THE GLOBAL AND REGIONAL FACTORS IN THE VOLATILITY OF EMERGING SOVEREIGN BOND MARKETS

Thanh Huong Dinh and Duc Khuong Nguyen***
*University of Paris 12 Val-de-Marne, France
**ISC Paris School of Management, France

Abstract

This paper examines how much the volatility of sovereign bond markets in Latin American emerging countries is influenced by volatiliy shocks to global and regional markets. After estimating the GARCH-based conditional volatility for sample markets, we measure the parts of sovereign bond market volatility attributable to the global and regional factors within the dynamic framework of a SVAR model. We find significant and persistent volatility spillovers from global and regional factors to sovereign bond markets with a dominant effect issued by global sovereign bond market. We also evidence that the global and regional markets are, on average, responsible for more than 45% of the variance of volatility changes in three of five selected emerging countries over a 12-week ahead forecast horizon.

Keywords: Emerging Markets, Sovereign Debt, SVAR Model, Volatility Spillovers

JEL classification numbers: F34, F37, G15

Correspondence: Duc Khuong Nguyen, Department of Finance and Management, ISC Paris School of Management, 22 Boulevard du Fort de Vaux, 75017 Paris cedex, France. Email: *dnguyen@groupeisc.com*.

1 INTRODUCTION

Emerging sovereign bond markets have deepened markedly over the last decade. At the end of 2004, the average sovereign debt to GDP ratio of the 18 emerging countries which account for close to 90% of the capitalization of the JPMorgan Emerging Market Global Bond Index (EMBIG) was estimated at 39%. With a sovereign debt to GDP ratio of 49%, the Latin American region experienced the highest sovereign debt level among emerging countries[1]. These changes, encouraged by the low returns in mature market asset classes coupled with the better macroeconomic performance in emerging countries, led to higher country credit ratings attributed to emerging markets and growing attention from global investors.

As sovereign bond markets have become an important source of emerging market external financing, a large research literature has been devoted to the study of their institutional and financial determinants. The majority of previous studies are concerned by explaining and modeling the dynamic changes in sovereign bond spreads, an indicator of country default risk carefully watched by global investor community, which reflect the ability of an emerging country to reimburse the sovereign debt at the due date. The incomplete list of references includes, among others, Andritzky and *al.* (2007), Jüttner and *al.* (2006), Batten and *al.* (2006), Min and *al.* (2003), and references therein. For example, Andritzky and *al.* (2007) relate changes in emerging market sovereign spreads to macroeconomic announcements and find that sovereign spreads react to rating actions and changes in the US interest rate rather than to country-specific factors. Jüttner and *al.* (2006) attempt to explain the unexplained residual returns in nineteen emerging sovereign bond markets by country-specific factors such as GDP growth rate, inflation rate and political and financial risks. The authors show that global market factors, local market risk and country-specific factors are relevant in pricing sovereign bond returns. As for the last two studies previously cited, various variables including the US interest rate term structure, local stock market index, exchange rate, liquidity and solvency indicators, and macroeconomic fundamentals are used to predict changes in sovereign spreads.

There is, however, less evidence about the volatility and volatility-spillover effects regarding sovereign bond markets in emerging countries while these issues are at the heart of debates on the worldwide financial stability. Indeed, the purpose that the growing volatility and financial instability in

[1] These data are taken from the IMF's Global Financial Stability Report: Market Developments and Issues, April 2006.

international capital markets were partly due to the huge increase of sovereign debt asset class constitutes a current matter of both academic and policy interests. Previous works on emerging market sovereign debt that are mostly related to our study include Cifarelli and Paladino (2004), and Han and *al.* (2003). While the latter study examines the spillover effects of the 1994 Mexican debt crisis to nine other emerging markets, the formal investigates the impact of the Argentine default of December 2001 on volatility co-movements in Asian and Latin American emerging bond markets with the primary focus being on the problem of shift contagion. Another study, Gande and Parsley (2005), falls also into this category, but its main goal is to analyze the spillover effect of a sovereign credit rating change of one country on the sovereign credit spreads of other countries from 1991 to 2000. In this paper, the question we address is: *how important is the impact of global and regional markets on the volatility of sovereign bond markets in Latin America?*

Concretely, this paper will contribute to the above literature in several ways. First, we propose a simple framework to explore the dynamics of emerging market sovereign bond returns and their volatility in a globalization context. Second, we examine the degree to which emerging sovereign bond markets are interrelated to the global and regional risk factors on a basis of a structural VAR model. To a large extent, this degree of interdependences can be explained by the actual degree of integration of an emerging sovereign bond market within a region and with the world market. Finally, as a key contribution of this paper, we measure the quantity of spillover effects on the emerging market sovereign bond volatility that can be attributed to the global and regional factors. Using weekly data from five emerging sovereign bond markets in Latin America, two global benchmark indices, and two regional benchmark indices, we mainly find evidence of significant and persistent volatility-spillovers from global and regional markets to individual emerging countries. The global and regional markets are, on average, responsible for more than 45% of the variance of volatility changes in three of five selected countries over a 12-week ahead forecast horizon.

The remaining part of the paper is organized as follows. Section 2 introduces the empirical model that allows for the impact of the global and local factors on the sovereign bond returns and volatility. Section 3 describes the data used in the paper and their stochastic properties. Section 4 reports and interprets the empirical results. Section 5 summarizes the main findings of the paper and discusses future research perspectives.

