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Abstract

This paper empirically investigates the impact of changes in US real interest rates on sovereign default risk in emerging economies using the method of identification through heteroskedasticity. Policy-induced increases in US interest rates starkly raise default risk in emerging market economies. However, the overall correlation between US real interest rates and the risk of default is negative, demonstrating that the effects of other variables dominate the anterior relationship.

KEYWORDS: real interest rates; default risk; sovereign debt; identification through heteroskedasticity.

JEL CLASSIFICATION: F34, G15

*The views in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of any other person associated with the Federal Reserve System.

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1 Introduction

The theoretical economic effect of changes in US real interest rates on default risk in emerging economies has been studied by, amongst others, Guimaraes (2011) and the channel is often cited as a non-domestic driver of country risk premia (Neumeyer and Perri 2005). The mechanism runs that when US real interest rates rise, the opportunity costs to those who buy emerging economies' debt increase, which raises interest rates in emerging economies. This direct effect increases the debt burden on emerging economies, raising the risk that they will default on their debt and requiring emerging economies to offer even higher interest rates in compensation. Anecdotal evidence from the Latin American debt crisis of the 1980's and the Mexican crisis in 1994, both of which were preceded by sharp interest rate hikes in the US, suggests that this theoretical channel might be an important empirical one.

Empirically identifying this theoretical relationship is not trivial, however, owing to the usual problems of reverse causality and common omitted variables. The latter is especially problematic because US real interest rates and default risk in emerging economies are both affected by variables that cannot be easily measured, such as global market factors, risk appetite, and expectations about economic performance and the political scenario.

This paper identifies the effects of changes in US real interest rates on default risk in emerging economies using the method of identification through heteroskedasticity as set out by Rigobon (2003) and Rigobon and Sack (2004). As discussed in detail in Section 2, we take data on US real interest rates from inflation-indexed Treasury bonds, and proxy default risk using J.P. Morgan's Emerging Markets Bond Index Plus (EMBI+) premia in emerging economies over the period between 1998 and 2008. The idea behind the identification method is that there is a greater variance of changes in real interest rates on dates when the Federal Open Market Committee (FOMC) meets. The meetings of the FOMC can be seen as an extra shock to US interest rates, which have an impact on the EMBI+ premia.

The key identifying assumption is that the timing of FOMC meetings does not affect the EMBI+ premia through any channel other than the changes in real interest rates. Other shocks that directly affect the EMBI+ premia are assumed to be uncorrelated with the timing of FOMC meetings. This assumption resembles the desired characteristics of an instrument in IV regressions. However, the timing of FOMC meetings affects the variance, not the level of shocks, so a usual IV strategy cannot be employed. The methodology of identification through heteroskedasticity yields a synthetic instrument based on differences in the covariance matrices of our data between dates when the FOMC does and does not meet.

Our findings are presented in Section 3, where we show that unexpected policy-induced increases in interest rates lead to greater EMBI+ premia and, by implication, default risk in emerging economies. A 1 basis-point increase in 10-year US real interest rates raises EMBI+ premia by around 1 basis point, which means that the cost of borrowing in emerging economies rises substantially more than in the US. This confirms the hypothesised theoretical relationship between changes in US real interest rates and the risk of default and suggests that more attention ought to be paid to this relationship in the literature on default risk.

A positive correlation between default risk and US real interest rates would imply that emerging economies should issue debt contingent on US real interest rates because such a contingency would negate the increased default risk not associated with fundamental changes in emerging economies. Note, however, that this policy prescription depends not on the causal relationship between US real interest rates and the EMBI+ premium, but on the correlation between both. Omitted variables that significantly affect this correlation would also affect the performance of debt contracts contingent on US real interest rates.

In actuality, on dates when the FOMC does not meet, we observe a significant correlation with the opposite sign: changes in real interest rates are negatively related to changes in EMBI+ premia. Moreover, the overall correlation between real interest rates and the EMBI+ premium is negative: a 2 bp increase in the 10-year US real rate is on average related to a 1 bp decrease in the EMBI+. The results suggest that high real interest rates reflect favourable external conditions for emerging markets, which reduce the risk of default. This finding resonates with that of Longstaff et al. (2011), where global risk factors (proxied by US markets) are shown to be the major determinant of sovereign credit risk premia. Regardless of the precise reason for the negative correlation, the policy implication is clear: emerging economies should not issue debt contingent on US real interest rates.

Previous academic work has attempted to establish the nature of the relationship between US real interest rates and sovereign default risk by applying different methods to deal with the aforementioned endogeneity problems. Some of this work has relied on structural assumptions in vector autoregressions to identify the relationship (e.g., Uribe and Yue 2006). For our purposes, high-frequency data on financial prices can provide more information and allow for a cleaner identification strategy.[1]

[1] Uribe and Yue (2006) also study the effect of interest rates and the EMBI+ premium on variables like output,

An alternative to structural assumptions are 'traditional' instruments in IV strategies, such as in Zettelmeyer (2004), where changes in the policy rate are employed as instruments for longer-term real interest rates. This methodology also needs to assume that changes in the instrument do not affect EMBI+ premia through alternative channels. Moreover, the instruments themselves must be exogenous, which is a stronger, and therefore less desirable, assumption than that employed in this paper.

Additional studies investigate the direct effect of changes in the US federal funds target rate on emerging market spreads (Arora and Cerisola 2001). However, the theoretical relationship of interest is between default risk and the longer-term real interest rate, not the short-term nominal rate, which cannot be assumed to be endogenous. Moreover, even changes in the target rate might not be truly exogenous (see Rigobon and Sack 2004). In a more closely related exercise, Robitaille and Roush (2006) employ an event study approach using Brazilian data and find similar results to those of our paper.

