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Macroeconomic fundamentals, price discovery, and volatility dynamics in emerging bond markets

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ABSTRACT

This study characterizes volatility dynamics in external emerging bond markets and examines how prices and volatility respond to macroeconomic news. As in mature bond markets, surprises about macroeconomic conditions in emerging markets are found to affect both conditional returns and volatility of external bonds, with the effects 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. Global and regional macroeconomic news is at least as important as local news for both price and volatility dynamics.

1. Introduction

Economic data releases form the basis of economic analysis and commentary by market participants. Analysts at brokerages and investment firms pay close attention to the daily flow of economic information, a significant part of it consisting of pre-scheduled releases of economic data and indicators. Comparing the new information against previous forecasts, and adjusting expectations for the future creates economically valuable information that investment houses and clients try to exploit in their trading decisions. Therefore, there should be a close link between the announcement of macroeconomic data and market prices fluctuations, most notably so in the minutes surrounding the scheduled data release. Thus, a better understanding of market reactions should allow market participants to fine tune their investment strategies and risk management. Besides market participants, policy makers are interested in how markets respond to macroeconomic announcements in order to design more effective communication strategies.

Studies of macroeconomic data releases in mature markets already provide a nuanced view of the impact of news. Given that macroeconomic conditions are the main determinant of the benchmark curve, government bonds are the asset class that is most directly expected to react to macroeconomic announcements (Fleming and Remolona, 1999). Empirical studies across asset classes confirm that government bonds, next to foreign exchange markets, exhibit a reaction to macroeconomic announcements that is more pronounced than for other asset classes, such as equities (Andersen et al., 2007). The effect of data releases on bond prices is almost instantaneous (Fleming and Remolona, 1999; Balduzzi et al., 2001; Andersen et al., 2007), in line with theoretical models of market microstructure (see O'Hara, 1995, and the references therein). By contrast, price volatility is often found to remain elevated for a longer period in response to news (Fleming and Remolona, 1999).

Compared to mature bond markets, few studies have examined the role of macroeconomic surprises on financial markets in emerging countries. This is a notable gap in the literature, especially given the growing importance of emerging bond markets. To our knowledge, only one study has researched intraday moves

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of emerging bond markets, focusing on the effect of advanced country news on emerging market bond spreads.[1] Using hourly data, Robitaille and Roush (2006) find significant effects of US announcement of inflation and non-farm payroll surprises as well as interest rates on Brazilian external bond spreads for up to 2 h after their release. The magnitude of the impact on spreads is roughly comparable to the yield impact on mature markets. With regard to the volatility response, evidence from daily data on a sample of 12 emerging markets by Andritzky et al. (2007) shows that days of individual releases often exhibit lower bond price volatility, except for days with interest rate actions or rating changes.

In this paper, we analyze high-frequency price discovery and volatility dynamics in emerging bond markets and examine the role of local, regional, and global macroeconomic and monetary policy announcements. We model 10-min returns and volatility using intraday data on the most liquid external emerging market bonds (Brazilian, Mexican, Russian, and Turkish) for the period from October 2006 to February 2008. In addition, we compare intraday of emerging bond markets to those of a benchmark US bond.

When examining market reaction to news, we distinguish two types of adjustment: *repricing* (the price impact) and *repositioning* (the volatility impact). *Repricing* involves a shift in asset prices as traders discern the implications of public news for the fair value of a bond, in line with the theoretical model of Kim and Verrecchia (1991b). Within this framework, 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.

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. The market microstructure literature suggests that this *repositioning* effect stems from information asymmetry between informed and liquidity traders (Admati and Pfleiderer, 1988) and investors' heterogeneity in interpreting public information (Kim and Verrecchia, 1997). In the Admati and Pfleiderer (1988) model, 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. Therefore, the news impact on volatility dominates the effect on prices, with volatility remaining at elevated levels long after prices have adjusted.

Our findings are consistent with theoretical predictions, while highlighting similarities and differences in responses of emerging and advanced market bonds to news. First, as in studies of mature bond markets (Fleming and Remolona, 1999; Balduzzi et al., 2001 and Andersen et al., 2007), we find that the initial price adjustment upon the arrival of new information is small and dissipates within minutes of the announcement. The direction and magnitude of the response are broadly similar for emerging and US bonds at very high frequencies (1-min intervals).

Second, 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 3 h after the announcement—about two times longer than in mature bond markets. This result suggests that the absorption of new information is occurring much more slowly in emerging markets than in mature markets. One possible explanation is the lower trading liquidity which leads to a stronger desire of dealers to concentrate trades (along the lines of Admati and Pfleiderer, 1988). Another explanation of the larger and more prolonged volatility response to news is the greater heterogeneity of views on macroeconomic fundamentals (Kim and Verrecchia, 1991a) in rapidly developing economies.

Third, although responses to news vary to some extent across countries and types of indicators, international news is generally at least as important as domestic news for both asset valuations and volatility dynamics in emerging markets. While the role of US news is obvious for the dollar-denominated bonds, the impact of German news on the volatility of Russian and Turkish bonds points to significant spillovers from regionally important economies. 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.

The rest of the paper is organized as follows. Section 2 describes the high-frequency data on bond prices and macroeconomic announcements and explains how the surprise content of news was measured. The intraday patterns of return volatility are discussed in Section 3, along with implications for the modeling framework in Section 4. The empirical findings are presented in Section 5. Section 6 concludes.

2. Intraday price data and announcements

The core of our dataset 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 four countries represent the top six sovereign issuers among emerging economies. Their benchmark bonds are among the most liquid and actively traded instruments in the asset class. In the last quarter of 2008, sovereign eurobonds with a daily trading volume of US$2.3 billion accounted for 18% of trading in emerging market debt instruments (Trade Association for the Emerging Markets, 2009).[2]

We compare the data for these four countries with similar, high-frequency data on a US treasury note to quantify differences between reaction of mature and emerging bond markets to news. 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 global macroeconomic data, we use announcements for the United States; for Russian and Turkish bonds we also use regional data, those for Germany. 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 US subprime market crisis, whose onset is identified as June 5, 2007 (see below). The main data source is Bloomberg.

[1] For other asset classes, a few studies provide evidence on the role of domestic versus global news in emerging markets, with mixed results for the impact on volatility. For instance, Wongswan (2006) examines high-frequency data for the Korean and Thai equity markets and finds that both global (US and Japanese) and local releases affect intraday volatility. In contrast, the results by Cai et al. (2009) suggest that US macroeconomic news have a strong impact on the returns and volatilities of exchange rates in a number of emerging economies while domestic announcements often do not.

[2] Emerging market debt trading was about US$13 billion a day at end-2008. The average daily trading volume of US treasuries alone was about US$10 billion at end-2008, according to primary dealer estimates (Trade Association for the Emerging Markets, 2009).