2 EMPIRICAL MODEL

A two-stage procedure is used to explore the impacts of global and regional factors on the volatility of emerging sovereign bond markets. In the first stage, the conditional volatility of all variables evolved in the study is estimated. Conditional volatility series are then employed in the second stage to investigate the spillover effects as well as the parts of the volatility of emerging sovereign bond markets caused by the global and regional factors.

To model the conditional volatility of a time-series variable, a number of choices are available to researchers. For instance, some studies have been based on the two-step regression procedure of Schwert (1989) which provides the so-called conditional rolling standard deviation. Another class of models, the AutoRegressive Conditional Heteroscedasticity (ARCH) initially introduced by Engle (1982) and its generalized version (GARCH) developed by Bollerslev (1986), is widely employed in recent finance literature. As far as the question of modeling high-frequency return variability is concerned, there exists a possibility to apply the realized volatility framework as described in Andersen and *al.* (2003) and references therein. In this study we adopt a GARCH-type volatility model because it appears to successfully capture the empirical regularities of asset returns in emerging markets such as leptokurtic distribution of unconditional returns and volatility clustering (see, *e.g.*, Bekaert and Harvey, 1997; and Kim and Singal, 2000).

Let r_{1t}, r_{2t}, r_{3t}, r_{4t}, and $r_{i,t}$ be the continuously compounded return on the JPMorgan Emerging Market Bond Index Global for all countries, MSCI World stock market index, EMBI Global for Latin America, S&P/IFCG stock market index for Latin America, and EMBIG for country i (i = 1,2...,5), we propose the following autoregressive structures for the conditional mean equations:

$$
\begin{aligned}
r_{1t} &= \lambda_0 + \lambda_1 r_{1,t-1} + \lambda_2 r_{2,t-1} + \varepsilon_{1t} && (1)\\
r_{2t} &= \gamma_0 + \gamma_1 r_{2,t-1} + \gamma_2 r_{1,t-1} + \varepsilon_{2t} && (2)\\
r_{3t} &= \varphi_0 + \varphi_1 r_{3,t-1} + \varphi_2 r_{1,t-1} + \varphi_3 r_{2,t-1} + \varphi_4 r_{4,t-1} + \varepsilon_{3t} && (3)\\
r_{4t} &= \eta_0 + \eta_1 r_{4,t-1} + \eta_2 r_{1,t-1} + \eta_3 r_{2,t-1} + \eta_4 r_{3,t-1} + \varepsilon_{4t} && (4)\\
r_{it} &= \delta_0 + \delta_1 r_{i,t-1} + \delta_2 r_{1,t-1} + \delta_3 r_{2,t-1} + \delta_4 r_{3,t-1} + \delta_5 r_{4,t-1} + \varepsilon_{it} && (5)
\end{aligned}
$$

Note that the first four return series are seen as the global and regional factors reflecting dynamic changes in the worldwide and regional stock and bond markets. According to the above specifications, both global and regional factors are allowed to affect the country i's conditional sovereign bond return, but the influence of the country i's bond sovereign return on regional and global market returns is not possible. The rationale for doing so is that global and regional factors are supposed to incorporate all information from individual countries.

The conditional variance σ_t^2 of the return innovations ε_t can be obtained by jointly estimating each conditional mean equation and a univariate GARCH(1,1) model which is stated as follows:

$$\sigma_t^2 = \varpi + \alpha\varepsilon_t^2 + \beta\sigma_{t-1}^2 \tag{6}$$

We employ the method of quasi-maximum likelihood estimation (QMLE) proposed by Bollerslev and Wooldrige (1992) to carry out the estimation issue. The optimization strategy is based on the BFGS algorithm.

The conditional volatility, as measured by the square root of the estimated conditional variance series, are then put into five dynamic structural VAR systems (SVAR) to analyze the aggregate impacts of the global and regional market volatilities on the volatility of each emerging sovereign bond market. The SVAR model we consider has the following form:

$$Y_t = \mathbf{C} + \sum_{s=1}^{p} \mathbf{B}_s Y_{t-s} + u_t \tag{7}$$

where $Y_t = (Y_{1t}, Y_{2t}, Y_{3t}, Y_{4t}, Y_{it})'$ represents the (5×1) vector of dependent variables. They refer to the volatilities of the global sovereign bond market, the global stock market, the local sovereign bond market, the local stock market and the emerging country i's sovereign bond market (i =1,2,...5); $\mathbf{C}$ is a (5×1) vector of constant terms; $\mathbf{B}_s$ refer to a (5×5) matrix of unknown coefficients; p is the optimal number of lags that can be determined using the Akaike Information Criterion (AIC); and $u_t = (u_{1t}, u_{2t}, u_{3t}, u_{4t}, u_{it})'$ is a (5×1) vector of uncorrelated volatility innovations having a positive definite covariance matrix $\Sigma = E(u_t u_t')$.

Once p is set, the VAR system can be straightforwardly estimated using OLS estimation procedure and the dynamic interrelationships between system variables can be apprehended through Granger-causality and block exogeneity tests. However, the VAR model as described in Equation (7) does not permit to explicitly investigate the effect of a shock to a particular variable on the others because of the possible interdependencies between the system innovations u_t (*i.e.*, the covariance matrix Σ is not diagonal). The solution well discussed in the econometric literature is to transform the standard VAR model into its moving average form as in Equation (8)[2]

$$Y_t = \mathbf{C}_t\theta + \sum_{s=0}^{\infty} \mathbf{\Psi}_s u_{t-s} \tag{8}$$

and to orthogonalize the system innovations as shown by Equation (9)

$$Y_t = \mathbf{C}_t\theta + \sum_{s=0}^{\infty} \mathbf{\Phi}_s v_{t-s} \tag{9}$$

