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Financial Linkages Between the United States and Latin America—Evidence from Daily Data

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Financial Linkages Between the U.S. and Latin America: Evidence from Daily Data

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Abstract

This paper investigates the linkages between the financial markets in the United States and the seven largest Latin American economies, focusing on the impact of shocks originating in the U.S. stock, bond, and currency markets. After documenting that cross-country linkages were different in "tranquil" and "turbulent" times within our sample, we find that: (i) for stock markets, recent episodes of market turbulence stood out from preceding ones by showing an increased sensitivity of Latin American markets to U.S. shocks; (ii) currency markets in Latin America exhibited a decrease in cross-market linkages with the U.S. during the last episodes of volatility, consistent with increased exchange rate flexibility in the region; and (iii) the external bond markets in Latin America remained on a trend of weakening linkages with U.S. corporate bonds, while they increased their sensitivity to movements in other emerging market bond markets..

JEL Classification Numbers:

Keywords: Financial linkages, Latin America, U.S. shocks , financial markets

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I. INTRODUCTION

With financial markets becoming increasingly integrated, financial market linkages are also believed to be an increasingly important mechanism for the transmission of shocks across countries. Starting from the early 1990s, in particular, there has been a tremendous increase in financial liberalization in developing countries and a substantial increase in financial interdependencies of Latin America with the United States (Calvo and others (1993), Edwards and others (2003)).This process in turn raises the question of whether increased financial liberalization and interdependence have magnified the spillovers of financial shocks from the United States to Latin America.

Episodes of financial market turbulence originating in industrial countries—and in the United States in particular—are often thought to have a major impact on emerging market economies. For instance, the IMF's Fall 2006 *Global Financial Stability Report* described the global market turbulence in May-June (2006) as having its roots in growing concerns about rising inflationary pressures in advanced economies. Against a backdrop of a continued global expansion and rising oil and commodity prices, increased uncertainty about the extent of monetary tightening needed to keep inflation under control in major countries led to an increase in investor's risk aversion that led in turn led to sharp corrections in risky asset prices, interest rate increases, and a rise in volatility. This turbulence affected emerging markets in Latin America and elsewhere, with equity prices falling, exchange rates depreciating sharply and sovereign bond spreads widening.

This paper aims at investigating the linkages between the financial markets in the United States and those of the seven largest Latin American economies using daily data,[2] Focusing on spillovers[3] of shocks that originate in the U.S. stock, bond, and currency markets. In particular, this paper aims at documenting changes in the linkages that occur both across periods of different market volatility and over time. After documenting that cross-country linkages were different from tranquil times, we find that recent episodes of market turbulence stood out from preceding episodes (the paper covers a sample period that ends in August 2006, and thus does not include some short-lived bursts of market turbulence in 2007). Our main results can be summarized as follows. First, for stock markets, most recent episodes of market turbulence were unusual because they showed an increased sensitivity of Latin American markets to U.S. shocks, reversing a trend of weakening linkages. Second, currency markets in Latin America exhibited a decrease in cross-market linkages with the United States during the last episode of volatility, which was consistent with increased flexibility in exchange rate regimes compared with the 1990s. Third, the sovereign external bond markets in Latin America displayed a trend of weakening linkages with U.S. corporate bonds while becoming more sensitive to to movements in other emerging market bond markets.

[2] The Latin American countries considered in this paper are Argentina, Brazil, Chile, Colombia, Mexico, Peru, and Venezuela. These represent approximately 90 percent of the Latin American and Caribbean region's GDP.

[3] Masson (1998) employs the term "spillovers" for effects that arise from macroeconomic interdependence among developing countries, but following Gelos and Sahay (2001), this paper uses the term in a broader sense where a "spillover" is any type of impact on other countries financial markets.

The remainder of this paper is structured as follows. Section II briefly overviews some related findings on financial market inter-linkages, in particular between the United States and Latin America. Section III outlines the criteria we use to identify periods of turbulence in the United States from 1997-2006 and describes the data used in this paper. Section IV investigates the linkages between financial markets in the United States and Latin America, with a focus on comparing their strength during tranquil and turbulent periods. Section V tracks financial linkages between these two regions over time and, in particular, asks whether the May-June 2006 episode of financial volatility in the United States—the most recent one in our sample—was "abnormal". Section VI summarizes and concludes.