2 Data and empirical methodology

Our measure of the interest rate, i, is from 10-year inflation-indexed Treasury bonds.[2] To quantify the risk of default, e, we use J.P. Morgan's Emerging Markets Bond Index Plus (EMBI+), which is comprised of medium-term debt of more than one year to maturity.[3] All data are obtained from the Global Financial Database (*www.globalfinancialdata.com*).

We want to obtain long data series with minimal concern for events that might obfuscate a potential relationship. For this reason we select emerging economies that have not defaulted, and use daily data running from January 1998 to December 2008. We are interested in how a change in the interest rate affects the EMBI+ premia, so our sample consists of values of $\Delta e_t = e_{t+1} - e_{t-1}$ and $\Delta i_t = i_{t+1} - i_{t-1}$ and is divided in two: the sub-sample C corresponds to the dates of monetary policy shocks, and the sub-sample N corresponds to dates with no shocks.[4, 5]

There are two endogeneity concerns that mean a simple ordinary least squares regression will not identify the effect of changes in US real interest rates on the risk of default (EMBI+ premia). First, changes in the EMBI+ premia can cause changes in the interest

and in that case our methodology cannot be applied.

[2] Our analysis is robust to the use of alternative measures of the real interest rate based on inflation-adjusted nominal Treasury rates of 3 months and 10 years. See Appendix A.

[3] EMBI+ tracks total returns for traded US dollar- and other external currency-denominated Brady bonds, loans, Eurobonds and local market instruments.

[4] For additional justification for using data in differences rather than levels, see Appendix B.

[5] Sub-sample C contains the dates of scheduled and unscheduled FOMC meetings and the Federal Reserve Chairman's semi-annual monetary policy testimony to Congress. For a full list of these dates, see *http://www.federalreserve.gov/monetarypolicy/fomccalendars.htm*

rate, for example, when default risk falls and in response investors switch demand from safe Treasury assets to emerging market debt. Second, and more importantly, the interest rate and the exchange rate are influenced by other common omitted variables. The following system of equations is a simple representation of both endogeneity issues[6]:

$$\Delta e_t = \alpha \Delta i_t + z_t + \eta_t \quad (1)$$

$$\Delta i_t = \beta \Delta e_t + \gamma z_t + \varepsilon_t \quad (2)$$

Where Δi_t is the change in US real interest rate; Δe_t the change in the EMBI+ premium; z_t a vector of omitted variables including, for example, external market conditions; ε_t a monetary policy shock; and η_t a shock to EMBI+.

The objective is to identify α in Equation 1. Our identification strategy is borrowed from Rigobon and Sack (2004), who show that the impact of monetary policy shocks on asset prices can be identified because the variance of shocks is substantially larger on the days in sub-sample C. Their paper used the identification strategy to establish a significant response of 10-year Treasury yields to monetary policy shocks.

That monetary policy shocks can influence 10-year real interest rates means that the variance of changes in these rates is significantly larger on the days in sub-sample C. This effect is not large, but is large enough to significantly affect the variance of Δi_t. We exploit this effect by combining it with the assumption that the policy shock to real interest rates neither affects EMBI+ through z_t nor η_t, but only through its effect on Δi.

In sum, we assume that the variance of interest rate shocks (ε_t) in sub-sample C is higher than the variance in sub-sample N; whilst the variances of η_t and z_t are the same across both sub-samples. As is usual in other identification strategies for our underlying system of equations, we assume z_t, ε_t and η_t have no serial correlation and are uncorrelated with each other. Our assumptions can be written in terms of the second moments of the shocks in the two sub-samples C and N in the following way:

$$\sigma_\varepsilon^C > \sigma_\varepsilon^N$$

$$\sigma_\eta^C = \sigma_\eta^N$$

$$\sigma_z^C = \sigma_z^N$$

To help justify the underlying assumptions, Table 1 shows the increase in the variation in the US real interest rate and the change in covariance between the real interest rate

[6] We show in Appendix C that allowing for a richer lag structure does not materially affect the results.

and EMBI+ premia over the sub-samples. The fact that the standard deviations of EMBI+ premia appear to decrease from sub-sample N to sub-sample C, when we expect mild increases, suggests that we require a more accurate statistical test of whether our assumptions on the variance of shocks over the two sub-samples are valid.[7] Applying the test set out in Levene (1960), reported in Table 2, we established that the standard deviation of the real interest rate increases significantly in sub-sample C, while the variance of EMBI+ does not significantly change because the effect of the variance increase in Equation 2 only weakly effects the variance of EMBI+ through the interest rate.[8]

Table 1: Data descriptives

	Standard deviation		Covariance with US real rate	
	Sub-sample C	Sub-sample N	Sub-sample C	Sub-sample N
US real rate	0.093	0.063	.	.
Emerging Market	24.491	29.020	0.198	-0.211
Latin America	25.017	32.317	0.278	-0.253
Brazil	30.249	48.318	0.357	-0.278
Bulgaria	24.476	27.181	0.175	-0.117
Mexico	19.221	21.876	0.066	-0.214
Panama	12.486	14.849	0.028	-0.208
Peru	20.892	20.939	0.128	-0.185
Venezuela	43.545	50.526	0.852	-0.263

Note: 131 observations in sub-sample C, 2,604 days in sub-sample N.