where $\mathbf{C}_t\theta$ is the deterministic part of the Y_t. The transition from Equation (8) to Equation (9) rests on the following conditions: $\mathbf{\Phi}_s = \mathbf{\Psi}_s\mathbf{A}$, $\mathbf{A}^{-1}u_t = v_t$, with $\mathbf{A}$ being a (5×5) matrix of parameters to be estimated. The assumption of orthogonal innovations, that is $E(v_t v_t') = \mathbf{I}$ (identity matrix), imposes that $\mathbf{A}^{-1}\Sigma\mathbf{A}'^{-1} = \mathbf{I}.$ Accordingly, such a matrix $\mathbf{A}$ can be any solution of $\mathbf{AA}' = \Sigma$. Given the objective of the paper, we decide to generate the orthogonal innovations by imposing the structural decompositions suggested by Sims (1980). Precisely, the transformation from u_t into v_t is governed by:

$$\begin{aligned}
u_{1t} &= a_{11}v_{1t} \\
u_{2t} &= a_{21}u_{1t} + a_{22}v_{2t} \\
u_{3t} &= a_{31}u_{1t} + a_{32}u_{2t} + a_{33}v_{3t} \\
u_{4t} &= a_{41}u_{1t} + a_{42}u_{2t} + a_{43}u_{3t} + a_{44}v_{4t} \\
u_{it} &= a_{i1}u_{1t} + a_{i2}u_{2t} + a_{i3}u_{3t} + a_{i4}v_{4t} + a_{ii}v_{it}
\end{aligned} \tag{10}$$

Based on this structural mechanism, we explicitly favour the following order of volatility-spillovers: *from bond market to stock market, from global market to regional market, and from global and regional market to country i's market*. The matrix $\mathbf{\Phi}_s$ is referred to as the orthogonal impulse response functions (IRF) of Y_t after s periods when the system is shocked by one variable. Since we have five variables in each system, there are 25 series of orthogonal IRF. The element $\Phi_{i,j}$ of the matrix $\mathbf{\Phi}_s$ is straightforwardly interpreted as the orthogonal effect of a one-unit shock in the jth variable on the ith variable of the system. The total IRF of the country i's sovereign bond volatility to the system shocks at period k can be computed as $\Phi_i^k = \Phi_{i1}^k + \Phi_{i2}^k + \Phi_{i3}^k + \Phi_{i4}^k + \Phi_{ii}^k$. The global effects on country i's volatility refer

[2]Under the moving average representation, the system dependent variables are expressed in terms of current and past values of innovations in each equation.

to the sum of the first two elements, whereas the regional effects are sized by taking the sum of the third and fourth elements.

In addition to the IRF, it is also possible to compute the forecast error variance decomposition (FEVD) which answers the question: what portion of the forecast error in predicting a particular variable is due to its own structural shocks as well as to shocks in other variables. For example, the forecast error of the country i's sovereign bond volatility is:

$$Y_{iT+h} - Y_{iT+h|T} = \sum_{s=0}^{h-1} \phi_{ij}^{s} v_{j,T+h-s}, \; with \; j = (1,2,3,4,i) \tag{11}$$

Since the innovations are orthogonal, the variance of the h-step ahead forecast error for country i's sovereign bond volatility is defined by:

$$Var(Y_{iT+h} - Y_{iT+h|T}) = \sum_{s=0}^{h-1} (\phi_{ij}^{s})^2 \sigma^2 v_j, \; with \; j = (1,2,3,4,i) \tag{12}$$

Then, the portion of the global and regional factors in the variance of the h-step ahead forecast error for country i's sovereign bond volatility is measured as:

$$FEVD_{i,global\ \&\ regional}(h) = \frac{\sum_{s=0}^{h-1} (\phi_{ij}^{s})^2 \sigma^2 v_j}{Var(Y_{iT+h} - Y_{iT+h|T})}, \; with \; j = (1,2,3,4) \tag{13}$$

To sum up, the proposed empirical model (GARCH and SVAR) will allow us to determine the influence of the global and regional markets on the volatility of five sovereign bond markets in Latin America. Within each SVAR system, there are four variables related to the volatility of the global and regional markets, and one variable representing the volatility of the sovereign bond market under consideration. We discuss the data and result issues in the next sections.

3 DATA AND STATISTICAL PROPERTIES

The present paper covers five emerging sovereign bond markets in Latin America: Argentina, Brazil, Chile, Colombia and Mexico. The JPMorgan Emerging Markets Bond Index Global (EMBIG) is used to compute

Table 1: Basic statistics of the weekly data

Indices	Mean (%)	Std. Dev.	JB stat.	Q(6)	ARCH(6)
ARG	-0.185	0.036	2387.39^{++}	15.57^{+}	24.16^{++}
BRA	0.254	0.031	507.83^{++}	14.34^{+}	64.13^{++}
CHI	0.177	0.009	52.68^{++}	5.83	3.12
COL	0.270	0.016	459.20^{++}	10.54	58.20^{++}
MEX	0.239	0.011	50.39^{++}	19.21^{+}	20.41^{++}
$\text{EMBIG}^{\text{All}}$	0.183	0.018	7702.65^{++}	17.09^{++}	23.07^{++}
MSCIW	0.056	0.022	830.29^{++}	4.27	2.45
EMBIG^{LA}	0.150	0.021	1952.66^{++}	13.25^{+}	31.91^{++}
IFCG^{LA}	0.188	0.037	47.33^{++}	12.36^{+}	18.70^{++}