II. Related Literature

There is abundant theoretical and empirical work on the transmission of financial shocks across countries. We briefly review this literature.

Most research on cross-country linkages has been carried out under the umbrella of the "contagion" literature that has flourished over the last two decades. The objective of this line of research has been to quantify the strength of spillovers across markets during and after financial crises. While the earlier literature dates back to the aftermath of the October 1987 U.S. stock market crash (Eun and Shim (1989), King and Wadhwani (1990) and Hamao and others (1991)), it was after the 1997 Asian crisis that research on contagion became increasingly popular.[4] The definition of the term "contagion" as well the relative importance of different propagation channels of financial shocks have, however, remained a topic of debate.

The most commonly accepted definition of contagion is that contagion occurs if a shock to one market (in the "crisis" country) results in an increased correlation between that market and another country's market. Most early research found support for the existence of this type of financial contagion in stock market returns after a major crisis. However, an important contribution by Forbes and Rigobon (2002) disputed these early findings by pointing out that the correlation coefficients—the tool commonly used to gauge changes in comovements across markets—lead to biased estimates of correlations across markets if market volatility changes across crisis and non-crisis periods (that is, in the presence of heterosckedasticity), as is often the case during turbulent periods. Once they correct for this bias, they find virtually no evidence of contagion. Recently, the contagion literature has moved beyond the initial approach of assessing the strength of comovements in asset price returns. Contagion may not be limited to asset returns, though. Diebold and Yilmaz (2006) have recently documented the existence of strong contagion in volatilities across markets.

An extensive strand of this literature, particularly relevant to our paper, has documented how the United States is a major source of spillovers to financial markets around the globe (Ng(2000), and Chan-Lau and Ivaschenko (2002)). Arora and Cerisola (2000) showed that the stance and predictability of U.S. monetary policy influences country risk, proxied by sovereign bond spreads, as they are important determinants of economic growth in

[4] For comprehensive surveys of the empirical literature, see Claessens and others (2001).

developing countries. Similarly, Wongswan (2005) found that surprises in U.S. monetary policy announcements have significant impacts on Latin American stock markets and other developing stock markets. Pagan and Soydemir (2000) found evidence of strong linkages between the stock markets of Mexico and the United States; linkages between the U.S. stock market and the stock markets of Argentina, Brazil, and Chile were weaker but significant.[5] Canova (2005) took a broader perspective and studied the transmission of U.S. demand and supply shocks to Latin America. He found that U.S. monetary shocks produce significant fluctuations in Latin America, but other demand shocks and supply shocks do not.

Our paper contributes to this literature by undertaking a comprehensive analysis of the linkages among the U.S. and Latin American stock, currency and bond markets using daily data and a new criterion to identify periods of market turbulence. By undertaking this comprehensive analyis of linkages we study whether there are has been a systematic pattern—and whether this has changed in recent times—in linkages between financial markets of the two regions. Our purpose is to address the following questions: How closely are financial markets in the two regions related? Are financial linkages different during periods of financial market turbulence in the United States? Are these linkages stable over time? Were the recent episodes of volatility "abnormal"?[6]

III. Identifying Tranquil vs. Turbulent Times

Our starting point is a definition of market turbulence in the United States. We define "tranquil" and "turbulent" according to a criterion that uses the financial markets' own forward-looking assessement of market volatility. This is embedded in the implied stock market volatility in the United States, reported by the Chicago Board Options Exchange. More specifically, the Volatility Index (VIX) measures market expectations of near-term volatility conveyed by stock index option prices. Since stock market volatility is commonly associated with periods of financial turmoil, the VIX is often referred as an "investor fear gauge".[7] As already mentioned, a key advantage of using implied volatility is that it is forward-looking. A second advantage is that it is generally believed to be exogenous to emerging market economies, and thus it provides a clear identification of episodes of market turbulence that constitute external shocks for these economies . Historically, the VIX has hit its highest levels during times of financial turmoil and investor fear and abates when markets recover and investor fear subsides. It also seems to have a well-documented relationship with future recessions (IMF (2006)). Finally, the VIX is particulary relevant to the questions addressed in this paper because of its tendency to jump during past episodes of "sudden stops" to emerging market capital inflows, as emphasized by Caballero and Panageas (2004).