We are not assuming that the FOMC ignores factors that affect emerging market default risk, nor are we supposing that FOMC decisions have no impact on emerging market prices – that is actually the effect we are estimating. We are precisely assuming that FOMC decisions do not directly reveal important information about emerging markets that might otherwise affect EMBI+ premia, they are only affecting EMBI+ premia through changes in US real interest rates. The underlying view is that the Committee might have private information about how it will react to movements in emerging markets and how it plans to conduct monetary policies in general but does not know more than the market about emerging economies.

[7] We cannot apply standard tests of variance equality, because they require that the underlying data be normally distributed. As is reported in Appendix D, demonstrated through plots of each variables' quantiles against those of the normal distribution and empirical tests of skewness and kurtosis, none of our series are normally distributed.

[8] Although the test results are presented using the sample mean of the data, similar results are obtained when using the 50th percentile or 10% trimmed mean.

Table 2: Levene (1960) test of equal variance

	Test statistic based on mean	p-value
US real rate	12.371	0.000
Emerging Market	0.215	0.643
Latin America	0.458	0.499
Brazil	2.273	0.132
Bulgaria	0.000	0.977
Mexico	0.031	0.860
Panama	0.021	0.884
Peru	0.908	0.341
Venezuela	0.635	0.801

Note: Null hypothesis is equal variance

Now, consider the following variables:

$$\Delta I \equiv \left[\frac{\Delta i'_C}{\sqrt{T_C}}, \frac{\Delta i'_N}{\sqrt{T_N}}\right]'$$
$$\Delta E \equiv \left[\frac{\Delta e'_C}{\sqrt{T_C}}, \frac{\Delta e'_N}{\sqrt{T_N}}\right]'$$
$$w \equiv \left[\frac{\Delta i'_C}{\sqrt{T_C}}, \frac{-\Delta i'_N}{\sqrt{T_N}}\right]'$$

A major result in Rigobon and Sack (2004) is that α can be consistently estimated by a standard instrumental variables approach with the novel instrument, w, which is correlated with the dependent variable, ΔI, but is neither correlated with z_t nor η_t. It is correlated with ΔI because the greater variance in sub-sample C implies the positive correlation between $\left(\Delta i'_C/\sqrt{T_C}\right)$ and $\left(\Delta i'_C/\sqrt{T_C}\right)$ more than outweighs the negative correlation between $\left(\Delta i'_N/\sqrt{T_N}\right)$ and $\left(-\Delta i'_N/\sqrt{T_N}\right)$. It is neither correlated with z_t nor η_t because the positive and negative correlation of each part of the vector cancel each other out.

The usual assumption in IV regressions is that the instrument affects the dependent variable only through the regressor. The key difference here is that instead of having a variable assumed to be correlated with ε and uncorrelated with any of the other variables, we assume that the variance of ε is larger on the days in sub-sample C and the variances of other variables are the same in both sub-samples.

3 Results

Table 3 presents the results from implementing our identification strategy, which reveals that policy shocks to real interest rates are positively correlated with emerging economies' EMBI+. This coincides with our original intuition that when the US tightens monetary policy, it is harder for emerging economies to borrow, and the risk of default proxied by EMBI+ increases.

Table 3: The response of EMBI+ premia to interest rate shocks

	Co-eff	Std Err	T-stat
Emerging Market	0.868	0.179	4.840
Latin America	1.115	0.195	5.717
Brazil	1.334	0.269	4.969
Bulgaria	0.649	0.170	3.808
Mexico	0.607	0.138	4.394
Panama	0.496	0.094	5.264
Peru	0.659	0.140	4.697
Venezuela	2.279	0.318	7.162

Note: Each estimation uses 2,735 observations.

The magnitude of the response is large: an unexpected increase in the 10-year real interest rate of one basis point leads to an increase in the EMBI+ premium of a similar order of magnitude.

Table 4 shows the results from analysis of the relationship between US real interest rates and EMBI+ premia in each separate sub-sample (the results across both samples are in Table 5). Crucially, the 'normal' correlation between ΔE and ΔI is actually negative (and smaller in absolute value) in sub-sample N. Our interpretation is that increases in US real interest rates are correlated with other things that are good for emerging markets and thus decrease their cost of borrowing. Future research ought to investigate which aspects of international financial markets, correlated with US real interest rates, are most important to the risk of emerging market default.

The results in Table 3 are substantially different from the OLS estimates using only the sub-sample C presented in Table 4. While the former shows a strong positive relation, the latter shows a mild and insignificant effect. Rosa (2011) has noted that, in some applications, the results from employing the identification through heteroskedasticity methodology are not much different from a simple OLS using the subsample where the FOMC meets. That is not the case here since we are using the long-term interest rates, where endogeneity is likely to be much more important than when the policy rate is used,

Table 4: Separate analysis of sub-samples

	Sub-sample C			Sub-sample N		
	Coeff	Std Err	T-Stat	Coeff	Std Err	T-stat
Emerging Market	0.230	0.224	1.029	-0.494	0.087	-5.700
Latin America	0.317	0.228	1.390	-0.591	0.096	-6.131
Brazil	0.406	0.275	1.474	-0.649	0.145	-4.492
Bulgaria	0.217	0.226	0.960	-0.274	0.081	-3.363
Mexico	0.089	0.177	0.503	-0.500	0.065	-7.692
Panama	0.036	0.114	0.311	-0.487	0.044	-11.186
Peru	0.146	0.191	0.766	-0.430	0.062	-6.937
Venezuela	0.924	0.389	2.371	-0.617	0.151	-4.076

Note: 131 observations in sub-sample C, 2,604 days in sub-sample N.