Notes: ARG, BRA, CHI, COL and MEX represent the return index of sovereign bond markets in Argentina, Brazil, Chile, Colombia, and Mexico. The mean is expressed in percentage. JB stat., Q(6) and ARCH(6) are respectively the empirical statistics of the Jacque-Bera test for normality based on excess skewness and kurtosis, the Ljung-Box test for autocorrelation of order 6, and the Engle(1982)'s test for conditional heteroscedasticity against a 6-order ARCH effects. + and ++ indicate the rejection of the null hypothesis of normality, no autocorrelation and homocedasticity at 5% et 1% respectively.

the return index of individual countries. The global and regional factors capture information from global sovereign bond market, global stock market, regional sovereign bond market, and regional stock market. They are respectively represented by the JPMorgan EMBI Global for all countries ($\text{EMBIG}^{\text{All}}$)[3], the MSCI World market index (MSCIW), the JPMorgan EMBI Global for Latin America (EMBI^{LA}), and the S&P/IFCG stock market index for Latin America (IFCG^{LA}). Except for the bond market data which come from JPMorgan, other data are extracted from Datastream International. All index returns are continuously compounded returns at weekly frequency and are computed as follows: $r = \ln(P_t/P_{t-1})$, where P_t is the index price at time t. The study period ranges from 26 April 1998 to 10 July 2005 for Argentina and Brazil, from 6 June 1999 to 10 July 2005 for Chile, from 19 December 1999 to 10 July 2005 for Colombia, and from 21 March 1999 to 10 July 2005. For the global and regional benchmarks, the data are available from 26 April 1998 to 10 July 2005.

[3]The JP Morgan EMBI Global for all countries is a market-capitalization-weighted index which currently tracks total returns for US dollar denominated debt instruments issued by emerging market sovereign and quasi-sovereign entities: brady bonds, loans, eurobonds. Currently, this bond index covers 188 instruments across 33 emerging countries.

Table 2: Unconditional correlations among sample markets

	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ARG (1)	0.305	0.166	0.194	0.272	0.552	0.065	0.602	0.283
BRA (2)	1	0.297	0.540	0.619	0.813	0.198	0.876	0.668
CHI (3)		1	0.283	0.586	0.458	-0.200	0.394	0.117
COL (4)			1	0.558	0.605	0.173	0.579	0.451
MEX (5)				1	0.806	-0.003	0.746	0.470
$\mathrm{EMBIG}^{\mathrm{All}}$ (6)					1	0.136	0.968	0.642
MSCIW (7)						1	0.153	0.460
$\mathrm{EMBIG}^{\mathrm{LA}}$ (8)							1	0.655
$\mathrm{IFCG}^{\mathrm{LA}}$ (9)								1

Statistical properties of weekly returns for sample markets and global and regional markets are reported in Table 1. Over the study period, sovereign bonds in Latin American emerging countries realized a relatively high performance compared with the benchmark bond and stock indices, the only exception being the Agentine market which experienced a weekly average of -0.185%. It is worth noting that the differences in terms of unconditional volatility (or standard deviation) between countries need to be interpreted with precaution because the study period is not the same for all indices used. What we can mention, however, is the disproportion between the realized return and the risk level in some markets. For example, the highest level of risk observed in Argentina is not proportionally rewarded by the highest return. By contrast, a relatively low risk in Mexico is associated with a second-largest return of the sample. The results of the normality test show that all weekly return series are highly deviated from a normal distribution. The Engle (1982)'s test for conditional heteroscedasticity rejects the null hypothesis of no ARCH effects for all return series, except for Chile and MSCIW series. Altogether, these stylized facts justify our decision to use GARCH model for the residual return variance. In addition, the presence of autocorrelation of order 6 for many return series coupled with highly significant coefficients of the first-order autocorrelation which are not reported here to conserve spaces supports the inclusion of the autoregressive terms in the mean equation.

Table 2 reports the unconditional correlations between sample markets. We observe that the correlation coefficients among emerging sovereign bond markets range from 16.6% (ARG-CHI) to 61.9% (BRA-MEX). These markets comove largely with the global and regional sovereign bond markets with the lowest coefficient being 39.4% (CHI-EMBI^{LA}), less with the regional stock market and much less with the global stock market (i.e., two correlation coefficients are negative). As a result, there is still room for diversification benefits through investing in emerging bond markets.

4 RESULTS AND INTERPRETATIONS

In this section, we start with presenting the results from the joint estimation of the conditional mean equation and GARCH-based conditional variance equation for all return series evolved in our study. We then center on the dynamic interrelations between the volatility of emerging sovereign bond markets and that of the global and regional benchmarks within a SVAR framework as described in Section 2. The main objective is to show how movements of the global and regional markets impact the volatility of emerging sovereign bond markets.

4.1 *Major preliminary results*

Table 3 reports estimated parameters of the conditional mean and variance equations for five sovereign bond markets and four global and regional markets. At the sight of parameter estimates in Panel A, we observe that weekly sovereign bond returns in studied emerging countries are generally unpredictable from past returns of local, regional and global markets. The only exception is the case of Brazil where past returns in local bond, global bond and global stock markets significantly impact current returns. For global and regional markets, there is only an evidence of return predictability pattern in case of IFCG stock market index for Latin America.

