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Impact of financial market uncertainty and macroeconomic factors on stock–bond correlation in emerging markets☆

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ABSTRACT

This paper examines the impact of global financial market uncertainty and domestic macroeconomic factors on stock–bond correlation in emerging markets. In particular, by applying the wavelet analysis approach, we are able to examine stock–bond correlations over different time horizons in ten emerging markets. We find that stock–bond correlation patterns vary significantly between the time horizons. In particular, the correlation in short horizon changes the sign rapidly showing sustainable negative episodes while the correlation in long horizon stays positive most of the time. The most important factor influencing stock–bond correlation in short horizon is the monetary policy stance, while the factors with the greatest long-term impact are inflation and stock market uncertainty. Finally, global stock market uncertainty plays a more significant role than global bond market uncertainty in explaining stock–bond correlations in emerging markets.

1. Introduction

This article focuses on the impact of global financial market uncertainty and domestic macroeconomic factors on stock–bond correlation in emerging markets on short and long time horizons. Examining the dynamics of the time-varying co-movements between stocks and bonds is important for several reasons. The stock–bond correlation is one of the most influential inputs to investors' asset allocation decisions. Moreover, investors' portfolio optimization, risk management, and hedging choices may be vastly improved by taking into consideration the relationship between two main asset classes. Finally, policymakers are increasingly using the information about the joint behavior of stocks and bonds in determining the market views on the inflation and the economic activity of a country. The issue of stock–bond correlation in emerging markets has recently been gaining considerable attention due to increasing demand for the emerging market assets by international investors seeking the benefits of portfolio diversification. In particular, government bonds of emerging markets have become an attractive investment target in recent decades due to the following reasons: (i) emerging markets are among the world's fastest growing economies in which government bonds represent the second largest source of financing

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since the 1990s; and (ii) increasing market liquidity and transparency in emerging bond markets (see e.g., Bunda et al., 2009; Piljak, 2013).

The purpose of this study is two-fold. By applying the wavelet analysis approach, we are able to examine stock–bond correlations over different time horizons in ten emerging markets during the period 2001–2013.[1] Assessment of stock–bond correlation dynamics at different time horizons is important for international investors in the context of portfolio rebalancing decisions.[2] In addition, the advantage of applying wavelet analysis to examining co-movement dynamics between asset classes is related to simultaneous consideration of time and frequency domains in one integrated framework. Second, we investigate the impact of global financial market uncertainty (both stock and bond market uncertainty) and domestic macroeconomic factors on the stock–bond correlations on short- and long-term horizons. In line with earlier studies on the relationship between the stock–bond correlation and macroeconomic factors (Ilmanen, 2003; Yang et al., 2009), we include inflation, business cycle patterns, and the monetary policy stance in our analysis.

The literature on stock–bond correlations has traditionally focused on developed markets (Andersson et al., 2008; Campbell and Ammer, 1993; Cappiello et al., 2006; Ilmanen, 2003). The most prominent issue within this stream of literature is related to examining various factors driving the stock–bond correlations. The debate on this issue remains open, given the mixed evidence in the literature on the role of macroeconomic factors in driving stock–bond correlations. In particular, one segment of the literature documents the importance of macroeconomic fundamentals, specifically inflation, business cycle environment, and monetary policy stance, in explaining stock–bond correlations (Ilmanen, 2003; Li, 2004; Yang et al., 2009). Yang et al. (2009) provide convincing evidence of time-varying stock–bond correlations over macroeconomic conditions (the business cycle, the inflation environment, and monetary policy stance) by using data from the US and the UK covering the past 150 years. Ilmanen (2003) proposes inflation as a key driver of the stock–bond correlation. High inflation periods lead to changes in common discount rates that dominate the cash-flow expectations and lead to a positive correlation between the two asset classes. Further findings demonstrate that stocks tend to outperform bonds during business cycle expansions, while bonds outperform stocks during business cycle contraction periods. Finally, easing the monetary policy has a positive effect on both stocks and bonds exhibiting a positive relation with the correlation of those two asset classes.

Andersson et al. (2008) use data from the US, the UK, and German markets and find that inflation expectation is an important determinant of the stock–bond correlation, while economic growth expectation is not a relevant factor. Specifically, their result shows that stock and bond prices move in the same direction when inflation expectations are high. In contrast, Baele et al. (2010) argue that macroeconomic factors play only a minor role in explaining stock–bond correlations in the US market. A more recent study by Aslanidis and Christiansen (2014) provides new insights into the role of macroeconomic fundamentals in explaining stock–bond correlations. They find that macroeconomic factors have only little explanatory power when the stock–bond correlation is largely positive; but when the stock–bond correlation is largely negative, then macroeconomic fundamentals are most useful explanatory variables. The rationale behind this finding is that macroeconomic factors are important for bonds in all periods, while for stocks they are important only in extremely volatile periods.

One additional segment of the related literature provides evidence that stock market uncertainty plays an important role in explaining stock–bond correlations (Andersson et al., 2008; Connolly et al., 2005, 2007; Kim et al., 2006). These studies use implied volatility from equity index options as a proxy for stock market uncertainty, and suggest that implied volatility changes have an impact on market participants' risk aversion, therefore affecting the stock–bond correlation. Considerable attention in these studies has been paid to the "flight-to-safety" phenomenon, in which the correlation between stocks and bonds becomes significantly negative during periods of high market uncertainty (Gulko, 2002; Connolly et al., 2005; Andersson et al., 2008; Baur and Lucey, 2009). In particular, the financial equity markets crashes make investors more risk averse, as they shift their funds from stock to bond markets.

In the literature on stock–bond correlation, studies examining emerging markets are relatively scarce. Panchenko and Wu (2009) use a sample of 18 emerging markets to investigate how stock–bond co-movement is affected by emerging stock market integration, while Boyer et al. (2006) examine correlations between stocks and bonds in emerging markets within the context of financial crisis contagion. More recently, Christopher et al. (2012) address the issue of the effects of sovereign credit ratings on time-varying stock–bond correlations in emerging countries worldwide. Finally, Bianconi et al. (2013) examine the behavior of stock and bond return volatility and the correlation for the BRIC countries conditional on a measure of US financial stress.