Table 5: Full sample analysis

	Co-eff	Std Err	T-stat
Emerging Market	-0.423	0.082	-5.174
Latin America	-0.503	0.091	-5.535
Brazil	-0.547	0.135	-4.038
Bulgaria	-0.226	0.077	-2.934
Mexico	-0.443	0.062	-7.194
Panama	-0.437	0.041	-10.586
Peru	-0.375	0.059	-6.347
Venezuela	-0.467	0.143	-3.266

Note: Each estimation uses 2,735 observations.

and the correlation between variables in the N sample is different from the causal effect.

4 Concluding remarks

The strong and positive relation between exogenous changes in US real interest rates and the EMBI+ premium highlights the importance of US interest rate shocks. The fact that the overall correlation between US rates and the EMBI+ premium is negative highlights the importance of other aspects of international financial markets, such as favourable external conditions to emerging economy borrowing. From a policy perspective, our result has implications for proposals to issue debt that is contingent on exogenous factors that affect the ability to repay. One of these ideas is that a higher US real interest rate makes it more difficult for emerging market economies to repay, so reducing emerging market debt payments when US interest rates increase would be welfare improving. Our finding that the overall correlation is negative implies that making emerging market sovereign debt contingent on US real interest rates would have an opposite result from the desired effect. Research on sovereign default should note that shocks affecting foreign real interest rates might have very different effects on emerging market default risk.

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A Appendix - alternative US interest rates

In this appendix we prepare four alternative estimates of US real interest rates which are then used in place of the real rates reported in the main text as a robustness exercise.

We obtain two nominal interest rate series and two inflation measures from the Global Financial Database (*www.globalfinancialdata.com*). Both interest rate series are constant maturity, consistent with the data in the main text. We use a 3 month T-Bill rate consistent with existing quantitative studies in the literature, and a 10 year Treasury Bond rate consistent with the data in the main text because we maintain that long term rates are a more appropriate measure of the opportunity cost to investors in emerging market sovereign debt.

The first measure of inflation is based on the Bureau of Labor Statistics monthly Consumer Price Index. We obtain the annual inflation rate in the year prior to each month, and average over the previous three months' annual inflation rates to obtain a monthly estimate of future inflation. The second measure is the University of Michigan survey of annual CPI inflation expectations, which are also reported monthly. Both monthly series are assigned to the last working day of the month and subsequently cubic splined to obtain interpolated daily series of annual expected inflation.

Each gross interest rate is divided by both gross expected inflation measures and netted. Figure 1 below shows the comparison of rates over time, and Table 6 shows the cross-correlations between the series.

Tables 7 – 16 show the results from repeating the analysis described in the main text with the full sample, individual sub-samples (FOMC and non-FOMC meeting days) and applying the method of identification through heteroscedasticity for the four alternative measures of real interest rates.

When using T-Bill rates, the standard errors are generally lower but the coefficients are much smaller. There are fewer significant coefficients and the magnitudes appear to be lower (no statistical tests of differences were run). Running the analysis separately on the sub-samples shows that the coefficients on the days when the FOMC meet are again insignificant, but those days when the FOMC do not meet appear to be of smaller magnitude although they remain significantly negative.

When using T-Bond rates, the coefficients are generally of comparable magnitudes but the standard errors are much larger resulting in fewer significant positive coefficients. This is probably reflecting the fact that our measures of expected inflation are noisy when applied to daily data. All coefficients that are significant are positive.