The fact that the coefficients associated with either ARCH term or GARCH term or both (*i.e.*, α and β) in conditional variance equations suggests that GARCH(1,1) model successfully fits the return data on both emerging sovereign bond markets and benchmark markets[4]. In Chile, the constant term and ARCH coefficient are found to be significant at 10% level of risk. More importantly, the parameters of GARCH(1,1) model are highly significant for the MSCIW series, even though the Engle (1982)'s test for

[4] The properties of the standardized residuals for all estimated models are examined using the Jacque-Bera's test for normality, the Ljung-Box test for autocorrelation and the Engle (1982)'s test for conditional heteroscedasticity. We mainly found that the degree of autocorrelation is significantly reduced and no-ARCH effects are present in residual return series for all cases. To conserve spaces, detailed results of the residual diagnosis are not reported here, but they are available under request.

Table 3: Model estimates

Panel A. Country i's sovereign bond market (r_{it})					
Coeff.	ARG	BRA	CHI	COL	MEX
δ_0	-0.000	0.003*	0.002**	0.003*	0.003**
δ_1	0.062	0.072**	-0.078	0.045	-0.066
δ_2	0.747	0.705**	0.144	0.282	0.253
δ_3	-0.344	-0.678**	-0.081	-0.224	-0.234
δ_4	0.048	0.022	0.011	-0.024	0.060
δ_5	-0.002	0.028	-0.002	0.026	-0.007
ϖ	0.000	0.000*	0.000	0.000**	0.001**
α	0.208	0.205*	0.162	0.426*	0.290*
β	0.791**	0.787**	0.329	-0.058	-0.143*

Panel B. Global and regional markets ($r_{1t}, r_{2t}, r_{3t}, r_{4t}$)				
Coeff.	EMBIG$^{\text{All}}$	MSCIW	EMBIG$^{\text{LA}}$	IFCG$^{\text{LA}}$
Const.	0.004**	0.000	0.004	0.003
$r_{1,t-1}$	-0.046	0.163	0.086	0.121
$r_{2,t-1}$			-0.094	
$r_{3,t-1}$	-0.043	0.055	0.033	0.232**
$r_{4,t-1}$				-0.047
ϖ	0.000*	0.001**	0.000*	0.000
α	0.326*	0.075**	0.314*	0.066
β	0.699**	-0.311**	0.713**	0.895**

Notes: this table provides the estimates of the empirical model. r_{1t}, r_{2t}, r_{3t}, and r_{4t} refer respectively to the weekly return series of the EMBIG$^{\text{All}}$, MSCIW, EMBIG$^{\text{LA}}$, and IFCG$^{\text{LA}}$. Const. refers to the constant term of the conditional variance equation. * and ** indicate the signification of the associated coefficients at 5% et 1% respectively. See also notes of the Table 1.

Table 4: Statistics for weekly conditional volatility series

	Mean	Maximum	Minimum	Std. Dev.	Skewness	Kurtosis
ARG	0.033	0.129	0.014	0.022	2.116	7.708
BRA	0.025	0.088	0.011	0.015	2.325	8.115
CHI	0.009	0.018	0.008	0.001	2.993	16.875
COL	0.015	0.058	0.008	0.005	4.160	26.029
MEX	0.011	0.025	0.007	0.002	3.258	17.693
$\mathrm{EMBIG}^{\mathrm{All}}$	0.014	0.040	0.007	0.006	1.519	5.696
MSCIW	0.022	0.033	0.018	0.002	3.131	18.563
$\mathrm{EMBIG}^{\mathrm{LA}}$	0.018	0.050	0.008	0.008	1.432	4.834
$\mathrm{IFCG}^{\mathrm{LA}}$	0.034	0.052	0.027	0.004	1.067	4.508

a six-order ARCH effects indicates an absence of autoregressive conditional heteroscedasticity in the raw return series (see, Table 1). Evidently, our proposed model is capable to capture the time-varying feature and persistence in the volatility of emerging, global and regional markets.

Table 4 sheds the light on the estimated conditional volatilities which are obtained from taking the square root of the estimated GARCH-variances from December 26, 1999 to July 10, 2005. On average, we observe that the IFCG stock market index for Latin America experienced a highest weekly conditional volatility (3.4%), followed by Argentina with 3.3%, Brazil with 2.5% and MSCI World stock market with 2.2%. Chilean sovereign bond market recorded the lowest level of conditional volatility over the same period with only 0.9% per week. It is also possible to notice that conditional volatility series are highly non-normal due to the significant level of kurtosis coefficients.

4.2 *Volatility-spillover effects*

From the estimated conditional volatilities, setting up five SVAR models consists of the first step to examine the volatility-spillover issue. We base on the Akaike Information Criteria (AIC) to determine the optimal number of lags for each system. Accordingly, a VAR(3) model is proved to be convenient for systems including either Argentina or Brazil or Colombia; and a VAR(1) model for systems including either Chile or Mexico. In a follow-up to the estimation of these VAR models, we can use the orthogonal transformations as shown by Equation (10) to generate the structural IRF and FEVD. To insure the robustness of previous VAR specifications, we perform

Table 5: Wald tests for lag exclusions in the VAR models

	Sys. ARG	Sys. BRA	Sys. CHI	Sys. COL	Sys. MEX
Lag 1	1274.59	1277.24	5446.17	743.38	6008.34
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Lag 2	127.82	124.05		51.13	
	(0.00)	(0.00)		(0.00)	
Lag 3	124.49	130.43		37.64	
	(0.00)	(0.00)		(0.05)	
df	25	25	25	25	25

Notes: This table provides the Chi-squared test statistics χ^2 for joint significance of all lagged endogeneous variables in each equation at different lags for each of five VAR systems under consideration (systems for Argentina, Brazil, Chile, Colombia and Mexico). The numbers in parentheses are the associated p-values. *df* refers to the degree of freedom.

the Wald test for the lag exclusion and report the results in Table 5. As we can see, all lags included in each of the five systems are relevant in explaining the dynamics of the system's endogenous variables.