Our study contributes to the literature in three ways. First, we add to the literature on the stock–bond correlation by providing new evidence of the impact of macroeconomic factors and global financial market uncertainty from the perspective of emerging markets. Second, by using the advantageous methodological framework of the wavelet analysis, we are able to examine differences in the importance of macroeconomic and financial market uncertainty factors for the stock–bond correlations in long and short horizons. Third, we extend the literature on financial market uncertainty by examining

[1] A wavelet analysis approach has been applied in several studies to analyze financial time-series. For example, Rua and Nunes (2009), Kiviaho et al. (2014), and el Alaoui et al. (2015) apply wavelet squared coherency to analyze international co-movement of stock market returns. Kim and In (2007) apply wavelet analysis to examine the relationship between changes in stock prices and bond yields in G7 countries, while Aloui et al. (2015) utilize wavelet approach to examine co-movement between Islamic stocks and bonds in the Gulf Cooperation Council (GCC) countries.

[2] The true long-term relationship between stock and bond returns can be altered in a short horizon due to short-term noise: investors' immediate consumption needs and portfolio optimization (see Harrison and Zhang, 1999).

connections between global bond market uncertainty and stock–bond correlations. Related studies on stock–bond correlation have focused on the impact of uncertainty coming from stock markets (Andersson et al., 2008; Connolly et al., 2005, 2007; Kim et al., 2006), while our study differs from these in that it also examines the impact of uncertainty originating from the bond market.

The empirical findings reported in this article show that global financial market uncertainty and domestic macroeconomic factors play an important role in explaining the stock–bond correlation in emerging markets. In addition, time-varying stock–bond correlation patterns vary significantly between time horizons. The short horizon correlation changes the sign rapidly, showing sustainable negative episodes during crisis periods, which is consistent with the "flight-to-quality" phenomenon. The long horizon correlation stays positive most of the time, indicating that emerging market stock and bond prices move in the same direction signifying "equity like"[3] properties of emerging market bonds in the long run.

Our findings also suggest that the most important factor influencing the stock–bond correlation on a short horizon is the monetary policy stance, while the factors with the greatest impact on the stock–bond correlation in the long run are inflation and stock market uncertainty. Our empirical findings further demonstrate a positive long run relationship between inflation and stock–bond correlation suggesting that both stock and bond prices in emerging markets tend to move in the same direction during periods of high inflation. Moreover, our analysis shows that high equity market uncertainty, as measured by implied volatility, leads to a higher co-movement of stock and bond prices in emerging markets. Finally, global stock market uncertainty plays a more significant role than global bond market uncertainty in explaining stock–bond correlations in emerging markets.

The remainder of this paper is organized as follows. Section 2 presents data and the descriptive statistics. In Section 3, we present a brief description of the wavelet analysis approach. The empirical results are presented in Section 4, while Section 5 provides conclusions.

2. Data

2.1. Stock and bond market returns

The empirical analysis is performed using monthly data for stock and bond returns on ten emerging markets and the United States. The selection of the emerging markets in our sample is based on the country composition of the J.P. Morgan Emerging Market Bond Index Plus (EMBI+).[4] Stock market indices for each emerging market in the study are provided by Morgan Stanley Capital International (MSCI). The inclusion of the US market in the study was due to its role as a global factor in the international financial markets as well as for purposes of comparison with the emerging markets. Stock and bond markets of US are represented respectively by the S&P 500 index and 10-year US government bonds. Similarly to Rua (2010), stock and bond price indices are converted to the monthly returns by taking the first difference of the natural log for each stock and bond price index. The use of monthly frequencies is commonly used in the literature (see e.g., Kim and In, 2007; Aslanidis and Christiansen, 2014) and is due to the fact that data on macroeconomic factors used in further analysis are available only on a monthly level. The source of the data is Thomson Reuters Datastream. The sample period spans from January 2001 until December 2013, leading to the sample size of 156 observations for all markets included in the study. The starting point for the sample period is dictated by the availability of data.

Table 1 presents the summary statistics for stock and bond market returns for ten emerging markets and the US. As shown in Panel A, all the emerging markets in the sample have positive and higher average stock returns than the US during the period under study. The highest stock returns are recorded for Colombia, Venezuela, and Peru. The volatility levels of each of the emerging stock markets from the sample are higher than the volatility of the US market. The least volatile emerging stock markets are those of Mexico and the Philippines with standard deviations of 0.071 and 0.073 respectively, while the most volatile emerging stock markets are those of Turkey, Venezuela, and Argentina. Panel B presents the statistical properties of the bond returns for emerging markets and the US. Similarly to the pattern observed for stock markets, average returns of emerging market bonds are higher than the US (except for Argentina). Standard deviations of emerging market bonds are greater than for the US with the exceptions of Bulgaria and Mexico, suggesting that emerging countries have generally riskier bond markets. The emerging market with the most volatile bond returns is Argentina. The distribution of both stocks and bonds return series is non-normal, with kurtosis exceeding 3 in all cases (leptokurtic series) and showing negative skewness (except for the US bonds).

The unconditional stock–bond correlations for each country included in the study are reported in Table 2. All emerging markets exhibit a positive and statistically significant correlation between stocks and bonds. The level of unconditional stock–bond correlation differs substantially within the emerging market sample group, ranging from 0.130 (Venezuela) to

[3] Emerging markets bonds are often considered to be "equity like" assets because of higher country risk in emerging economies (see Kelly et al., 1998; Panchenko and Wu, 2009; Piljak, 2013).

[4] EMBI+ includes 18 countries. Our sample is limited to those countries with data available on stocks, bonds and macroeconomic factors for the entire sample period The EMBI+ is J.P. Morgan's most liquid US dollar emerging markets debt benchmark. It tracks returns for actively traded debt instruments in emerging markets including Brady bonds, Eurobonds, and traded loans issued by sovereign entities. The EMBI+ index includes only issues with a current face amount outstanding of $500 million or more and remaining life of more than 2.5 years. The J.P. Morgan indices are the most widely used and comprehensive emerging market sovereign debt benchmarks.

Table 1
Descriptive statistics for stock and bond market returns.