Figure 1: US Real Interest Rates

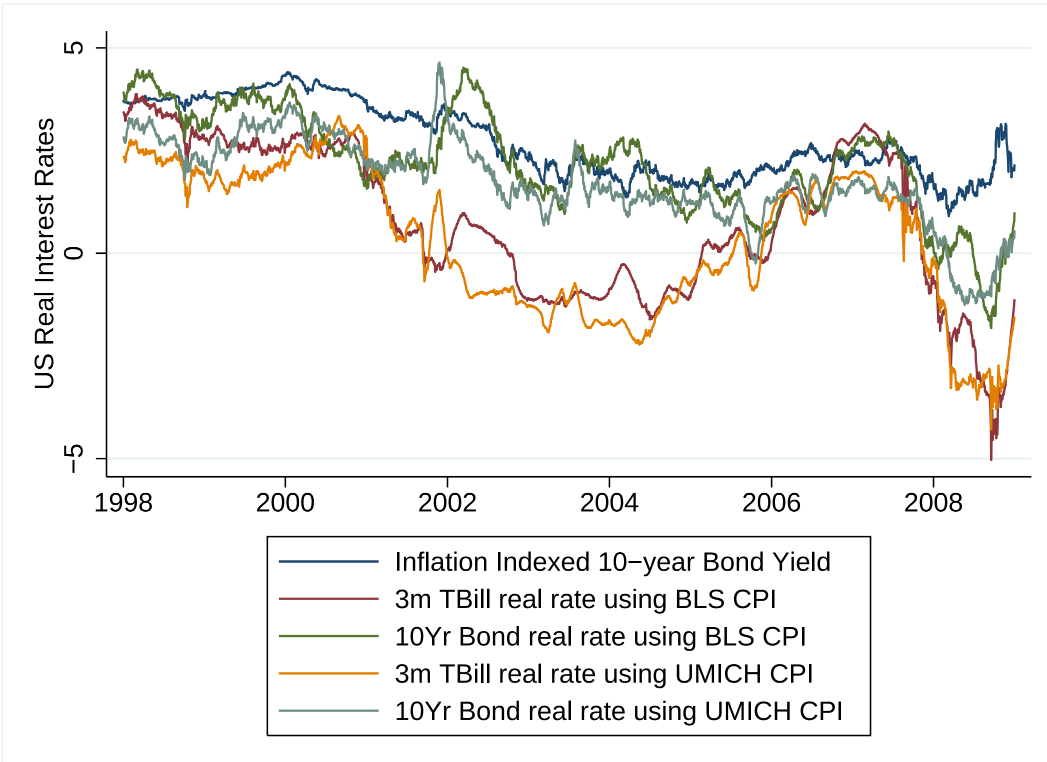

Table 6: Correlation between real interest rate measures

	TIPS Yield	T-Bill & BLS CPI	T-Bill & UMICH CPI	T-Bond & BLS CPI
T-Bill & BLS CPI	0.753	.		
T-Bill & UMICH CPI	0.766	0.936	.	
T-Bond & BLS CPI	0.763	0.769	0.620	.
T-Bond & UMICH CPI	0.846	0.710	0.745	0.862

A.1 T-Bill rates and BLS CPI inflation expectations

Table 7: Full sample analysis (T-Bill & BLS CPI)

	Co-eff	StdErr	T-stat
Emerging Market	-0.301	0.060	-4.986
Latin America	-0.332	0.067	-4.950
Brazil	-0.325	0.100	-3.248
Bulgaria	-0.147	0.058	-2.552
Mexico	-0.211	0.045	-4.688
Panama	-0.207	0.031	-6.678
Peru	-0.237	0.044	-5.419
Venezuela	-0.479	0.106	-4.539

Table 8: The response of EMBI+ premia to interest rate changes (T-Bill & BLS CPI)

	Co-eff	StdErr	T-stat
Emerging Market	0.227	0.107	2.122
Latin America	0.165	0.115	1.443
Brazil	0.199	0.160	1.244
Bulgaria	0.211	0.105	2.014
Mexico	0.177	0.081	2.174
Panama	0.114	0.055	2.078
Peru	0.224	0.084	2.677
Venezuela	0.137	0.189	0.726

Table 9: Separate analysis of FOMC and non-FOMC meeting days (T-Bill & BLS CPI)

	Sub-sample C			Sub-sample N		
	Co-eff	StdErr	T-stat	Co-eff	StdErr	T-stat
Emerging Market	-0.007	0.146	-0.045	-0.339	0.065	-5.247
Latin America	-0.055	0.148	-0.369	-0.368	0.072	-5.105
Brazil	-0.033	0.178	-0.184	-0.364	0.108	-3.358
Bulgaria	0.053	0.152	0.347	-0.173	0.062	-2.812
Mexico	0.005	0.115	0.047	-0.239	0.048	-4.970
Panama	-0.028	0.074	-0.373	-0.230	0.033	-6.934
Peru	0.019	0.125	0.154	-0.271	0.047	-5.809
Venezuela	-0.135	0.269	-0.502	-0.524	0.113	-4.639

A.2 T-Bill rates and Univ. of Michigan CPI inflation expectations

Table 10: Full sample analysis (T-Bill & UMICH CPI exp.)

	Co-eff	StdErr	T-stat
Emerging Market	-0.241	0.059	-4.117
Latin America	-0.248	0.065	-3.810
Brazil	-0.301	0.097	-3.098
Bulgaria	-0.146	0.056	-2.617
Mexico	-0.203	0.044	-4.661
Panama	-0.191	0.030	-6.343
Peru	-0.238	0.043	-5.595
Venezuela	-0.476	0.102	-4.651

Table 11: The response of EMBI+ premia to interest rate changes (T-Bill & UMICH CPI exp.)

	Co-eff	StdErr	T-stat
Emerging Market	0.282	0.112	2.513
Latin America	0.186	0.120	1.553
Brazil	0.238	0.168	1.416
Bulgaria	0.280	0.110	2.541
Mexico	0.235	0.086	2.747
Panama	0.153	0.058	2.646
Peru	0.281	0.088	3.203
Venezuela	0.224	0.199	1.126

Table 12: Separate analysis of FOMC and non-FOMC meeting days (T-Bill & UMICH CPI exp.)

	Sub-sample C			Sub-sample N		
	Co-eff	StdErr	T-stat	Co-eff	StdErr	T-stat
Emerging Market	0.038	0.145	0.263	-0.276	0.063	-4.405
Latin America	-0.016	0.147	-0.109	-0.277	0.070	-3.964
Brazil	-0.013	0.177	-0.074	-0.336	0.105	-3.214
Bulgaria	0.081	0.151	0.539	-0.174	0.059	-2.929
Mexico	0.031	0.115	0.271	-0.232	0.046	-4.994
Panama	-0.007	0.074	-0.094	-0.213	0.032	-6.642
Peru	0.040	0.124	0.318	-0.272	0.045	-6.033
Venezuela	-0.102	0.268	-0.380	-0.522	0.109	-4.783

A.3 10Yr Bond rates and BLS CPI inflation expectations

Table 13: Full sample analysis (T-Bond & BLS CPI)

	Co-eff	StdErr	T-stat
Emerging Market	-0.865	0.064	-13.484
Latin America	-0.962	0.071	-13.497
Brazil	-0.975	0.108	-8.997
Bulgaria	-0.377	0.063	-6.014
Mexico	-0.873	0.046	-18.825
Panama	-0.577	0.032	-17.893
Peru	-0.576	0.047	-12.267
Venezuela	-1.027	0.114	-8.986

Table 14: The response of EMBI+ premia to interest rate changes (T-Bond & BLS CPI)