2.1. Intraday bond prices

We focus on the benchmark bonds for each of the four countries. The Brazilian 11% 2040 bond with an outstanding volume of US$4.2 billion is by far the most liquid emerging market bond with an annual trading volume of US$215 billion in 2007 and US$193 billion in 2008. The high liquidity of this bond is also reflected in its average bid-ask spread of US$0.12 per US$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% 2017 as the largest issue, with an outstanding amount of about US$3.5 billion and showing the lowest bid-ask spread (US$0.22). Russia's 2030 bond is the largest Russian global issue, with an outstanding amount of US$20 billion. This forms a significant weight of close to 8% in the EMBIG. It is also the second-most traded eurobond in the emerging market asset class, and trades at an average bid-ask spread of about US$0.23. Turkey's 11.875% 2030, the third-most traded emerging market eurobond, enjoys an annual trading volume of about US$80 billion. Its outstanding value is US$1.5 billion, making it the largest bond issued by Turkey, and the average bid-ask spread is reported to be US$0.42. For comparisons with mature markets' behavior, this dataset for emerging market bonds is complemented by tick-by-tick data for the corresponding on-the-run 10-year US 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 mature markets.

The primary price data on emerging market bonds are 10-min mid-quotes, where the mid-quote is an average of the bid and ask prices available on Bloomberg, one of the most widely used information systems for bond traders. Most trading in emerging market bonds takes place OTC, 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 min (see Goodhart et al., 1996). 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-min return series from quotes posted between 8.00 and 9.00 a.m. Eastern Standard Time (EST) to study the impact of surprises in US macroeconomic news.

To get the data into a form suitable for analysis, we make several adjustments to eliminate erroneous quotes. Firstly, we exclude quotes posted (1) 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); (2) on weekends; and (3) on major US and UK public holidays.[3] Secondly, we remove (1) bid and ask quotes with non-positive prices; (2) observations for which the absolute bid/ask price change is greater than 10% of the previous bid/ask price (see Huang et al., 1994); and (3) quotes posted on days with a very large fraction of zero 10-min returns (95% or more; there were 35 such days, mostly in the case of Mexico). The cleaning filters remove 0.4% of all quotes. Finally, we replace overnight returns with their unconditional means in order to remove overnight, weekend, and public holiday effects (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 summary statistics for the 1- and 10-min return series. Within our sample, the Russian and Turkish bonds are the most liquid EM 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 fourfold during the subprime crisis, to levels comparable with the liquidity in the other two bonds. The average returns are, as expected, zero for both 1- and 10-min series, with the standard deviation ranging from 0.3 basis points for 1-min US returns to 2.3 basis points for 10-min Mexican returns. Generally, the Latin American returns are the most variable. Apart from the 10-min 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 US T-note returns are the least volatile with the average absolute return equal to 0.2 basis points.

2.2. 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, 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.

Information on macroeconomic developments in a given period is released in stages: releases of high-frequency data (for example, monthly data on CPI, industrial production, and retail sales) are followed by releases of quarterly data (for example, on GDP). Many data releases follow a preannounced release schedule. 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.[4] 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 a changing schedule of 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).

2.3. Measures of surprise

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

$$S_{k,t} = \frac{\text{Actual}_{k,t} - \text{Expectation}_{k,t}}{\hat{\sigma}_k}, \quad (1)$$

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 $\hat{\sigma}_k$ is the standard deviation of all surprises ($\text{Actual}_{k,t} - \text{Expectation}_{k,t}$) for that macro-

[3] The US holidays are Martin Luther King Day, Presidents Day, Memorial Day, Independence Day, Labor Day, and Thanksgiving. The UK holidays are Easter Monday, May Day Holiday, Spring Bank Holiday, and Summer Bank Holiday. Christmas and New Year's Day are celebrated in both countries. The average number of emerging bond trades removed due to public holidays is 701, or 0.4% of the initial sample. For the US treasury notes, 4276 observations were removed, or 1.5% of the initial sample.

[4] 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-min bond returns.

Table 1
Summary statistics for 1- and 10-min bond returns.

	Brazil		Mexico		Russia		Turkey		US	
	10 min	1 min	10 min	1 min	10 min	1 min	10 min	1 min	10 min	1 min
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%	
Final sample size	27,300	19,500	24,948	17,820	29,160	19,440	29,250	19,500	30,600	20,340
Liquidity	166	18	210	25	236	29	230	26	659	55
Before crisis	60	9	129	21	188	27	170	18	561	52
During crisis	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

Note: The table reports sample sizes and summary statistics for the 10-year US 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 US and UK public holidays, and days with majority of zero 10-min returns (95% or more) are removed from the sample. For the 1-min sample only quotes posted between 8.00 and 9.00 a.m. EST are retained. Liquidity is proxied by the average number of bid/ask quotes arriving per trading day over the period November 6, 2006–February 20, 2008. The beginning of the US 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. *Sample period*: October 1, 2006–February 20, 2008. *Data sources*: Bloomberg, Tullett Prebon.

economic series over the sample period. Thus, $S_{k,t} = 2$ implies a surprise that is two standard deviations greater than zero for that particular indicator. 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, 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. Secondly, this approach facilitates the analysis of the effects of macroeconomic releases for which few analysts' forecasts are available.

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 and 256 for Brazil. Market expectations are available for at least 75% of the releases (Brazil), with virtually all new German, Mexican, and US announcements being accompanied by the corresponding survey data. The median survey is comprised of forecasts by 31 analysts on average. The largest number of analysts is surveyed in the US (61) while the least are surveyed in Russia (9). Overall, there is only a weak association of the size of a surprise with the number of analysts' forecasts, with the marginal contribution of an additional analyst smaller for emerging markets.

3. Preliminary data analysis

This section provides a preliminary investigation of our high-frequency financial data that motivates our modeling framework in Section 4. There are two data characteristics that have important implications for our modeling framework: the intraday seasonality in the volatility series and the striking structural break in the data generating process due to the onset of the subprime crisis in June 2007.

Intraday financial variables, such as volatility, bid/ask spreads, and trade frequencies, are well known for their characteristic intraday seasonality, see for example Andersen and Bollerslev (1998) and Engle and Russell (1998). Fig. 1 attests that systematic time-of-day patterns are also present in the emerging market external bonds considered in our study. A visual inspection of patterns in the return volatility (defined as absolute values of 10-min returns) highlights systematic time-of-day seasonality, with volatility rising during the opening hours of the UK and US markets (around 2 a.m. and 9 a.m. EST, respectively). We assume that the intraday behavior can be approximated by a cubic spine. Splines are piecewise polynomial smoothing functions that are often employed to model intraday seasonality in high-frequency financial data. Following Engle and Russell (1998), we set the knots at each hour and add an extra knot at 8.30 a.m. to control for the opening of the US market.