As pointed out in Section 2, the structural IRF allows us to investigate how conditional volatilities in emerging sovereign bond markets react to structural shocks in global and regional markets. To this end, we normalize the shocks (or impulses) to the orthogonal innovations of global and regional markets into one standard deviation and look at the volatility responses of the emerging bond market under consideration. We have computed the impulse responses of individual sovereign bond markets to one standard deviation innovations on global and regional markets from period 1 (or a week) through period 12 (or a three-month period)[5]. The results are reported in Table 6.

Globally, the results indicate that sovereign bond markets in Latin American emerging countries respond markedly and persistently to the structural volatility shocks in global and regional markets. An inside view of the results permits to draw three major trends in the volatility-spillover patterns between markets.

First, structural innovations in the volatility of global markets have

[5] It is worth noting that 'period 1' indicates the responses of the country i's sovereign bond market volatility to structural one standard deviation shock in global and regional markets one period after the beginning of the shock. The instantaneous effects of global and regional factors are captured by the matrix of coefficients $\mathbf{B}_s$ in Equation (7). They can be obtained from the authors under request.

Table 6: IRF of emerging sovereign bond market volatility to structural shocks on global and regional markets

	ARG		BRA		CHI		COL		MEX	
Period	*Glo.*	*Reg.*	*Glo.*	*Reg.*	*Glo.*	*Reg.*	*Glo.*	*Reg.*	*Glo.*	*Reg.*
1	0.37	0.14	0.38	0.17	0.02	-0.02	0.26	-0.03	0.16	-0.01
2	0.38	0.11	0.35	0.16	0.02	0.00	0.03	-0.04	0.01	0.00
3	0.47	0.04	0.41	0.14	0.02	0.00	0.01	-0.01	0.00	0.00
4	0.44	0.02	0.40	0.12	0.01	0.01	-0.01	0.04	0.00	0.00
5	0.45	0.01	0.40	0.11	0.01	0.01	0.04	0.03	0.00	0.00
6	0.41	0.00	0.37	0.10	0.01	0.01	0.04	0.01	0.00	0.00
7	0.38	0.00	0.35	0.09	0.01	0.01	0.02	0.03	0.00	0.00
8	0.35	-0.01	0.32	0.08	0.01	0.01	0.02	0.03	0.00	0.00
9	0.32	-0.01	0.30	0.07	0.01	0.01	0.02	0.02	0.00	0.00
10	0.29	-0.02	0.28	0.06	0.01	0.01	0.02	0.02	0.00	0.00
11	0.27	-0.02	0.25	0.05	0.01	0.00	0.02	0.02	0.00	0.00
12	0.24	-0.02	0.23	0.05	0.01	0.00	0.02	0.02	0.00	0.00

Notes: This table reports the impulse responses of the volatility in individual emerging sovereign bond markets to a one standard deviation innovations on global and regional markets from period 1 to 12. *Glo.* and *Reg.* refers respectively to the sum of resposes caused by shocks on global bond and stock markets, and the sum of responses caused by shocks on regional bond and stock markets. The impulse responses for a particular period are expressed in percentage.

caused much greater response on the volatility of emerging sovereign bond markets than those in regional markets. Regarding the size of impulse responses, it is particularly important in Argentina and Brazil. For example, the response to the shock in global markets of the volatility of sovereign bond markets in Argentina is estimated at 0.37% after one period. It reaches its peak response of 0.45% after 5 periods and still remains significant after 12 periods at 0.24%. The same schema is followed by sovereign bond market in Brazil whose response to the global shocks range from 0.23% at period 12 to 0.41% at period 3. For Chile, Colombia and Mexico, their response to volatility shocks affecting the global and regional factors, albeit persistent over time, is quite small. In Mexico, for example, the response drops to a near-zero value after about 3 periods.

Second, with respect to different types of market, the average impulse responses to one standard deviation innovation in stock markets over 12 periods is are lower than those induced by bond markets for three countries: Argentina (0.07% against 0.30%), Brazil (0.11% against 0.32%) and Chile (0.00% against 0.01%). The opposite is valid for Colombia (0.04% against 0.015%) and Mexico (0.007% against 0.006%).

Finally, the volatility-spillover effects lead to increased volatility in almost emerging sovereign bond markets following original shocks to return volatility of global and regional markets. Effectively, apart from some negative values in response to shocks in regional markets (periods 8 to 12 for Argentina, period 1 for Chile, periods 1 to 3 for Colombia, and period 1 for Mexico) and only one negative value caused by shock to global markets, all other responses are positive.

To make comparisons between emerging sovereign bond markets, we compute their aggregate and accumulated responses to shocks issued from both global and regional markets over twelve periods, and show the results in Figure 1. It is observed that the sovereign bond markets in Argentina and Brazil receive the most important spillovers from the volatility in global and regional markets. At one week, Brazil's response to both global and regional markets is equal to 0.542%, but its accumulated value gradually increases over time and attains 5.222% after 12 weeks. Similarly, starting with a value of about 0.514%, the accumulated response from Argentina to volatility shocks in global and regional markets is estimated at 4.617% over a 12-week period. Only a small amount is found of volatility spillovers from global and regional markets to Chile, Colombia and Mexico.

Further information about the impact of global and regional markets on the volatility of sovereign bond markets in Latin American can be apprehended from the analysis of forecast error variance decomposition (FEVD).