[5] There are many other studies on both short-run and long-run linkages between the U.S. and Latin American equity markets. These include Chen and others (2002); Fernandez-Serrano and Sosvilla-Rivero (2003); and Garrett and others (2004)).

[6] Gelos and Sahay (2001) and Chakrabarti and Roll (2002) carried out a similar exercise for transition economies.

[7] The measure being used here is the "new" VIX. Details on the computation of VIX are provided in http://www.cboe.com/micro/vix/vixwhite.pdf.

A simple preliminary exercise suggests that the VIX measure of market volatility is likely to affect the behavior of U.S. markets in a nonlinear fashion, which justifies a criterion for identifying tranquil and turbulent periods based on VIX. To see this, we estimated the following simple equation:

$$Y_t = \alpha + \beta_1 \, VIX_{t-1} + \beta_2 \, VIX^2_{t-1} + \nu_t \qquad (1)$$

The dependent variable, Y_t, represents, in turn, the daily percentage change in U.S stock prices, the daily percentage change in the U.S. dollar exchange rate against the euro, and the change in U.S. corporate spreads, depending on the market under consideration. The dependent variable is regressed on the lagged VIX value and the lagged VIX value squared.

Table 1: VIX regressions

	Dependent variables		
	U.S Stock price index (percentage change)	U.S Exchange rate against the Euro (percentage change)	U.S Corporate bond spreads (basis points, daily change)
Lagged VIX	0.052**	-0.0067	-0.83***
	(0.023)	(0.012)	(0.182)
Lagged VIX squared	-0.0015***	0.00015	0.021***
	(0.0005)	(0.0002)	(0.0043)
Constant	-0.332	0.075	7.156***
	(0.223)	(0.133)	(1.81)
Observations	2520	1998	2497

Notes: See Appendix for data sources and definitions. *, **, and *** denote significance levels at the 10, 5 and 1 percent levels based on robust standard errors. The standard errors are in parenthesis.

Estimation results, presented in Table 1, show that the stock market is more likely to fall, the dollar to depreciate, and corporate spreads to widen when the VIX rises sufficiently. These findings are consisent with market views that VIX values above 25 are "large", and provide the rationale for a criterion that identifies two regimes for market volatility.

> ***Criterion:*** *A turbulent period starts on the trading day when the change in the VIX is greater than three times the 20-day rolling standard deviation of the VIX as of the previous day:* [8]

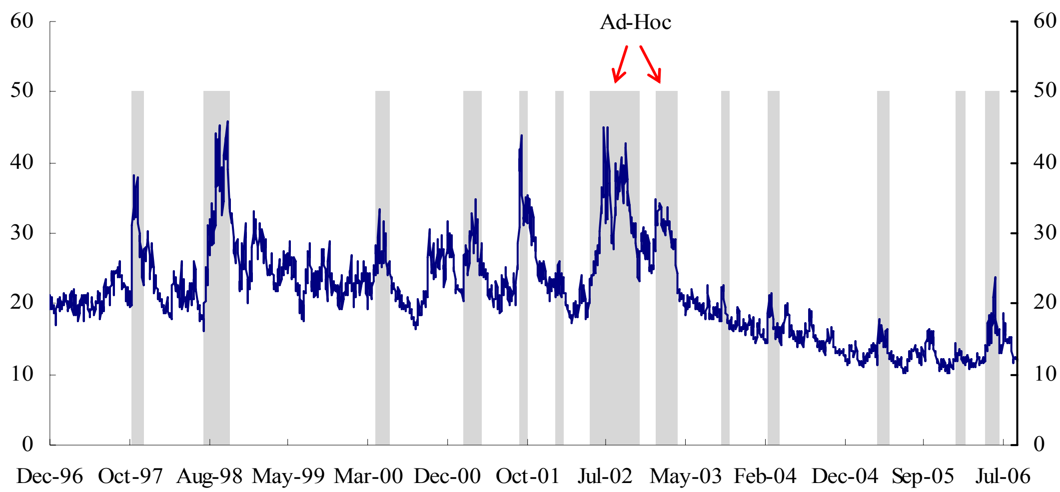
$$VIX_t > VIX_{t-1} + 3\sigma_{t-1} \qquad (2)$$

[8] The standard deviations are based on 20-day rolling averages of VIX data. We chose 20 days as typically there are 20 trading days in a month

The turbulent period ends on the trading day when the 20-day rolling averages of VIX continuously decrease for at least five trading days. A tranquil period begins the day after the previous turbulent period ended.