Intraday volatility of the emerging market external bonds follows an inverse U-shaped pattern, which is characteristic of mature markets as well (see Andersen and Bollerslev, 1998, and the references therein). The mean of intraday absolute returns peaks during the US market opening. 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 US and UK openings, particularly for euro-denominated Russian and Turkish bonds. We also use separate splines for Mondays and Fridays to control for some weekly patterns present in the data: Fridays seem to be the most volatile days, and Mondays the least.

Intraday volatility behavior also differs before and during financial crisis (compare the dashed and solid lines in Fig. 1, respectively). Before the crisis, the US market opening was associated with an increase in volatility, but differences in volatility during the openings of the UK and US markets diminish during the crisis.

Table 2
Macroeconomic news announcements.

	Brazil		Mexico		Russia		Turkey		US		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		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				17	17		
Net debt and 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		17	17	16	16
Personal spending									16	16		
Personal income					14	14		16	16			
Consumer credit	11								16	16		
Housing indicators									60	55		
Economic indicator			13	13					16	16	16	16
Industry indices									51	51	51	51
Consumer confidence			14	14			13		16	16		
CPI	78	77	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

Note: 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). Private bank lending is used instead of consumer credit. Net debt and 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 and reserves report the reserves. For Turkey, tourist arrivals are used instead of retails sales. For the United States, 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 is non-farm 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.

Average daily volatility increased across all emerging markets during the financial crisis, pointing to increased market activity,[5] and heightened uncertainty. To control for differences in volatility, we include separate cubic splines for the crisis period in the model.

To formally identify the start of the financial crisis, we employ a Markov-switching vector autoregression model of Hamilton (1989).[6] The model identifies June 5, 2007 as the most likely date of the structural break. 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 US dollar depreciation.

4. Two-stage modeling of returns and volatility

Following Andersen and Bollerslev (1998) and Andersen et al. (2003, 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] Let R_t be a 10-min logarithmic return for a single bond series, $t = 1,\ldots,T \cdot N$, where T is the number of calendar days in the sample and N is the number of 10-min 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 $S_{k,t}$ is defined by (1). 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 Eq. (2) would yield asymptotically consistent but inefficient estimates, because the variance of return innovations, ε_t, is time-varying. To deal with this inefficiency, we first model time-varying volatility of return innovations. We then use the reciprocal of the fitted volatility series as weights for the WLS estimation of the mean Eq. (2) and thus obtain the correct standard errors of the parameters in (2).

Absolute return residuals $|\hat{\varepsilon}_t|$ 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). The proxy for intraday volatility is assumed to follow the following multiplicative process:

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

[6] The model is a mean-adjusted, two-regime Markov-switching vector autoregression model that searches for a joint structural break in the emerging bond market data while controlling for changes in the US government bond yield. The model is estimated using daily logarithmic returns of the four external emerging bonds over a time period from January 2006 to February 2008 (544 daily observations). The detailed description of the model is not presented here for brevity but can be obtained from the authors.

[7] For other applications of this approach, see Andersen et al. (2000), Bollerslev et al. (2000) and Wongswan (2006).

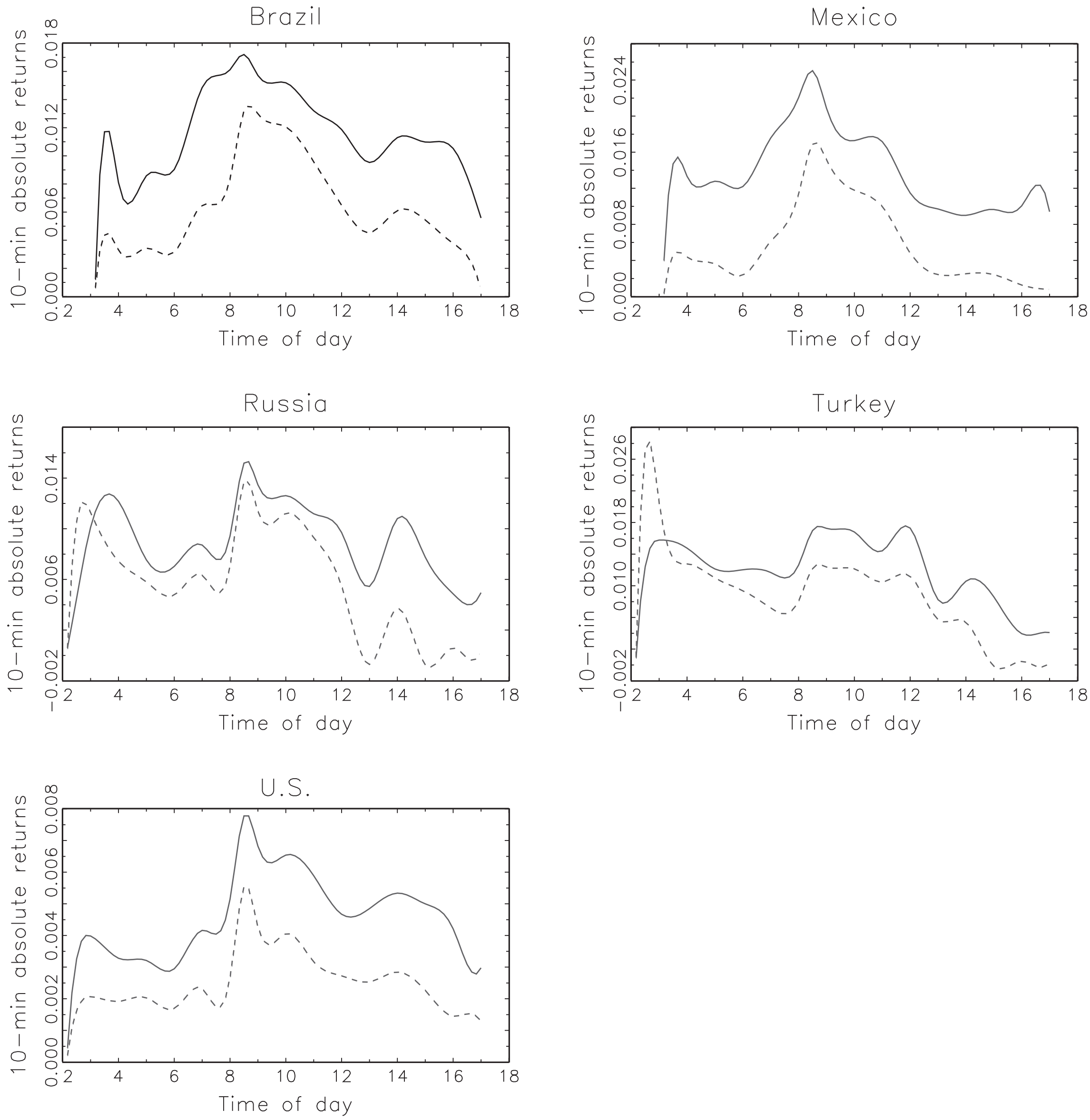

Fig. 1. Intraday volatility patterns before and during the subprime crisis. *Note*: The figure graphs the intraday patterns of return volatility (defined as absolute 10-min returns) for the US 10-year treasury note and emerging market external bonds: Brazil 2040, Mexico 2017, Russia 2030, and Turkey 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 US 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.