Figure 1: Accumulated responses of individual sovereign bond markets to shocks in global and regional factors

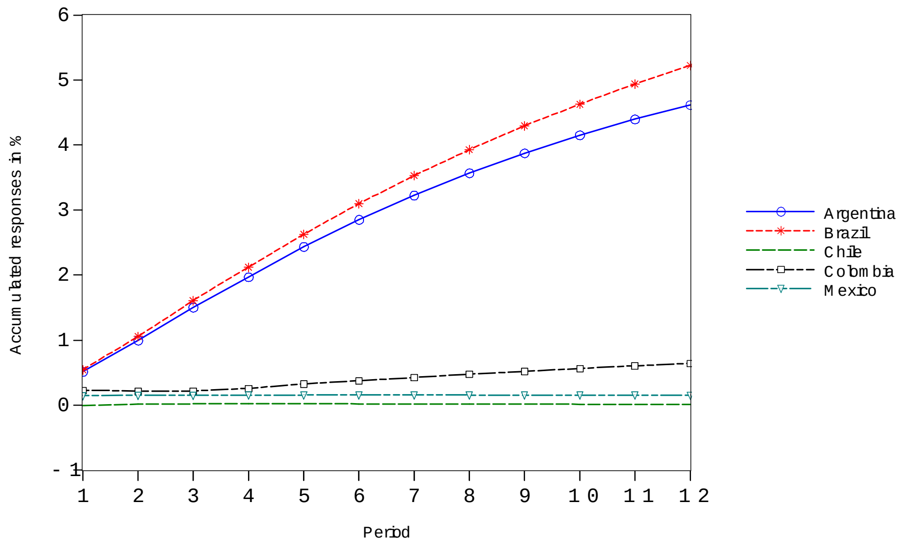

Table 7 presents the results for FEVD expressed in percentage. For each emerging sovereign bond market, its forecast error variance is decomposed in five parts attributable to the variance of innovations in five markets: *GB* (global sovereign bond market, EMBIG^{All}), *GS* (global stock market, MSCIW), *RB* (regional sovereign bond market, EMBIG^{LA}), *RS* (regional stock market, IFCG^{LA}), and *SB* (emerging sovereign bond market). At a particular forecast horizon, the whole part of volatility innovation variations in an emerging sovereign bond market to which the global and regional markets are responsible can be evaluated by using Equation (13) or by taking the sum of *GB*, *GS*, *RB* and *RS*.

In general, the results from FEVD are consistent with those from structural IRF. That is, two sovereign bond markets, Argentina and Brazil, are mostly exposed to changes in volatility of global and regional factors. For instance, global markets explain on average 35.60% and 64.61% of volatility variations in Argentina and Brazil respectively, of which global stock markets are responsible of only 1.81% and 1.21% respectively. For these markets, the role of regional factors is much less important as they only count for 15.76% and 6.12% respectively. Two other markets, Colombia and

Table 7: FEVD of emerging sovereign bond market volatility into innovation variances of global and regional markets

Step ahead	ARG					BRA					CHI					COL					MEX				
	GB	*GS*	*RB*	*RS*	*SB*	*GB*	*GS*	*RB*	*RS*	*SB*	*GB*	*GS*	*RB*	*RS*	*SB*	*GB*	*GS*	*RB*	*RS*	*SB*	*GB*	*GS*	*RB*	*RS*	*SB*
1	29.60	0.11	17.27	3.85	49.16	66.57	0.05	5.80	1.57	26.01	1.41	0.28	3.47	0.20	94.64	22.56	0.04	1.35	0.31	75.75	45.51	0.09	1.58	0.48	52.33
2	29.46	0.52	15.50	3.68	50.85	66.61	0.19	5.60	2.29	25.31	2.50	0.54	2.94	0.25	93.77	21.97	0.61	1.71	0.30	75.40	45.32	0.24	1.68	0.53	52.23
3	30.34	1.86	13.75	4.62	49.42	64.60	1.15	4.12	3.05	27.08	3.61	0.59	3.10	0.28	92.42	21.77	0.73	2.00	0.47	75.04	45.27	0.24	1.77	0.59	52.13
4	31.86	2.14	12.37	4.80	48.83	63.91	1.52	3.29	3.36	27.92	4.59	0.62	3.56	0.31	90.93	21.66	1.18	1.99	1.47	73.69	45.22	0.24	1.86	0.63	52.04
5	34.16	2.13	11.14	4.75	47.83	63.75	1.56	2.65	3.60	28.45	5.42	0.63	4.09	0.33	89.54	21.60	1.32	1.98	1.77	73.33	45.17	0.24	1.93	0.67	51.98
6	35.14	2.15	10.34	4.76	47.61	63.55	1.53	2.25	3.70	28.97	6.11	0.64	4.58	0.35	88.33	21.57	1.53	1.99	1.86	73.06	45.13	0.24	1.98	0.71	51.93
7	35.65	2.17	9.74	4.77	47.67	63.13	1.51	1.97	3.77	29.61	6.68	0.64	5.00	0.37	87.31	21.52	1.56	2.00	2.24	72.69	45.10	0.24	2.03	0.74	51.89
8	35.91	2.18	9.27	4.80	47.84	62.67	1.48	1.77	3.79	30.28	7.16	0.65	5.36	0.38	86.45	21.46	1.60	1.99	2.55	72.40	45.06	0.24	2.07	0.77	51.85
9	35.99	2.16	8.90	4.85	48.10	62.20	1.44	1.63	3.79	30.94	7.56	0.65	5.66	0.40	85.73	21.41	1.69	1.99	2.74	72.17	45.04	0.24	2.10	0.80	51.82
10	35.95	2.14	8.60	4.90	48.41	61.73	1.40	1.52	3.76	31.59	7.90	0.65	5.91	0.42	85.12	21.37	1.74	1.98	2.93	71.97	45.02	0.24	2.12	0.82	51.80
11	35.81	2.12	8.35	4.96	48.76	61.25	1.36	1.43	3.72	32.23	8.18	0.65	6.12	0.43	84.62	21.33	1.78	1.98	3.11	71.79	45.00	0.24	2.14	0.84	51.78
12	35.62	2.10	8.15	5.02	49.12	60.79	1.32	1.36	3.68	32.85	8.42	0.65	6.30	0.44	84.19	21.30	1.82	1.98	3.25	71.65	44.99	0.24	2.16	0.85	51.76
Average	*35.60*		*15.76*		*48.63*	*64.61*		*6.12*		*29.27*	*6.39*		*5.02*		*88.59*	*22.93*		*3.83*		*73.24*	*45.38*		*2.56*		*51.96*