	Co-eff	StdErr	T-stat
Emerging Market	1.316	0.509	2.586
Latin America	1.909	0.591	3.233
Brazil	2.944	0.825	3.570
Bulgaria	1.317	0.478	2.755
Mexico	0.686	0.373	1.840
Panama	0.679	0.268	2.533
Peru	0.684	0.372	1.837
Venezuela	2.682	0.905	2.963

Table 15: Separate analysis of FOMC and non-FOMC meeting days (T-Bond & BLS CPI)

	Sub-sample C			Sub-sample N		
	Co-eff	StdErr	T-stat	Co-eff	StdErr	T-stat
Emerging Market	-0.378	0.210	-1.801	-0.899	0.067	-13.453
Latin America	-0.322	0.213	-1.511	-1.007	0.074	-13.521
Brazil	-0.101	0.259	-0.389	-1.036	0.114	-9.101
Bulgaria	0.000	0.221	0.002	-0.404	0.065	-6.194
Mexico	-0.526	0.161	-3.259	-0.898	0.048	-18.615
Panama	-0.297	0.105	-2.828	-0.597	0.034	-17.758
Peru	-0.298	0.180	-1.657	-0.595	0.049	-12.251
Venezuela	-0.200	0.392	-0.510	-1.085	0.119	-9.128

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Table 16: Full sample analysis (T-Bond & UMICH CPI exp.)

	Co-eff	StdErr	T-stat
Emerging Market	-0.761	0.063	-12.149
Latin America	-0.824	0.070	-11.813
Brazil	-0.910	0.105	-8.643
Bulgaria	-0.364	0.061	-5.976
Mexico	-0.830	0.045	-18.373
Panama	-0.537	0.031	-17.056
Peru	-0.559	0.046	-12.244
Venezuela	-0.994	0.111	-8.960

Table 17: The response of EMBI+ premia to interest rate changes (T-Bond & UMICH CPI exp.)

	Co-eff	StdErr	T-stat
Emerging Market	2.144	0.807	2.656
Latin America	2.722	0.928	2.934
Brazil	4.267	1.332	3.203
Bulgaria	2.227	0.767	2.904
Mexico	1.334	0.599	2.227
Panama	1.180	0.441	2.677
Peru	1.294	0.579	2.237
Venezuela	4.266	1.458	2.925

Table 18: Separate analysis of FOMC and non-FOMC meeting days (T-Bond & UMICH CPI exp.)

	Sub-sample C			Sub-sample N		
	Co-eff	StdErr	T-stat	Co-eff	StdErr	T-stat
Emerging Market	-0.282	0.213	-1.327	-0.793	0.065	-12.166
Latin America	-0.240	0.216	-1.114	-0.862	0.073	-11.852
Brazil	-0.056	0.261	-0.215	-0.966	0.110	-8.747
Bulgaria	0.063	0.222	0.284	-0.392	0.063	-6.206
Mexico	-0.473	0.164	-2.890	-0.853	0.047	-18.217
Panama	-0.254	0.107	-2.380	-0.555	0.033	-16.975
Peru	-0.254	0.181	-1.399	-0.579	0.047	-12.279
Venezuela	-0.127	0.395	-0.321	-1.051	0.115	-9.127

B Appendix - estimation in levels

The analysis presented in this appendix is intended to justify time-differencing the data in the paper. We show that (i) there is no significant increase in the variance of the levels of the US real interest rate on the dates the FOMC meets, which is inconsistent with the fundamental assumption underpinning the methodology of identification through heteroskedasticity; and (ii) the data we use are highly persistent over time, and as a result the usual tests cannot reject a unit root. An analysis in levels would be subject to the critique that any results were spurious.

The fundamental assumption underpinning the methodology of identification is not directly testable because we cannot identify the shocks. But the best available evidence we have suggests that it is appropriate to apply the methodology in differences, but not in levels. Table 19 shows the descriptive statistics for our variables in levels using data defined to capture the level of each variable on the *day after* the FOMC meeting dates. The analysis is repeated in Table 20 using the level of variables on the *same day* as the FOMC meeting. In both cases, and similar to Table 1, there is no significant difference in the standard deviation of EMBI+ variables on the days when the FOMC meets from the days when it does not. In Table 19 there is a (weakly) significant reduction in the standard deviation of the US real interest rate on the days when the FOMC meets, and in Table 20 there is no significant change. This is not consistent with the assumption that the variance of the interest rate would significantly increase on FOMC meeting days.

Table 19: Data descriptives (levels)

	Standard deviation		Covariance with US real rate		Levene (1960) test of equal variance	
	FOMC	No FOMC	FOMC	No FOMC	mean test	p-value
US real rate	0.885	0.898	.	.	2.717	0.066
Emerging Market	314.595	319.333	194.756	202.617	0.103	0.749
Latin America	296.342	295.865	124.524	127.392	0.037	0.847
Brazil	421.413	418.673	153.673	156.705	0.078	0.780
Bulgaria	302.345	313.245	223.860	238.411	0.449	0.503
Mexico	180.834	184.149	114.845	120.151	0.183	0.668
Panama	119.021	120.635	61.070	63.281	0.009	0.924
Peru	217.518	213.622	124.616	123.782	0.032	0.858
Venezuela	381.318	386.208	130.639	152.410	0.008	0.927

Notes: Levene (1960) test statistic based on mean; null hypothesis is equal variance
FOMC means the set of days immediately after FOMC meetings

Table 21 shows the results from tests of stationarity on the variables in levels and

Table 20: Data descriptives (levels)