$$|\hat{\varepsilon}_t| = h(\text{deterministic volatility}) \cdot g(\text{stochastic volatility}) \cdot u_t, \quad (3)$$

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. As mentioned above, this behavior is modeled using cubic splines $\phi(t)$ with hourly knots and an extra knot for 8.30 a.m. EST. The stochastic volatility is assumed to be a function of the short- and long-run persistence effects, and announcements effects. More specifically, the functional form of Eq. (3) is

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

where the left-hand-side variable, $\ln|\hat{\varepsilon}_t|$, is the logarithm of the absolute value of the residual of Eq. (2), $A_{k,t-j'}$ is the announcement dummy for macroeconomic indicator k at time t, and $\sigma_{d(t)}$ is the daily volatility over the day containing the 10-min return t that captures the long-run persistence effects (Andersen and Bollerslev, 1998). We proxy $\sigma_{d(t)}$ with the average of 10-min absolute return innovations over the previous day, i.e. $d(t-1)$.[8] Finally, the short-run persistence effects, or autoregressive conditionally heteroskedastic (ARCH) effects, are estimated using the lags of $\ln|\hat{\varepsilon}_t|$. As above, the ARCH lag length I' and the response length J' are determined using model selection criteria.

We determine the lag structure in the conditional mean equation by testing for up to 6 h of autoregressive (AR) effects and for

[8] We also tried to proxy $\sigma_{d(t)}$ with one-day-ahead predictions from a daily generalized autoregressive conditionally heteroskedastic GARCH (2,2) model, as advocated by Andersen et al. (2003). We chose the estimator based on the average of 10-min absolute return innovations over the previous day $d(t-1)$ because it fits the data better, as judged by the AIC and BIC statistics.

different coefficients during the financial crisis, choosing the best model specifications based on the 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. The lag lengths for the emerging market bonds are much larger than for the US treasury note. This suggests a more pronounced interdependence of the emerging market bonds, possibly mirroring a longer volatility response to news arrival.

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 0 min (i.e., without lagged response) to 3 h. 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 min 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.

The key in estimating Eq. (4) is to ensure that the fitted volatility innovations $\hat{u}_t$ are i.i.d. random variables, that is, without any autocorrelation or heteroscedasticity. These assumptions are broadly satisfied in our data set in the multiplicative volatility model, as per Eq. (4). In contrast, the additive volatility model that is common in the literature on mature markets (see, for example, Andersen et al. (2003, 2007)) does not capture the deterministic behavior of seasonal effects as well as the multiplicative volatility model. This is illustrated in Fig. 2 that plots autocorrelation patterns in observed volatility and volatility residuals from the two models; the multiplicative model accounts for more of the diurnal seasonality and the dynamic dependencies in the data. Still, there is some remaining autocorrelation in residuals from Eq. (4) so we ensure the robustness of the standard errors and the validity of hypothesis testing by using the heteroscedasticity- and autocorrelation-consistent (HAC) standard errors, obtained using the Newey–West procedure.

Table 3
AR–ARCH specification.

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

Note: The lag structure of the conditional mean and variance equations for emerging market external bonds and the 10-year US 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-min log-return, $\sigma_{d(t)}$ is the long memory volatility over the day containing the 10-min 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 6 h (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. At this stage, no news variables are included in the model. 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 US subprime market crisis is identified as June 5, 2007. *Data sources*: Bloomberg, Tullett Prebon.

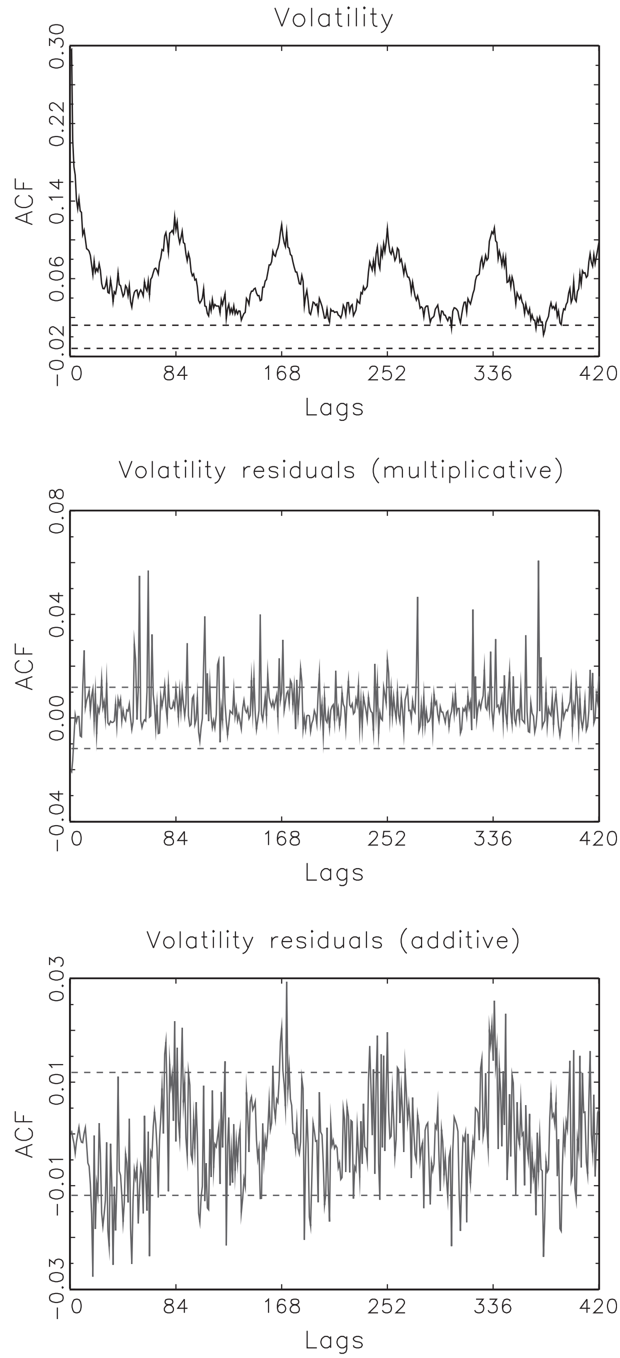

Fig. 2. Autocorrelation of 10-min return volatility and volatility residuals. *Note*: The solid lines represent the autocorrelation function for 10-min return volatility (top panel), volatility residuals $\hat{u}_t = |\hat{\varepsilon}_t|/\hat{\sigma}_t^2$ (center panel), and volatility residuals $\hat{u}_t = |\hat{\varepsilon}_t| - \hat{\sigma}_t^2$ (bottom panel) for a sample bond (Brazilian 2040 Bond). The dashed lines represent 95% confidence intervals. Eighty-four 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.