	Argentina	Brazil	Bulgaria	Colombia	Mexico	Peru	Philippines	Russia	Turkey	Venezuela	US
Panel A: Stock market returns											
Mean	0.0053	0.0103	0.0123	0.0235	0.0117	0.0169	0.0098	0.0123	0.0060	0.0190	0.0038
Median	0.0137	0.0153	0.0189	0.0310	0.0184	0.0198	0.0156	0.0246	0.0255	0.0137	0.0117
Maximum	0.4247	0.2509	0.3484	0.2225	0.1590	0.2394	0.1762	0.2770	0.3707	0.4838	0.1037
Minimum	−0.5392	−0.3864	−0.5816	−0.3308	−0.3664	−0.4470	−0.2788	−0.4350	−0.5318	−0.6398	−0.1839
Std. Dev.	0.126	0.105	0.109	0.085	0.071	0.090	0.073	0.101	0.141	0.127	0.045
Skewness	−0.760	−0.786	−1.164	−0.594	−1.219	−0.970	−0.406	−0.790	−0.622	−0.743	−0.836
Kurtosis	5.489	4.880	8.905	4.527	7.399	6.517	3.914	4.993	4.350	9.482	4.430
Panel B: Bond market returns											
Mean	−0.0005	0.0092	0.0064	0.0090	0.0068	0.0088	0.0094	0.0108	0.0089	0.0093	0.0042
Median	0.0111	0.0131	0.0068	0.0119	0.0077	0.0109	0.0085	0.0109	0.0110	0.0145	0.0050
Maximum	0.2912	0.2349	0.0678	0.1155	0.1171	0.1159	0.0747	0.1046	0.1175	0.1246	0.0940
Minimum	−0.5781	−0.2099	−0.1739	−0.1340	−0.0753	−0.1584	−0.0970	−0.1369	−0.1715	−0.2553	−0.0736
Std. Dev.	0.101	0.049	0.023	0.031	0.023	0.036	0.024	0.030	0.040	0.051	0.023
Skewness	−1.683	−0.454	−2.902	−0.827	−0.132	−1.071	−0.560	−0.698	−0.941	−1.462	0.054
Kurtosis	10.738	11.935	26.598	7.954	6.837	7.125	4.870	6.997	6.544	8.173	4.514

This table presents the summary statistics for stock (Panel A) and bond market returns (Panel B) in the emerging markets and the US. Data period spans from 1 January 2001 to 31 December 2013 for a total of 156 monthly observations.

Table 2
Unconditional stock–bond correlations.

	Correlation	*t*-Statistics	Probability
Argentina	0.4786***	6.7640	0.0000
Brazil	0.6832***	11.6102	0.0000
Bulgaria	0.4023***	5.4533	0.0000
Colombia	0.5385***	7.9304	0.0000
Mexico	0.4312***	5.9316	0.0000
Peru	0.5249***	7.6528	0.0000
Philippines	0.4609***	6.4447	0.0000
Russia	0.6197***	9.7988	0.0000
Turkey	0.6752***	11.3607	0.0000
Venezuela	0.1304	1.6325	0.1046
US	−0.3662***	−4.8831	0.0000

The table shows the unconditional correlations of stock and bond returns for the emerging markets and the US.
*** Statistical significance at the 1% level.

0.683 (Brazil). On the opposite side, the US market exhibits a negative statistically significant correlation of stock and bond returns during the time period under study (−0.366).

2.2. Domestic macroeconomic factors and global financial market uncertainty

The impact of domestic macroeconomic factors on the stock–bond return correlation of emerging markets is examined using monthly data on inflation, business cycle patterns, and the monetary policy stance. The consumer price index (CPI), the industrial production index (IP), and the three-month interbank interest rates (IIR) of each emerging market from the sample are used as a proxy for the domestic inflationary environment, business cycle patterns, and monetary policy stance respectively.[5]

To examine the impact of global stock and bond market uncertainty on the emerging markets stock–bond return correlation, we use implied volatilities extracted from the prices of stock and bond index options. The option-implied volatility is widely regarded as the best available estimate for market uncertainty. To capture the uncertainty of US stock and bond markets, we use VIX and MOVE implied volatility indices, constructed respectively by the Chicago Board Options Exchange and Bank of America Merrill Lynch. The VIX is calculated from S&P 500 Index option bid/ask quotes and represents a 30-day measure of the expected volatility of the S&P 500 Stock Market Index. The Merrill Lynch Option Volatility Estimate MOVE index is a yield curve weighted index of the normalized implied volatility on 1-month Treasury options representing a market estimate of future Treasury bond yield volatility.[6]

[5] The data on the three-month interbank interest rates for Mexico and Peru were not available, so we used the one-month interbank interest rates instead.

[6] The MOVE Index is a weighted average of volatilities on the two-, five-, ten-, and thirty-year contracts and is a widely used measure of government bond volatility.

3. The wavelets analysis approach

Wavelet transforms provide an extremely useful and practical set of methods for analyzing economic time-series.[7] Wavelets can unravel both the time varying and frequency specific behavior of the variables. The classical frequency analysis method, the Fourier transform, can only reveal static frequency properties. The wavelet transform, in turn, can reveal the dynamic behavior of the variable on different frequencies. For our purpose of studying the correlation structure between bond and stock markets, wavelet correlation analysis provides an appropriate framework for unraveling the dynamic and frequency specific properties of the correlation. Our analysis closely follows the approach of Rua (2010) and Croux et al. (2001).

In wavelet analysis, the time and frequency localized properties of a time-series are extracted with the help of a wavelet function $\psi_{\tau,s}(t)$ by dilating and translating it with

$$\psi_{\tau,s}(t) = \frac{1}{\sqrt{s}}\psi\left(\frac{t-\tau}{s}\right) \tag{1}$$

where s is the frequency parameter and τ expresses the position in time. By convoluting the function $\psi_{\tau,s}(t)$ with a time-series $x(t)$, we obtain the wavelet transform $W^x(\tau, s)$:

$$W^x(\tau, s) = \frac{1}{\sqrt{s}}\int_{-\infty}^{\infty} x(t)\psi^*\left(\frac{t-\tau}{s}\right)\,dt \tag{2}$$

where * is the complex conjugate. Now from the wavelet transformations W^x and W^y of two time-series $x(t)$ and $y(t)$ it is possible to obtain a wavelet correlation measure between these two variables:

$$\rho_{xy}(\tau, s) = \frac{\mathbb{R}(W^{xy}(\tau, s))}{\sqrt{|W^x(\tau, s)|^2|W^y(\tau, s)|^2}} \tag{3}$$

where $W^{xy}(\tau, s)$ is the cross-wavelet spectrum. The wavelet correlation measure $\rho_{xy}(\tau, s)$ takes values in $[-1,1]$ and so is similar to the classical correlation coefficient. As the wavelet function, we use the Morlet wavelet $\psi_{\tau,s}(t) = \pi^{-1/4}e^{i\omega_0 t}e^{-t^2/2}$, with $\omega_0 = 6$.