Notes: This table gives the percentage of forecast error variance of each emerging sovereign bond market, which is due to the variance of its own volatility innovations and the variance of volatility innovations in global sovereign bond market (GB), global stock market (GS), regional sovereign bond market (RB) and regional stock market (RS). The last row provides the average effects of global, regional and country factors respectively.

Mexico, are also largely sensible to volatility shocks in global factors whose average effects add up to 22.93% and 45.38% respectively. Once again, the primary effect comes from the global sovereign bond market. The influence of global and regional factors is smallest in Chilean sovereign bond market. On average, about 88.59% of its forecast error variance originated from the variations of its own innovations. This may be indicative of the low degree of integration between Chile and other markets of the world.

5 CONCLUSION

This paper investigated the global and regional factors in the volatility of sovereign bond markets in emerging countries. Using weekly data from five Latin American markets and four global and regional benchmark indices, we first estimated the conditional volatility of these markets and then studied their exposures to volatility innovations in global and regional factors within a structural VAR model (SVAR). The volatility-spillover mechanism we introduce in this paper was set according to the following rules: *global market* $\rightarrow$ *regional market* $\rightarrow$ *domestic market*, and *bond market* $\rightarrow$ *stock market*.

Overall, our results show the existence of significant amounts of volatility spillovers from global and regional markets to emerging sovereign markets, especially to Argentina and Brazil. The spillover effects are particularly much higher from global markets than from regional markets, and also more important from bond markets than from stock markets. The importance of the global factors can be explained by their informative content. Effectively, the presence of extra-regional information should be a significant source of volatility innovations in emerging sovereign bond markets. Empirical results also reveal that variations in volatility shocks to global markets contribute, on average, up to 22.93%, 35.60%, 45.38% and 64.61% of the forecast volatility innovations in Colombia, Argentina, Mexico and Brazil. Hence, if the goal is to insure financial stability and to implement any new strategies in sovereign bond markets, government and quasi-sovereign entities in Latin American emerging countries have an interest in considering the worldwide economic conditions.

References

Andersen, T., Bollerslev, T., Diebold, F.X. and Labys, P. (2003), "Modeling and forecasting realized volatility", *Econometrica*, 71, 529-626.

Andritzky, J.R., Bannister G.J., Tamirisa, N.T. (2007), "The Impact of Macroeconomic Announcements on Emerging Market Bonds", *Emerging Markets Review*, 8, 20-37.

Batten, J.A., Fetherston, T.A., Hoontrakul, P. (2006), "Factors Affecting the Yields of Emerging Market Issuers: Evidence from the Asia-Pacific Region", *International Financial Markets, Institutions and Money*, 16, 57-70.

Bekaert, G., Harvey, C.R. (1997), "Emerging Equity Market Volatility", *Journal of Financial Economics*, 43, 29-78.

Bollerslev, T. (1986), "Generalized Autoregressive Conditional Heteroscedasticity", *Journal of Econometrics*, 31, 307-327.

Bollerslev, T., Wooldridge, J.M. (1992), "Quasi-maximum Likelihood Estimation and Inference in Dynamic Models with Time-varying Covariances", *Econometric Reviews*, 11, 143-179.

Cifarelli, G., Paladino, G. (2004), "The Impact of the Argentine Default on Volatility Co-movements in Emerging Bond Markets, *Emerging Markets Review*, 5, 427-446.

Engle, R.F. (1982), "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of UK Inflation", *Econometrica*, 50, 987-1008.

Gande, A., Parsley, D.C. (2005), "News Spillovers in the Sovereign Debt Market", *Journal of Financial Economics*, 75, 691-734.

Han, K.C., Lee, S.H., Suk, D.Y. (2003), "Mexican Peso Crisis and its Spillover Effects to Emerging Market Debt", Emerging Markets Review, 4, 310-326.

Jüttner, D.J., Chung, D., Leung, W. (2006), "Emerging Market Bond Returns: An Investor Perspective", *Journal of Multinational Financial Management*, 16, 105-121.

Kim, E.H., Singal, V. (2000), "Stock Market Openings: Experience of Emerging Economies", *Journal of Business*, 73, 25-66.

Min, H-G., Lee, D-H., Nam, C., Park, M-C., Nam, S-H. (2003), “Determinants of Emerging-market Bond Spreads: Cross-country Evidence”, *Global Finance Journal*, 14, 271-286.

Schwert, G.W. (1989), “Why Do Stock Market Volatility Change Over Time?”, *Journal of Finance*, 44, 1115-1153.

Sims, C.A. (1980), “Macroeconomics and Reality”, *Econometrica*, 48, 1-48.