5. Emerging markets' reaction to news

We estimate the news response model for emerging market external bonds and the 10-year US treasury note as

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

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

where R_t is the 10-min log-return, $\phi(t)$ is a cubic spline that estimates the intradaily and weekly seasonality, $\sigma_{d(t)}$ is the long memory volatility over the day containing the return t, $S_{k,t}$ is the standardized news corresponding to a macroeconomic fundamental k released at time t, $A_{k,t}$ is a dummy variable indicating the release of this fundamental, and I and I' denote the autoregressive (AR/ARCH) effects, as specified in Table 3.

5.1. Impact of macroeconomic news on returns

Previous research has shown that bond prices in mature markets do not necessarily exhibit distinctive adjustments in response to new data releases (Balduzzi et al., 2001). We also do not find strong evidence for repricing effects in 10-min data. Few indicators significantly contribute to explaining the conditional mean, and even these effects are not consistent across countries. One possible reason is that the economic interpretation of macroeconomic news is ambiguous and depends on the underlying shocks, resilience of the economy, and the cyclical position (the latter has been emphasized by Goldberg and Leonard, 2003).

The lack of evidence in 10-min data does not necessarily imply that there will be no evidence in 1-min returns. Bond prices in developed markets do not always react to data releases, but when they do, prices adjust within minutes of the announcement (Fleming and Remolona, 1999). Such an immediate and short-lived effect would not be picked up in 10-min interval data. We therefore follow Green (2004) and undertake a simple event study with 1-min returns, focusing on US releases occurring between 8.00 and 9.00 a.m. EST. This time window contains a large portion of important US data releases and coincidences with highly active trading across time zones (about 10% of all quotes arrive between 8.00 and 9.00 a.m. EST).

Table 4 reports the contemporaneous and total impact of surprises in US news, obtained by estimating the following model:

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

where only the most recent lagged return is included in the model to keep the specification parsimonious while accounting for the bid/ask bounce (see Dacarogna et al. (2001), for a discussion and stylized facts). The robust standard errors are estimated using the Newey–West procedure.

The contemporaneous effect reported in Table 4 denotes the percentage change in return when data about a macroeconomic indicator k is released (β_{k0}). We also calculate the total (accumulative) effect as the percentage change in return during the total observation window. We consider window lengths of 1 min (i.e. no lagged response) to 10 min, and find that the most significant after-release impact is observed within the 3 min following an announcement. This implies that the total effect is calculated over a window of 4 min, i.e. $\left(\sum_{j=0}^{3}\beta_{kj}\right)$.

Many positive surprises in announcements of real activity indicators trigger price declines, however, more consistently so for the US treasury note than for emerging market external bonds. The direction and magnitude of responses are broadly similar for emerging and US bonds, except for current account news (Fig. 3).

5.2. Impact of news arrival on return volatility

The impact of macroeconomic news on volatility, which reflects investors' repositioning in response to new information, is much more significant than the price response. 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 international macroeconomic announcements. This is illustrated in Figs. 4 and 5, which present the 10-min volatility response to arrivals of all macroeconomic news, inflation reports, and policy interest rate decisions for domestic economies and the United States. Releases of domestic and US macroeconomic data increase volatility by one and a half times on average, with responses lasting for up to 3 h. The volatility effect is thereby more pronounced for emerging market bonds than for the US treasury note. For the US treasury note, our results are comparable to other studies which find that trading activity rises within minutes of the announcement and remains elevated for up to 90 min (Fleming and Remolona, 1999; Balduzzi et al., 2001).

The reaction of emerging market bonds to US news is strong and largely homogeneous, with the response dissipating slower than for in the US treasury market. Domestic news triggers a more muted and differentiated response. The volatility impact on Brazilian bonds is moderate and dissipates quickly, similarly to the impact on the US treasury note, whereas Turkish bonds show a lasting increase in volatility. The model of Brock and LeBaron (1996) suggests that volatility persistence is caused by lower levels of transparency and precision of an information signal. While this provides a plausible explanation in the case of emerging market data releases, it does not explain why the volatility persistence is higher for emerging market bonds than the US treasury note in response to US data releases. Given that emerging market dollar bonds are priced off the corresponding US treasury benchmark, it would be natural to expect a less immediate and more protracted adjustment. A more plausible explanation, in our view, relates to a higher degree of heterogeneity in investors' views on the impact of US macroeconomic conditions on emerging market spreads, in line with Kim and Verrecchia (1997).[9]

The pattern of markets' response to news is broadly similar across different types of indicators, for example, inflation releases. Federal Open Market Committee (FOMC) interest rate actions are inducing high volatility in the US dollar-denominated bonds of Brazil and Mexico, with volatility spiking two to three times higher in the first 10 min, 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). Despite being dollar-denominated, the response of Russia's and Turkey's bonds is insignificant or even negative. Local interest rate changes have a large, albeit delayed, effect only on the Brazilian bond. Two caveats, 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 (US), 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, global and regional news.[10] The contemporaneous effect denotes the percentage change in volatility when a macroeconomic indicator k is released (β_{k0}). The total effect denotes the total percentage change in volatility over the entire observation window (40 min) and is calcu-

[9] Interestingly, in contrast to predictions from the Admati and Pfleiderer (1988) model, the Russian bond exhibits volatility reversals. This finding can be related to the empirical results reported by DeGennaro and Shrieves (1997) that unscheduled policy news announcements—characteristic, in particular, of Russia in our sample—cause a decrease in volatility. The reverse effect on volatility was also reported by Li and Engle (1998) in a study of asymmetric effects of scheduled US macroeconomic announcements on the treasury futures markets.

[10] Coefficients for less important macroeconomic announcements, as listed in Table 2, are not presented here for brevity, but can be obtained from the authors.

Table 4
Impact of surprises in US macroeconomic news on 1-min returns.