4. Results

4.1. The stock–bond correlation at short-term and long-term horizons

In this section we report the stock–bond correlations obtained by applying the wavelet approach. Stock–bond correlation output is illustrated by contour plots involving three dimensions: frequency, time, and the wavelet correlation value (height). The frequency dimension is shown on the vertical axis and ranges from the highest frequency of two months (top of the plot) to the lowest frequency of four years (bottom of the plot). The time dimension is presented on the horizontal axis. Finally, the height dimension (wavelet correlation) is illustrated with different shades of gray in the figures. The correlation scale ranges from −1 to 1 and is interpreted in terms of the darkness of the gray color.

Three-dimensional setting of wavelet based correlation enables us to detect the areas of varying correlation between stock and bond series both over time and frequency bands. In this integrated framework, a dark gray area at the bottom (top) of the figures corresponds to a positive stock–bond correlation at low (high) frequencies, whereas a dark gray area at the left-hand (right-hand) side signifies a positive stock–bond correlation at the start (end) of the sample period (see Rua, 2010). Analogously, a negative stock–bond correlation is matched with the light gray color. The frequency scale enables us to separate the stock–bond return correlation between short term and long term. Due to our relatively small sample period of thirteen years, the short term is considered to be the fluctuations ranging between two to four months, while the long term can be thought of as fluctuations between one and three years.

Fig. 1 presents the stock–bond correlations obtained by applying the wavelet approach to emerging markets and the US. By visually assessing the stock–bond correlation graphs, it can be seen that the stock–bond correlation of both the emerging countries and the US varies considerably across frequencies and over time. These are discussed in more detail in the following sections.

On short-term horizons (high frequency) stock–bond correlations tend to change the sign and magnitude rapidly, going from extremely positive to negative episodes for most of the emerging markets in the sample. During the period from the beginning of 2001 until the end of 2002 (the period corresponding to the "Dotcom market crash"), Argentina,[8] Bulgaria, Colombia, Russia, and Venezuela show sustainable episodes of negative stock–bond correlation. The emerging countries with the biggest drop in the correlation of stock and bond returns during this time period are Venezuela (from +0.85 to −0.70) and Argentina (from +0.45 to −0.50). Other emerging markets in the sample, specifically Mexico, Peru, the Philippines, and

[7] For more information on Wavelet analysis see Torrence and Compo (1998) and Grinsted et al. (2004).
[8] This time period also coincides with Argentina's debt default crisis.

Turkey showed an increasing negative change in the magnitude of the stock–bond correlation during this period. Another major decrease with negative patterns of short-term stock–bond correlation is discernible during the period corresponding to the financial crisis of 2008 in the case of most of the emerging markets. Negative correlation is observed in the case of Brazil, Bulgaria, Ecuador, Mexico, Peru, Russia, and Venezuela. The country with the biggest drop in the correlation during this period is Russia, with a change from +0.70 to −0.65. The remaining emerging markets in the sample showed a considerable decrease in the magnitude of the stock–bond correlation; however the correlation remains positive in the short-term horizon.

Overall, the short-term horizon analysis of the stock–bond correlation in emerging markets demonstrates that the stock–bond correlation varies considerably over time. In addition, we observe sustained negative episodes of correlation in