	Standard deviation		Covariance with US real rate		Levene (1960) test of equal variance	
	FOMC	No FOMC	FOMC	No FOMC	mean test	p-value
US Real Rate	0.883	0.898	.	.	0.668	0.414
Emerging Market	314.952	319.314	194.621	202.629	0.070	0.792
Latin America	298.070	295.774	123.374	127.455	0.054	0.816
Brazil	426.906	418.392	151.228	156.836	0.091	0.764
Bulgaria	309.204	312.911	227.779	238.222	0.096	0.757
Mexico	182.428	184.070	115.595	120.116	0.147	0.702
Panama	120.181	120.577	61.350	63.272	0.018	0.893
Peru	216.637	213.664	123.413	123.843	0.018	0.894
Venezuela	379.584	386.308	130.098	152.424	0.003	0.953

Notes: Levene (1960) test statistic based on mean; null hypothesis is equal variance
FOMC means the set of days on which FOMC meetings are held

first differences. Both tests include a constant but no trend term; the Phillips-Perron specification includes seven Newey-West lags.

The variables in levels are all non-stationary. Identical specifications for the differenced time-series employed in the paper show they are stationary. We conclude that it is more appropriate to specify the model in terms of differences than in levels.

Table 21: Stationarity test statistics

	Levels		First Differences	
	Phillips-Perron	Dickey-Fuller	Phillips-Perron	Dickey-Fuller
US real rate	-1.32	-1.28	-24.36	-25.14
Emerging Market	-1.11	-1.03	-22.70	-23.83
Latin America	-1.49	-1.46	-23.32	-24.66
Brazil	-2.84	-2.80	-22.36	-23.47
Bulgaria	-1.60	-1.59	-25.08	-25.26
Mexico	-1.51	-1.50	-23.05	-24.31
Panama	-0.88	-0.59	-24.74	-25.27
Peru	-1.95	-1.92	-25.21	-25.58
Venezuela	-0.44	-0.29	-25.50	-26.43

Notes: Null hypothesis is stationarity in all unit root tests
Phillips-Perron specifications use seven Newey-West lags
Critical values are -3.43 (1%); -2.86 (5%); -2.57 (10%)

C Appendix - dynamic model

This appendix reports the results from a dynamic specification of the model, as an investigation of dynamic effects, for example overshooting, in the reaction of the EMBI+ spread to changes in US real interest rates[9]. We maintain the definition of the variables as in the main text, i.e. $\Delta X_t \equiv X_{t+1} - X_{t-1}$, but re-specify the model as follows:

$$\text{Table 22:} \qquad \Delta E_t = \underbrace{\alpha_1 \Delta I_t}_{instrumented} + \alpha_2 \Delta I_{t-2} + \alpha_3 \Delta E_{t-2}$$

$$\text{Table 23:} \qquad \Delta e_t = \alpha_1 \Delta i_t + \alpha_2 \Delta i_{t-2} + \alpha_3 \Delta e_{t-2}$$

The Tables below should be compared with Tables 3 and 5 in the main text. Following the notation in the main text, the instruments employed in the 2SLS estimates of dynamic model in Table 22 are w, ΔI_{t-2}, and ΔE_{t-2}.

We find that in general the coefficients on the lags in both specifications were statistically insignificant and conclude that there is no systematic evidence of dynamic effects present in the data.

Table 22: Identification via heteroscedasticity dynamic analysis

	Co-efficients			Standard Error			T-statistic		
	US RR	L.US RR	L.DV	US RR	L.US RR	L.DV	US RR	L.US RR	L.DV
E. Market	0.96	0.00	7.34	0.17	0.00	6.50	5.57	2.56	1.13
L Am.	1.23	0.00	4.26	0.19	0.00	7.08	6.52	0.37	0.60
Brazil	1.48	0.00	2.49	0.26	0.00	9.81	5.69	0.17	0.25
Bulgaria	0.69	0.00	8.56	0.16	0.00	6.21	4.17	0.48	1.38
Mexico	0.68	0.00	6.18	0.13	0.00	4.99	5.15	1.55	1.24
Panama	0.54	-0.00	2.57	0.09	0.00	3.46	5.91	-0.01	0.74
Peru	0.73	0.00	5.22	0.13	0.00	5.05	5.43	1.66	1.04
Venezuela	2.28	0.00	-1.24	0.31	0.00	11.76	7.33	4.82	-0.11

Notes: DV – dependent variable – EMBI+ premium.

US RR – US real interest rate.

Each estimation uses 2,611 observations.

[9]We gratefully acknowledge this follows the suggestion of an anonymous referee.

Table 23: Full sample dynamic analysis

	Co-efficients			Standard Error			T-statistic		
	US RR	L.US RR	L.DV	US RR	L.US RR	L.DV	US RR	L.US RR	L.DV
E. Market	-0.39	-0.02	0.04	0.08	0.08	0.02	-4.64	-0.25	2.00
L. Am.	-0.47	-0.06	0.00	0.09	0.09	0.02	-5.00	-0.68	0.06
Brazil	-0.49	-0.16	0.00	0.14	0.14	0.02	-3.53	-1.11	0.13
Bulgaria	-0.20	0.17	-0.03	0.08	0.08	0.02	-2.49	2.12	-1.65
Mexico	-0.41	-0.03	0.00	0.06	0.06	0.02	-6.63	-0.47	0.19
Panama	-0.42	-0.06	0.01	0.04	0.04	0.02	-9.91	-1.39	0.75
Peru	-0.36	0.03	0.07	0.06	0.06	0.02	-6.02	0.51	3.67
Venezuela	-0.47	-0.13	0.03	0.15	0.15	0.02	-3.18	-0.88	1.27

Notes: DV – dependent variable – EMBI+ premium.