	Brazil		Mexico		Russia		Turkey		US	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
GDP (Adv)	−0.16	**−1.52**	−0.04	**−3.37**	−0.05	**−3.67**	0.15	**−2.51**	−0.09	**−1.45**
Personal consumption (Adv)	**−0.09**	0.14	−0.14	0.02	−0.09	−0.04	0.05	−0.44	**−0.19**	−0.05
GDP (Pre)	0.61	0.48	−0.18	1.13	**0.78**	**−1.23**	−0.19	−0.04	−0.10	0.08
Personal consumption (Pre)	0.65	0.68	−0.58	−1.20	0.25	−0.25	−0.36	−0.51	−0.09	0.13
Current account	0.64	**3.39**	0.13	1.07	−0.06	0.49	0.22	**1.27**	−0.05	−0.14
Trade balance	0.14	0.45	0.04	**−1.16**	−0.12	−0.37	0.32	−0.34	−0.02	**−0.57**
Durable goods orders	0.09	−0.27	−0.32	−1.47	**−0.16**	−1.12	−0.51	**−1.32**	−0.08	**−0.94**
Retail sales	0.12	**−2.18**	−0.49	**−3.79**	−0.17	−1.17	−0.05	**−2.37**	−0.12	**−0.87**
Personal spending	−0.40	−0.67	0.04	−0.38	−0.08	**−0.95**	0.20	−0.33	−0.04	**−0.45**
Personal income	−0.16	**−1.86**	0.21	−0.47	0.14	0.01	−0.05	0.14	0.04	−0.01
Housing starts	**0.62**	−0.63	0.69	−0.83	**0.70**	−0.07	0.04	−0.63	0.12	**−0.75**
Building permits	0.25	0.22	**−1.04**	−0.47	−0.24	−0.09	0.04	0.30	**−0.19**	0.21
CPI	0.64	**−1.18**	**−1.03**	**−1.88**	0.03	0.64	−0.22	**−1.10**	−0.11	−0.46
Core CPI	**−0.74**	**−3.80**	0.06	**−4.89**	0.01	**−3.74**	0.12	**−3.46**	−0.19	**−2.26**
PPI	−0.32	−0.55	0.13	**−4.15**	0.63	−0.24	0.12	**−1.41**	0.04	**−0.96**
Unemployment	0.03	0.52	−0.20	0.27	−0.01	**0.76**	−0.18	0.45	−0.03	**0.60**

Note: We estimate the news response model for emerging market external bonds and the 10-year US 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-min 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 US macroeconomic announcement k made at 8.30 a.m. EST, $k = 1,\ldots,K$. *ContEff* denotes the contemporaneous impact of an announcement (β_{k0}). *TotEff* denotes the total impact of an announcement over the window of 4 min, 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 heteroscedasticity- and autocorrelation-consistent standard errors. *Sample period*: October 1, 2006–February 20, 2008. *Data sources*: Bloomberg, Tullett Prebon.

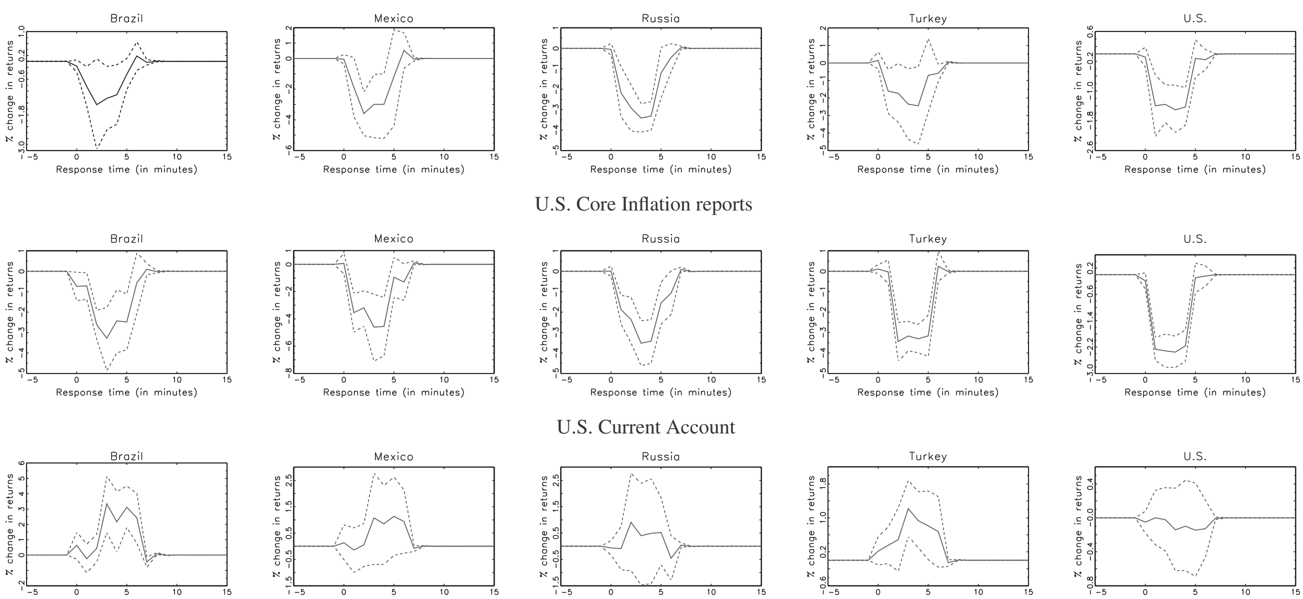

Fig. 3. Price response to surprises in US macroeconomic news. *Note*: The figures present the 1-min return response to arrivals of US GDP Advance statistics (top panel), core inflation reports (center panel), and current account news (bottom panel). The solid lines represent the median percentage change in returns, and the dashed lines represent the 95% confidence intervals. The estimates are obtained using Monte Carlo simulations based on parameter estimates reported in Table 4 and account for the estimation uncertainty. 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.

lated as $\sum_{j'=0}^{3}\beta_{kj'}$. All coefficient estimates provided in bold are significant at the 5% level.