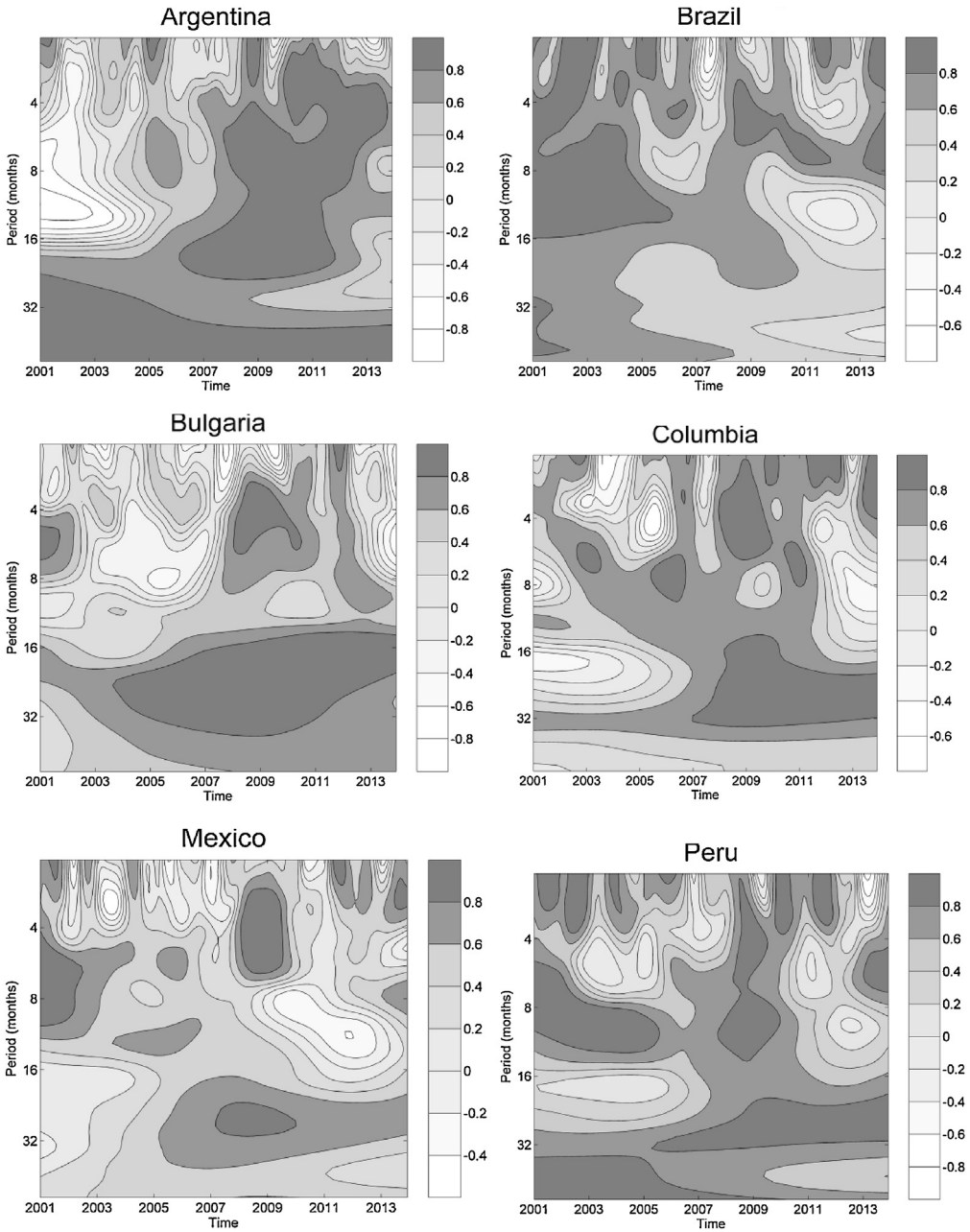

Fig. 1. Stock–bond correlations for Argentina, Brazil, Bulgaria, Colombia, Mexico, Peru, Philippines, Russia, Turkey, Venezuela, and the USA based on the wavelet correlation measure. This figure presents the wavelet based correlation measure of the stock–bond correlations for both the emerging markets and the USA. Time and frequency are represented on the horizontal and vertical axes respectively. The wavelet correlation value is illustrated by different shades of gray color, indicated on a gray scale from −1 to 1. Increasingly positive value of the stock–bond correlation coincides with deepening darkness of gray, imitating the height in the surface plot; while the increasingly negative stock–bond correlation is symbolized by lightening of gray color.

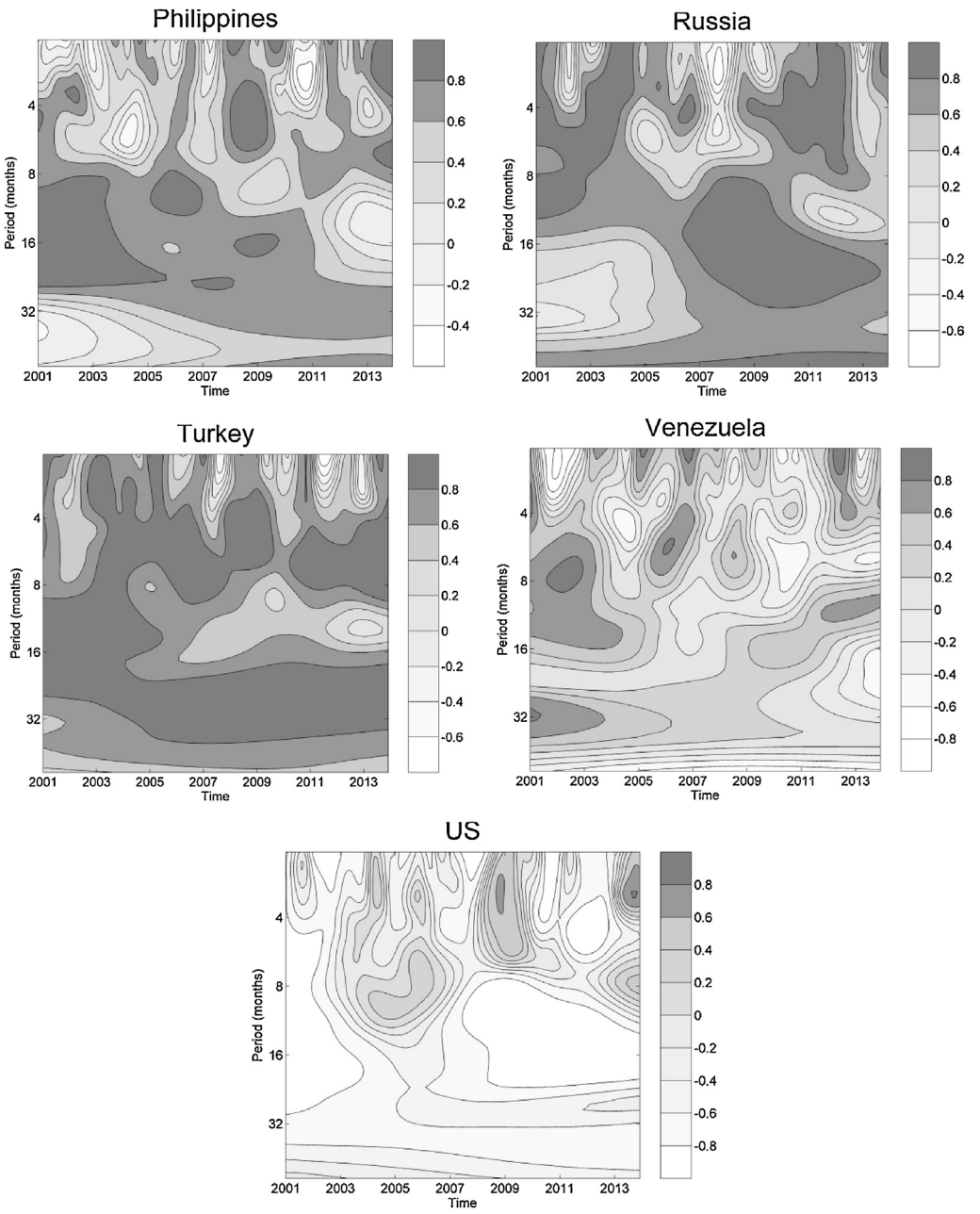

Fig. 1. (*Continued*).

the short term that seem to coincide with the crisis periods. This result is consistent with the "flight-to-safety" phenomenon observed in the developed markets (Gulko, 2002; Andersson et al., 2008; Baur and Lucey, 2009). Thus our empirical findings further suggest that short-term investors tend to switch their positions from stocks to bonds during crisis periods and that emerging market bonds provide a hedging opportunity for the emerging market stocks in the short run.