US RR – US real interest rate.

Each estimation uses 2,611 observations.

D Appendix - tests of variance

The increase in the variation in the US real interest rate and the change in covariance between the real interest rate and EMBI+ premia over the sub-samples are apparent from Table 1 in the main text, but the fact that the standard deviations of EMBI+ premia appear to decrease from sub-sample N to sub-sample C, when we expect mild increases, suggests we require a more accurate statistical test of whether our assumptions on the variance of shocks over the two sub-samples are valid.

Importantly, however, we cannot apply standard tests of variance equality, because they require that the underlying data be normally distributed. As the plots of each variables' quantiles against those of the normal distribution in Figure 2 demonstrate, and the empirical tests of skewness and kurtosis confirm in Table 24, none of our series are normally distributed.

Levene (1960) provides a test where the null is equal variance when samples are drawn from a distribution that is not Gaussian normal. The results from this test are presented in Table 25, and show that the variance of the US real interest rate significantly increases, but the variance of all EMBI+ premia does not change significantly.[10]

On the basis of these results, we conclude that the standard deviation of the real interest rate increases significantly on the days when the variance of interest rate movements is greater. We cannot reject the null that the variance of EMBI+ is the same in both sub-samples. According to our assumptions, the policy shocks should yield only

[10] The results are presented using the sample mean of the data, similar results are obtained when using the 50th percentile or 10% trimmed mean.

Figure 2: Q-Q plots of each variable quantiles against normal distribution quantiles

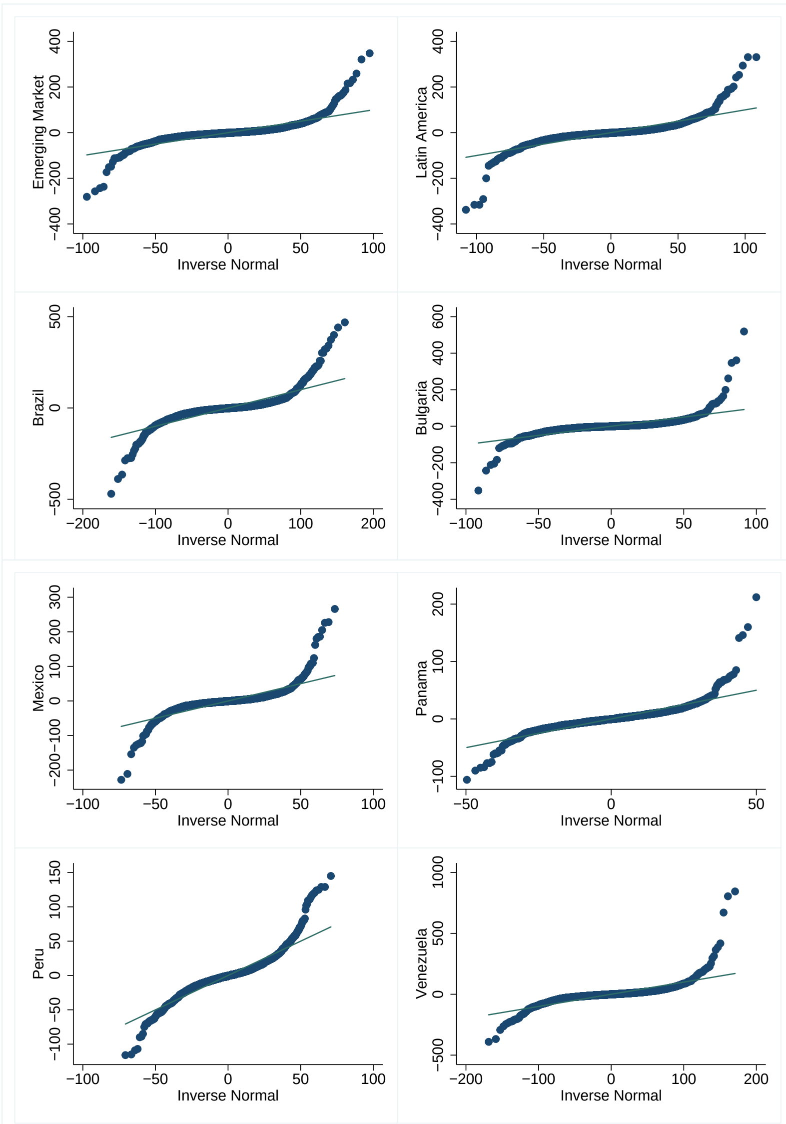

Table 24: Test of skewness and kurtosis

	skewness p-value	kurtosis p-value
US real rate	0.000	0.000
Emerging Market	0.000	0.000
Latin America	0.000	0.000
Brazil	0.000	0.000
Bulgaria	0.000	0.000
Mexico	0.000	0.000
Panama	0.000	0.000
Peru	0.000	0.000
Venezuela	0.000	0.000

Note: Null hypothesis is normal distribution

Table 25: Levene (1960) test of equal variance

	Test statistic based on mean	p-value
US real rate	12.371	0.000
Emerging Market	0.215	0.643
Latin America	0.458	0.499
Brazil	2.273	0.132
Bulgaria	0.000	0.977
Mexico	0.031	0.860
Panama	0.021	0.884
Peru	0.908	0.341
Venezuela	0.635	0.801

Note: Null hypothesis is equal variance

small increases in the variance of EMBI+, as the unexpected policy shocks to US real interest rates are only a small part of the variation of emerging market default risk, so the results of the tests on variances in both sub-samples, albeit not conclusive, are not at odds with the identifying assumptions.