The magnitudes and signs of coefficients are consistent with the illustrated impulse response functions. The volatility response to domestic news is the weakest in Russia, with most coefficients being insignificant and, at times, even negative. One particularity of Russia, as noted earlier, is that releases occur at irregular times. Further, new macroeconomic data tend to be preannounced in advance of the scheduled release date in speeches by government officials. In Turkey, where the volatility impact is delayed, several macroeconomic indicators are released simultaneously.[11] These two results suggest that investors process unscheduled or multiple news releases slowly, resembling the learning model of Kim and Verrecchia (1991a), in which the post-announcement return volatility is

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

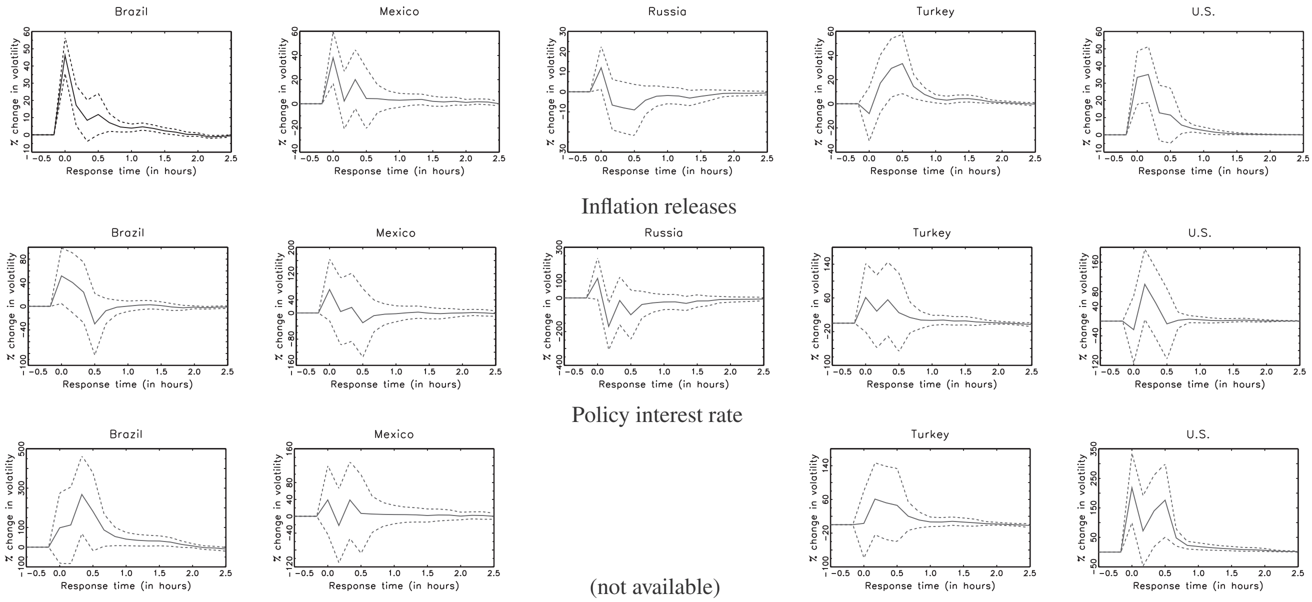

Fig. 4. Volatility response to local news arrival. *Note*: The figures present the 10-min volatility response to arrivals of all local macroeconomic news (top panel), inflation reports (center panel) and policy interest rate decisions (bottom panel, with no meaningful monetary policy interest rates series 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 based on parameter estimates reported in Table 5 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.

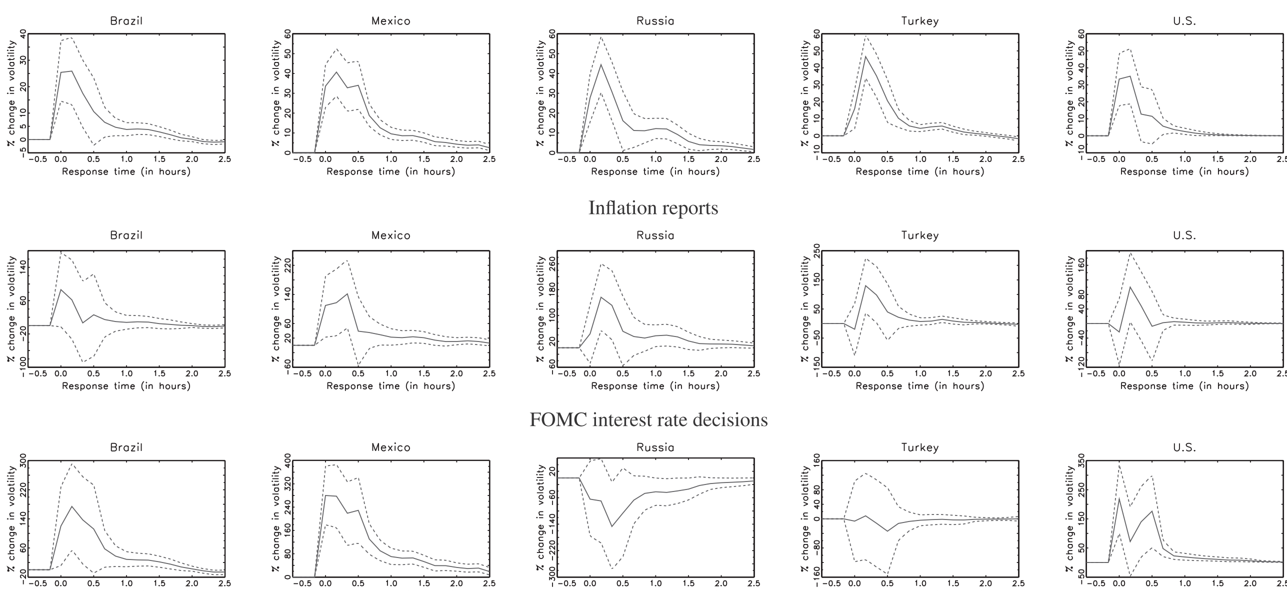

Fig. 5. Volatility response to US news arrival. *Note*: The figures present the 10-min volatility response to arrivals of all US macroeconomic news (top panel), inflation reports (center panel) and FOMC interest rate decisions (bottom panel). The solid lines represent the median percentage change in 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 based on parameter estimates reported in Table 5 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.

lower when announcements are unanticipated or of uncertain quality.

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. A careful analysis of all individual news coefficients in relation to the news releases calendar suggests that indicators released on a more timely, frequent basis might be seen as more relevant. In a study of 10-min returns in US futures markets, Veredas (2006) finds that traders show more

Table 5
Impact of news arrival on 10-min return volatility.

	Brazil		Mexico		Russia		Turkey		US	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
All domestic news	**46.11**	**51.69**	**38.28**	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**	**177.70**		
Interest rate	98.44	**466.52**	39.21	37.34			2.80	**116.16**		
All US news	**25.54**	**49.88**	**33.70**	**92.89**	**27.59**	**62.21**	**15.89**	**77.87**	**33.12**	**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**	**645.00**	**−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					**93.60**	**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		

Note: We estimate the news response model for emerging market external bonds and the 10-year US 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 10-min 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, $k = 1,\ldots,K$, and $A_{k,t}$ is a dummy variable indicating the release of this fundamental. I and I' denote the autoregressive (AR/ARCH) effects, as specified in Table 3. The average impact of domestic, US 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 US for BZ40 and MX17 bonds, (b) domestic, US and German for RU30 and TU30 bonds, and (c) US only for US 10-year treasury note. *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 min, 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 heteroscedasticity- and autocorrelation-consistent standard errors. *Sample period*: October 1, 2006–February 20, 2008. *Data sources*: Bloomberg, Tullett Prebon.

interest in macroeconomic indicators that are released more frequently—such as those of the consumer price index (CPI), employment, industrial production, and factory orders—than releases with a long delay—for example, GDP data. In the United States, Advance GDP figures mainly mirror earlier releases, such as monthly personal spending given that consumption accounts for more than 70% of GDP. Our results confirm that jointly released indicators of US personal income and spending tend to induce significant volatility in emerging market and US bonds. Hence, we do not find strong evidence that Advance GDP releases consistently raise volatility. Yet preliminary GDP (released 1 month later than Advance GDP), which also includes foreign trade data and revisions, does raise volatility. In contrast to the US, we find GDP releases to trigger larger volatility in emerging markets. In these countries, GDP appears to have a large marginal information content despite being released late in the reporting cycle, suggesting that investors' expectations are less well guided by releases of higher-frequency data.