The patterns of the long-term horizon (low frequency) correlation between emerging markets stock and bond returns, in turn, are quite different; the sign of the correlation remains positive and less volatile for all the emerging countries (with the exception of Venezuela, which shows a short period of negative correlation). The highest levels of positive correlations between stock and bond returns are found in Bulgaria, Russia, and Turkey (+0.95 for all) during the period following the financial markets crash of 2008. The highly positive stock–bond correlation on the long-term horizon throughout the entire sample lends no support to the "flight-to-safety" phenomenon. This result suggests that long-term investors do not see the emerging markets bonds as a safe asset compared to emerging market stocks. Therefore the emerging market bonds exhibit

properties of "equity like" assets due to the high country risk in emerging economies (Kelly et al., 1998; Panchenko and Wu, 2009; Piljak, 2013).

The next step in our analysis entails assessing the stock–bond correlation pattern for the US market at the short and long horizons, and comparison with patterns observed in the emerging markets. Similarly to emerging markets, the US stock–bond correlation on the short-term horizon changes rapidly from positive to negative. The lowest levels of negative correlation are found during the Dotcom crash (−0.80), and during the financial crisis of 2008 (−0.85). The stock–bond correlation for the US demonstrates a completely different pattern from the emerging markets on the long-term horizon. Unlike the emerging countries, the US market correlation between stock and bond returns remains negative on the long horizon, demonstrating the lowest values during periods coinciding with the "Dotcom crisis" and the financial crisis of 2008. The negative episodes in the US stock–bond correlation are consistent with the literature, suggesting that bonds tend to outperform stocks during crisis periods leading to a negative relationship of stock–bond returns (Ilmanen, 2003).

4.2. Impact of global financial market uncertainty and domestic macroeconomic factors on the stock–bond correlation

In the next stage of our analysis, we examine factors that may cause the time variation in the correlation between the stock and bond returns of emerging markets on different time horizons. Evidence in the literature on developed markets suggests that inflation and economic growth unconditionally determine the government bond yields (Andersson et al., 2008). In particular, there is a negative relationship of inflation and economic growth with bond prices. The impact of growth and inflation on stock prices is somewhat uncertain.[9] Nevertheless, some studies suggest that high inflation has a negative impact on stock prices (Ilmanen, 2003). Monetary policy easing has a positive effect on both stocks and bonds, hence the positive relation with the stock–bond correlation. Finally, financial market turbulence periods may cause risk-averse investors in developed countries to shift to safer assets, such as government bonds, causing "flight-to-safety" episodes.

To determine the impact of relevant factors affecting the stock–bond correlation in emerging markets we account for both global financial market uncertainty and domestic macroeconomic factors. The global uncertainty factors used are the VIX and MOVE indices that serve respectively as proxies for US stock and bond market uncertainty. The domestic factors used to proxy the business cycle fluctuations, the inflation environment, and the monetary policy stance are industrial production (IP), consumer price index (CPI) and three-month interbank interest rates (IIR) respectively. Both the global uncertainty and domestic macroeconomic factors used are at a monthly level with the sample period corresponding to the period used for the wavelet correlation analysis.

We conduct the regression analysis of the wavelet stock–bond correlation at different time frequencies on the aforementioned proxy variables for financial market uncertainty, domestic economic growth, inflation, and monetary policy stance.[10] A separate OLS regression is conducted for each emerging market in the sample as well as for the US.[11] Consequently, the following regression model is estimated:

$$WCOR_{i,f} = \alpha + \beta_1 VIX + \beta_2 MOVE + \beta_3 CPI_i + \beta_4 IP_i + \beta_5 IIR_i + \varepsilon_{i,f} \quad (4)$$

where $WCOR_{i,f}$ denotes the wavelet correlation between stock and bond returns for country i; f is the frequency domain given at two different levels, expressed in time units of 3 months (short-term horizon) and 2 years (long-term horizon).[12]

The regression results for the impact of global financial market uncertainty and domestic macroeconomic factors on the stock–bond return correlation in emerging markets and the US are reported in Table 3. As in most multi-country studies, slight differences in terms of significance levels and the coefficient signs of explanatory factors occur in the regression models. Nevertheless, several interesting findings can be drawn from the empirical results of the regressions. Generally, the results suggest considerable variations in factors impacting on the correlation at the short-term horizon (high frequency) as opposed to the long-term horizon (low frequency).

The short term horizon analysis (given in panel A) reveals that there is at least one highly statistically significant factor of interest for each individual country. The results show that the domestic monetary policy stance is the most influential factor in the short term, being highly statistically significant in seven out of ten emerging markets. The coefficient sign of three-month interbank interest rate changes across the countries, suggesting that the way in which monetary policy affects the stock–bond correlation is not consistent in all emerging markets. For instance, in certain countries (Brazil, Colombia, and Mexico) the sign of the IIR coefficient is positive, while for other countries (Argentina, Peru, Russia, and Venezuela) the sign is negative. A factor with moderate impact on the short-term stock–bond correlation in the emerging markets is US equity market uncertainty. The VIX index is statistically significant in five markets in the short horizon analysis. Furthermore, the MOVE index has only a minor effect on the correlation in the short run, being significant in only three emerging markets. The

[9] For more discussion on this issue please see Andersson et al. (2008).

[10] To check for the stationarity of the explanatory variables used in the regression analysis two unit root tests were performed, specifically Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP). The lag length criterion for the unit root tests is based on the Schwarz information criterion. The results suggest that the explanatory variables are stationary. Therefore the null hypothesis of a unit root can be rejected for the time series used in the regression analysis. Not all unit root tests results for explanatory variables are shown here due to space considerations, but they are available upon request.

[11] To check for multicollinearity between the explanatory variables we rely on Variance Inflation Factor (VIF) test. The results suggest no multicollinearity problem among the variables. The VIF test results are available upon request. Readers interested in the VIF measure should refer to O'Brien (2007).

[12] A similar approach to determining short and long horizons is applied in Kiviaho et al. (2014).

Table 3
Relationship of the stock–bond correlations with the domestic macroeconomic factors and the global financial market uncertainty in emerging markets and the USA.

