44.68		

Notes: We estimate the news response model for emerging market external bonds and the 10-year U.S. treasury note,

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \sum_{k \in news^*} \beta_k A^*_{k,t} + \varepsilon_t,$$

$$\ln|\hat{\varepsilon}_t| = \alpha + \phi(t) + \psi\sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\hat{\varepsilon}_{t-i}| + \sum_{k \in news^*} \sum_{j'=0}^{3} \beta_{kj'} A^*_{k,t-j'} + \ln u_t,$$

where R_t is the 10-minute log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the return t, and $\phi(t)$ denotes a cubic spline that estimates the intradaily and weekly seasonality. $A^*_{k,t}$ is a dummy variable indicating releases of grouped announcements: (1) domestic and U.S. for BZ40 and MX17 bonds, (2) domestic, U.S., and German for RU30 and TU30 bonds, and (3) U.S. only for the U.S. treasury note. For each group of announcements, we classifying the standardized surprise into two categories by absolute magnitude, with surprises in the lower 0.7 quantile defined as "small," and the others defined as "large." *ContEff* denotes the percentage change in volatility when news occurs (β_{k0}). *TotEff* denotes the total percentage change in volatility over the observation window of 40 minutes, calculated as $\sum_{j'=0}^{3} \beta_{kj'}$ and tested for significance using the $\chi^2(4)$ Wald statistic. Coefficients provided in **bold** are significant at the 5% level, using heteroskedasticity- and autocorrelation-consistent standard errors. *Sample period:* October 1, 2006 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

Table 8: Impact of News Arrival on 10-Minute Return Volatility Before and During the Subprime Crisis

	Brazil		**Mexico**		**Russia**		**Turkey**		**U.S.**	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
Domestic news										
Before crisis	-7.50	27.12	**43.17**	29.37	**21.42**	-12.52	**28.03**	**61.98**		
During crisis	**45.12**	**56.05**	23.34	38.67	8.39	-11.52	**55.76**	**83.54**		
U.S. news										
Before crisis	**47.18**	**90.68**	**46.42**	**139.84**	**41.54**	**81.37**	**14.84**	**91.15**	**26.43**	**88.94**
During crisis	5.90	7.09	**20.03**	**44.94**	**18.02**	**33.64**	**19.78**	**67.74**	**17.3**	**41.18**
German news										
Before crisis					**92.59**	**94.44**	-19.82	-5.56		
During crisis					**28.46**	10.18	**33.96**	-12.82		

Notes: We estimate the average news response model for emerging market external bonds and the 10-year U.S. treasury note,

$$R_t = \beta_0 + \sum_{i=1}^{I} \beta_i R_{t-i} + \sum_{k \in news^\dagger} \beta_k A_{k,t} + \varepsilon_t,$$

$$\ln|\hat{\varepsilon}_t| = \alpha + \phi(t) + \psi\sigma_{d(t)} + \sum_{i=1}^{I'} \beta_i \ln|\hat{\varepsilon}_{t-i}| + \sum_{k \in news^\dagger} \sum_{j'=0}^{3} \beta_{kj'} A_{k,t-j'} + \ln u_t,$$

where R_t is the 10-minute log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the return t, and $\phi(t)$ denotes a cubic spline that estimates the intradaily and weekly seasonality. $A_{k,t}$ is a dummy variable indicating releases of grouped announcements: (1) domestic and U.S. for BZ40 and MX17 bonds, (2) domestic, U.S., and German for RU30 and TU30 bonds, and (3) U.S. only for the U.S. treasury note. *ContEff* denotes percentage change in volatility when news occurs (β_{k0}). *TotEff* denotes the total impact percentage change in volatility over the window of 40 minutes, calculated as $\sum_{j'=0}^{3} \beta_{kj'}$ and tested for significance using the χ^2 Wald statistic. Coefficients provided in **bold** are significant at the 5% level, using heteroskedasticity- and autocorrelation-consistent standard errors. *Sample period before crisis:* October 1, 2006 – June 4, 2007. *Sample period during crisis:* June 5, 2007 – February 20, 2008. *Data sources:* Bloomberg, Tullett Prebon.

VII. Conclusion

This paper is among the first to provide systematic evidence of the volatility dynamics and the role of macroeconomic fundamentals in the price discovery process of emerging market bonds.

Our analysis of intraday data for selected external bonds suggests that the immediate price response to macroeconomic announcements is similar to that in mature bond markets in that it is nearly instantaneous as news is absorbed within a five-minute period. Like in mature markets, this re-pricing process is accompanied by a prolonged period of elevated trading activity as investors reposition their portfolios. However, for emerging market bonds, this process is more pronounced and drawn-out. Volatility remains elevated for more than one and a half hours after announcements—about twice as long as in mature bond markets—possibly owing to greater information asymmetries, lower liquidity, a larger share of international investors and the OTC features of external emerging markets. Even though overall volatility is consistently higher in emerging bond markets, these effects are clearly identified, while the intraday volatility pattern during the core trading hours shows similar features as in mature foreign exchange markets. Altogether, this evidence lends support to the notion that preannounced macroeconomic releases offer a window of opportunity for trading, which plays an important role in less liquid markets.

We do not find evidence that a simultaneous release of several macroeconomic indicators triggers a more pronounced volatility response than do separate releases of individual indicators, although evidence from Turkey suggests that joint releases cause a delayed response. However, it appears that market reaction weakens when indicators are released at random times during the day or do not follow a preannounced release schedule. Furthermore, we find some anecdotal evidence for the role of timeliness, marginal information content, and reliability of both data and expectation measures.

International and regional news tends to be at least as important as local news, confirming close links between emerging and mature markets and the importance of global macroeconomic fundamentals for the performance of foreign currency-denominated emerging market assets. Such systemic "news spillovers," characterized by a homogeneous pattern of responses across all emerging market bonds in the study, seem to be less pronounced in the U.S. treasury market, which tends to be driven mostly by U.S. data releases. In particular, the volatility effect of announcements related to inflation and monetary policy in the U.S. are more likely to overwhelm any local news. We also confirm strong asymmetric effects of good versus bad news, which are often observed in mature markets, and we find that U.S. macroeconomic data releases that contain large surprises have a disproportionately large impact.

Finally, we find that investors in emerging market bonds have become more uncertain about the accuracy of macroeconomic news in the wake of the U.S. financial crisis. Consequently, they shifted their attention away from releases of U.S. (and German) news, possibly based on the view that macroeconomic developments in the United States (and other mature market countries) have been driven by idiosyncratic factors - or because other types of news on financial stability have become more important. Despite a higher level of volatility and a significant increase in the number of quotes after the onset of the credit crisis, we do not identify a general change in response patterns.

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