5.3. 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 US financial crisis?

Existing evidence suggests that negative news tends to trigger a stronger response than positive news (see, for example, Gosnell et al., 1996; 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. First, 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 US real activity) or inflation. In line with Bauwens et al. (2005), 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 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. The results are reported in Table 6.

Consistent with many previous empirical studies, we find that negative local news produces more volatility over the total observation window than positive news. Also, negative US real economic news meets with a stronger response than positive news does, in particular so for Mexican, Turkish, and US bonds. In contrast, positive US inflation news causes greater volatility in all bonds.

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. The AIC and BIC criteria suggest that the optimal cutoff for our data lies between the

Table 6
Impact of positive and negative news arrival on 10-min return volatility.

	Brazil		Mexico		Russia		Turkey		US	
	ContEff	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*	*ContEff*	*TotEff*
Domestic news										
(+) Real activity	64.38	−36.35	**79.03**	26.95	5.68	−68.73	62.02	185.72		
(−) Real activity	113.56	**185.22**	**41.53**	80.65	**117.30**	60.90	**157.73**	137.49		
(+) Inflation	**88.31**	**74.32**	**168.50**	115.20	14.50	−77.83	13.26	24.33		
(−) Inflation	**54.03**	**80.10**	**165.73**	112.23	90.46	69.08	42.83	125.01		
US news										
(+) Real activity	9.34	57.64	1.71	55.69	1.47	**134.63**	−44.77	**83.59**	23.17	−9.47
(−) Real activity	37.45	30.50	34.96	**183.67**	3.89	74.77	−3.70	**141.47**	**52.62**	**172.95**
(+) Inflation	58.36	**179.03**	**103.68**	**390.86**	66.42	**193.90**	**53.29**	**231.97**	51.02	**171.95**
(−) inflation	26.18	80.17	**99.78**	**180.58**	−23.15	−7.58	−31.48	43.53	−17.54	83.71

Note: We estimate the news response model for emerging market external bonds and the 10-year US 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-min 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. I and I' denote the autoregressive (AR/ARCH) effects, as specified in Table 3. $A^*_{k,t}$ 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 US 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 min, 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 heteroscedasticity- and autocorrelation-consistent standard errors. *Sample period*: October 1, 2006–February 20, 2008. *Data sources*: Bloomberg, Tullett Prebon.

40% quantile (Brazil) and the 80% quantile (Mexico). We choose the 70% quantile to compare coefficients across countries and present the results in Table 7. The table provides some evidence that larger surprises in the US data trigger a more sizable and more immediate volatility reaction than large surprises in domestic news.

The last part of our analysis focuses on differences in response to domestic and international macroeconomic releases since the onset of financial turbulence in June 2007. These results are reported in Table 8. We find that the response to US macroeconomic releases has become less pronounced, with domestic news in Brazil and Turkey gaining in importance. Although intraday volatility has increased, the aggregate effect of US 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 et al. (2007) for periods of emerging market crises. The striking and statistically significant decline in importance of US 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

Table 7
Impact of surprise news in the upper and lower 0.70 quantile on 10-min return volatility.

	Brazil		Mexico		Russia		Turkey		US	
	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		
US 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		

Note: We estimate the news response model for emerging market external bonds and the 10-year US treasury note,

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

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

where R_t is the 10-min 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. I and I' denote the autoregressive (AR/ARCH) effects, as specified in Table 3. $A^*_{k,t}$ is a dummy variable indicating releases of grouped announcements: (1) domestic and US for BZ40 and MX17 bonds, (2) domestic, US, and German for RU30 and TU30 bonds, and (3) US only for the US 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 min, 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 heteroscedasticity- 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-min return volatility before and during the subprime crisis.

	Brazil		Mexico		Russia		Turkey		US	
	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**		
US 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**	**17.30**	**41.18**
German news										
Before crisis					**92.59**	**94.44**★	−19.82	−5.56★		
During crisis					**28.46**	10.18★	**33.96**	−12.82★		

Note: We estimate the average news response model for emerging market external bonds and the 10-year US 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-min 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. I and I' denote the autoregressive (AR/ARCH) effects, as specified in Table 3. $A_{k,t}$ is a dummy variable indicating releases of grouped announcements: (1) domestic and US for BZ40 and MX17 bonds, (2) domestic, US, and German for RU30 and TU30 bonds, and (3) US only for the US 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 min, 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 heteroscedasticity- and autocorrelation-consistent standard errors. Coefficients annotated with ☆ significantly differ between the two sample periods. *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.

period covered by the study, when bonds of higher-income emerging economies served as safe haven.

6. Conclusion

This study is among the first to provide systematic evidence of the volatility dynamics of emerging bond markets and the role of macroeconomic fundamentals in the price discovery process in these markets.

The analysis of intraday data for selected external emerging market bonds finds that the immediate price response to macroeconomic announcements is similar to that in mature markets in that it is nearly instantaneous. News is absorbed within five to 10 min and not protracted as the lower liquidity in emerging market bonds may suggest. Like mature markets, the short-lived repricing 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 drawn-out. Volatility remains elevated for more than 2 h after announcements—about twice as long as in mature bond markets. These effects are significant despite generally higher volatility in emerging bond markets, and clearly discernible from the intraday volatility pattern which shows similar features as in mature bond markets.

Global and regional news tends to be at least as important as local news for emerging bond markets, pointing to close links between emerging and mature economies and the importance of global macroeconomic fundamentals for the performance of foreign currency-denominated emerging market assets. 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. Our evidence from Turkey suggests that joint releases of several indicators cause a delayed response. It appears that market reaction weakens when indicators are released at random times during the day or do not follow a preannounced release schedule, as is the case for Russia. We also identify asymmetric effects of good versus bad news, which are often observed in mature markets. Also, US macroeconomic data releases that contain large surprises have a disproportionately large impact, while the same does not hold for local news surprises.

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