	α	VIX	MOVE	$CPI_{domestic}$	$IP_{domestic}$	$IIR_{domestic}$	R^2
Panel A: Short-term horizon (f = 0.25 year)							
Argentina	−0.7843**	0.0130***	−0.0008	0.0029	0.0061	−0.0095***	0.652
	(0.3841)	(0.0043)	(0.0015)	(0.0025)	(0.0040)	(0.0021)	
Brazil	1.2880	−0.0023	−0.0019	0.0003	−0.0196	0.0304**	0.233
	(0.8743)	(0.0067)	(0.0020)	(0.0003)	(0.0136)	(0.0144)	
Bulgaria	−0.5015	−0.0154***	0.0009	0.0000	0.0032	−0.0515	0.260
	(0.3509)	(0.0052)	(0.0016)	(0.0001)	(0.0040)	(0.0320)	
Colombia	−2.2137***	0.0096*	−0.0016	0.0178***	0.0037	0.0772***	0.495
	(0.4879)	(0.0054)	(0.0020)	(0.0056)	(0.0043)	(0.0264)	
Mexico	−2.1035**	−0.0040	0.0036**	0.0306***	−0.0122	0.0746***	0.584
	(1.0204)	(0.0055)	(0.0016)	(0.0056)	(0.0111)	(0.0192)	
Peru	0.8891	0.0178***	0.0012	−0.0072	0.0007	−0.0968***	0.460
	(0.7675)	(0.0043)	(0.0014)	(0.0139)	(0.0032)	(0.0247)	
Philippines	−0.5863	−0.0167**	0.0058***	0.0035	0.0048	−0.0517	0.386
	(0.8768)	(0.0082)	(0.0019)	(0.0064)	(0.0031)	(0.0475)	
Russia	2.5270***	0.0093	−0.0007	0.0023*	−0.0238**	−0.0510***	0.240
	(0.7120)	(0.0064)	(0.0023)	(0.0013)	(0.0102)	(0.0117)	
Turkey	1.3502**	−0.0097	0.0044***	−0.0016	−0.0070*	−0.0091	0.284
	(0.5489)	(0.0062)	(0.0017)	(0.0034)	(0.0043)	(0.0167)	
Venezuela	1.0331***	0.0051	−0.0016	0.0006	0.0000	−0.0198***	0.228
	(0.3275)	(0.0057)	(0.0015)	(0.0005)	(0.0000)	(0.0044)	
US	−3.0742	−0.0173*	0.0083***	0.0096**	0.0037	0.0121	0.190
	(2.0761)	(0.0099)	(0.0027)	(0.0045)	(0.0256)	(0.0545)	
Panel B: Long-term horizon (f = 2 years)							
Argentina	0.5106***	0.0039***	0.0004	0.0077***	0.0056***	0.0004	0.920
	(0.0604)	(0.0013)	(0.0003)	(0.0005)	(0.0006)	(0.0004)	
Brazil	0.9146***	0.0030***	0.0006**	−0.0001***	−0.0010	−0.0055**	0.789
	(0.1195)	(0.0009)	(0.0002)	(0.0000)	(0.0012)	(0.0027)	
Bulgaria	−0.0817	0.0029**	−0.0015***	0.0001***	0.0014*	0.0313***	0.858
	(0.0768)	(0.0014)	(0.0005)	(0.0000)	(0.0008)	(0.0067)	
Colombia	−1.6784***	0.0031*	−0.0002	0.0166***	0.0044***	0.0201**	0.930
	(0.1404)	(0.0019)	(0.0006)	(0.0015)	(0.0009)	(0.0083)	
Mexico	1.0286*	−0.0115**	0.0034***	0.0216***	0.0107	0.0067	0.740
	(0.5320)	(0.0049)	(0.0008)	(0.0052)	(0.0092)	(0.0163)	
Peru	−0.6752***	0.0036**	0.0000	0.0074**	0.0030***	0.0096	0.902
	(0.1873)	(0.0016)	(0.0005)	(0.0032)	(0.0008)	(0.0107)	
Philippines	0.7578***	−0.0007	0.0007***	0.0016**	0.0000	0.0160**	0.808
	(0.1070)	(0.0007)	(0.0002)	(0.0008)	(0.0003)	(0.0072)	
Russia	−0.7763***	0.0063*	0.0002	0.0019***	0.0081***	−0.0041	0.844
	(0.1896)	(0.0033)	(0.0009)	(0.0004)	(0.0026)	(0.0060)	
Turkey	2.0277***	0.0008	−0.0002	0.0076***	−0.0011*	−0.0180***	0.948
	(0.1030)	(0.0011)	(0.0003)	(0.0005)	(0.0006)	(0.0023)	
Venezuela	−0.0156	0.0023**	0.0000	−0.0023***	0.0002***	0.0009	0.958
	(0.0491)	(0.0009)	(0.0003)	(0.0001)	(0.0000)	(0.0007)	
US	−2.0932***	−0.0018**	−0.0005*	0.0044***	0.0073***	−0.0106**	0.909
	(0.1910)	(0.0009)	(0.0003)	(0.0004)	(0.0022)	(0.0042)	

This table presents the regression model results linking the short- and long-term horizons of the wavelet correlation with domestic macroeconomic factors and global financial uncertainty (Eq. (4)). The explanatory variables include two global factors originating in the US market: VIX (Chicago Board Options Exchange Implied Volatility Index as a proxy for global stock market uncertainty) and MOVE (Merrill Lynch Option Volatility Estimate Index as a proxy for global bond market uncertainty). Domestic macroeconomic factors include: CPI (the Consumer Price Index as a proxy for inflation environment), IP (the Industrial Production Index as a proxy for domestic business cycle fluctuations), and IIR (the three-month interbank interest rate as a proxy for monetary policy stance). Figures in parenthesis are the Newey-West robust standard errors.

* Statistical significance at 10%.
** Statistical significance at 5%.
*** Statistical significance at 1%.

business cycle pattern is the least influential macroeconomic factor in the short run as it is significant in only two markets, suggesting that the emerging market stock–bond return correlation is virtually unaffected by the domestic business cycle patterns at the short horizon.

Panel B of Table 3 reports the impact of global financial market uncertainty and domestic macroeconomic factors on the correlation between stock and bonds at the long-term horizon (low frequency). Generally, in comparison to the short-term horizon analysis, a significantly higher impact of factors used on the stock–bond correlation is found at the long-term horizon. For each emerging market there were at least three statistically significant variables of interest affecting the stock–bond correlation in the long run, while for certain countries there are four or even five significant factors. The explanatory power

of the model (*R*-squared) differs considerably between short- and long-term analyses, ranging from 22% to 65% in the short term, and from 74% to 96% in the long-term period.

The most influential macroeconomic factor for the long-term period stock–bond correlation is inflation, as the consumer price index variable is highly significant in all ten emerging markets in the sample. This result is consistent with the general literature, suggesting that inflation can be seen as one of the key driving factors for the correlation between stock and bond returns. In particular, our results demonstrate that the inflation and stock–bond return correlation at the long-term horizon are positively related, given that the sign of the estimated coefficient for inflation is positive in almost all emerging countries (except Brazil and Venezuela). Since bond prices are negatively related to inflation, our finding indicates that high inflation also has a negative impact on stock prices, which is in line with Ilmanen (2003) and Andersson et al. (2008). Hence, negative relation of inflation with both stocks and bonds consequently leads to movement of stocks and bonds in the same direction, resulting in a positive relation between inflation and the stock–bond correlation.

The second most important factor in explaining the long-term horizon correlation of emerging stocks and bonds is global stock market uncertainty. US stock market implied volatility is found to be significant in nine out of ten emerging markets. A significant and positive sign for the VIX coefficient is found in seven countries, namely Argentina, Brazil, Bulgaria, Colombia, Peru, Russia, and Venezuela, suggesting that high stock market uncertainty has a negative effect on both stocks and bonds in those emerging markets in the long run. This finding further implies that the stock and bond prices on emerging markets tend to co-move more during periods of high uncertainty on the US equity market.

The third influential macroeconomic factor for the stock–bond correlation in the long run is the business cycle, appearing significant in eight emerging markets. The estimated coefficients of the industrial production index are positive and statistically significant in seven countries, specifically Argentina, Bulgaria, Colombia, Peru, Russia, Turkey, and Venezuela. This result indicates that the domestic trend in growth may have a similar effect on stock and bond returns in the long run, causing a positive correlation. The effect of monetary policy stance is similar on the short- and long-term horizons. Similarly to the short-term horizon, the sign of the IIR coefficient is not consistent on the long-term horizon. The empirical analysis also shows that the MOVE index is the least influential factor for the emerging market stock–bond correlation analysis in the long term. Generally the stock–bond correlation in emerging markets is virtually unaffected by the implied volatility of the US bond market. Therefore US stock market uncertainty plays a much bigger role than US bond market uncertainty as regards the impact of the correlation on stock and bond returns in emerging markets.

We continue our analysis by examining factors affecting the stock–bond correlation in the US market on the short and long horizons, and by providing a brief comparison with the case of the emerging markets. The regression results for the US market demonstrate that the implied volatility of both stocks and bonds impacts the correlation of stock–bond returns at the short and long horizons. The negative significant coefficient for VIX is consistent with the general literature on the stock–bond correlation in developed markets and the "flight-to-safety" phenomenon. Differently from the emerging markets, the US stock–bond correlation is affected by the uncertainty also originating from bond market. Finally, similarly to the emerging markets, the estimated coefficients on CPI and IP are positive and highly statistically significant at the long horizon, implying that growth in inflation and production has a positive impact on the stock–bond correlation.

5. Conclusions

This article examines the short- and long-term horizon patterns of the stock–bond correlation in emerging markets and the factors driving the time-varying correlations. In particular, we study the impact of global financial market uncertainty and domestic macroeconomic factors on the stock–bond correlation. We utilize the powerful tool of wavelet correlations, which enables us to simultaneously consider the time and frequency domains in the co-movement between stock and bond returns. Our study contributes to the literature by providing new evidence on the impact of macroeconomic factors and global financial market uncertainty on both short- and long-term stock–bond correlations in emerging markets. While earlier research has focused on the impact of uncertainty coming only from stock markets, we examine connections between global bond market uncertainty and stock–bond correlations.

Our empirical findings indicate that the stock–bond correlation in emerging markets differs considerably over time and between short and long horizons. Using data from 10 emerging markets, namely Argentina, Brazil, Bulgaria, Colombia, Mexico, Peru, the Philippines, Russia, Turkey, and Venezuela, we find that the short-term correlations between stocks and bonds change the sign rapidly, showing sustained episodes of negative correlation corresponding to the crisis periods. Hence the short-term analysis suggests that rapid changes in the correlation of emerging markets stocks and bonds during crisis periods are consistent with the "flight-to-quality" phenomenon. The long-term horizon analysis demonstrates that the stock–bond correlation in emerging markets remains positive throughout the entire sample period, suggesting "equity like" properties of emerging market bonds in the long run due to the country-specific risks.

Further results indicate that macroeconomic factors can explain the time variations in the correlation of stock and bond returns in emerging markets on both the short- and long-term horizons. Generally, macroeconomic factors have greater explanatory power in explaining the correlation in the long run (low-frequency) compared to the short run (high frequency). The most prominent macroeconomic factor in the short-term analysis is domestic monetary policy stance. Our analysis also suggests that monetary policy easing boosts the performance of both stocks and bonds, producing a positive relationship with the stock–bond correlation for Argentina, Peru, Russia, and Venezuela, while easing monetary policy in Brazil, Colombia, and Mexico leads to decoupling the performance of stocks and bonds in the short run.

The long-term horizon analysis shows that inflation and US stock market implied volatility are the most important macroeconomic factors responsible for time varying of the stock–bond return correlation. Furthermore, the long run analysis demonstrates a positive relationship between inflation and the stock–bond correlation in emerging markets. Since bond prices are negatively related to inflation, our finding indicates that high inflation also has a negative impact on stock prices. The empirical findings further indicate a positive relationship between US stock market uncertainty and the stock–bond correlation in emerging markets. In addition, global stock market uncertainty plays a more significant role than global bond market uncertainty in explaining stock–bond correlations in emerging markets.

The results of this study offer interesting insights for both short- and long-term investors, as they can benefit from taking account of the time and frequency domains analysis of the stock–bond correlation in making asset allocation decisions. Moreover, our findings are also helpful in shedding further light on the influence of macroeconomic factors and financial market uncertainty on the stock–bond correlation in emerging markets at the short and long horizons.

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