While arbitrary to some extent, this criterion has desirable properties. First, it identifies turbulent periods that begin with sudden spikes in volatility, as it requires that the change in VIX is at least three times the rolling monthly average of its standard deviation. Setting the required jump to three times the previous day's standard deviation guarantees that we do not pick up too many turbulent periods. Secondly, we require that a turbulent period ends only when the VIX has shown a tendency to abate. Both conditions are necessary in light of the high volatility of the VIX time series (Figure 1). This criterion identifies 11 episodes of turbulence, represented by a vertical bar in Figure 1, between January 1997 and August 2006.[9] We also chose to add two additional episodes that were not captured by our criterion because the increase in the VIX , while large, were more gradual than in other cases, and thus did not meet our criterion for turbulent periods even though visual inspection of the VIX time series reveals that the market underwent significant and persistent increases in volatility during these two periods (these two periods are labeled "*ad hoc*" in Figure 1).[10]

Figure 1: Implied Stock Market Volatility (VIX)



Notes: See Appendix for data sources and definitions.

Our variables of interest are defined as follows (see Appendix for data sources and definitions): daily stock market returns based on percentage changes of each country's aggregate stock market index;[11] daily percentage changes in the exchange rates of the U.S.

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[9] See data Appendix II for dates.

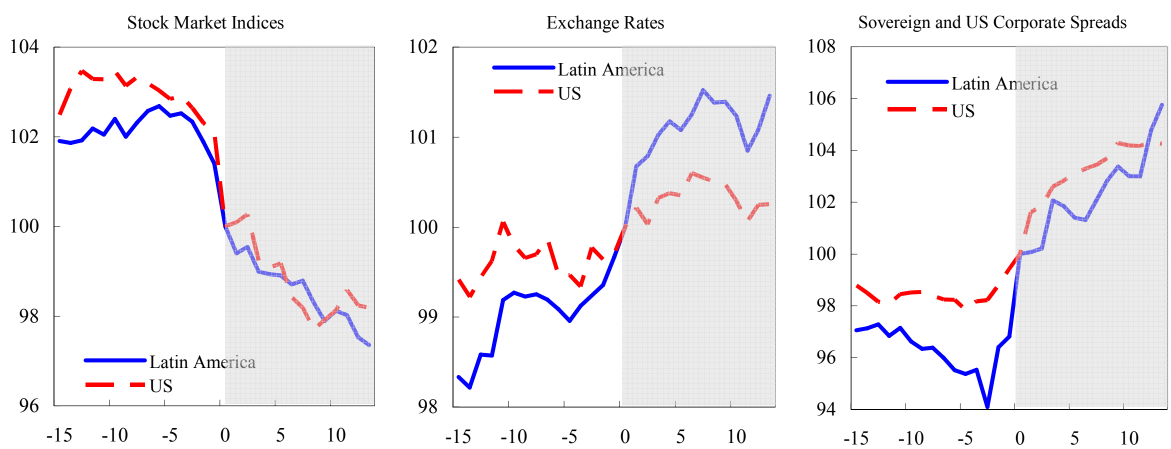
[10] We carried out our analysis with just the 11 episodes and found our results did not differ much from those obtained using the 13 episodes. Thus, we report results based on the 13 episodes only.

[11] As standard in the literature, daily returns are based on U.S dollars, which emphasizes the perspective of foreign investors.

dollar and Latin American currencies relative to the euro;[12] daily changes (in basis points) in U.S. corporate bond spreads, defined as the difference between high-yield corporate bonds and five-year U.S. treasury bonds; and, for the Latin American countries, daily changes (in basis points) in external government debt spreads over U.S. Treasuries.

A preliminary look at the data reveals that, at least for the first few days, the onset of turbulent periods seemed to affect markets in both the United States and Latin American countries. The onset of market turbulence in the United States was generally associated with a fall in stock market indices in both the United States and Latin America, exchange rate depreciations of the dollar and Latin American currencies against the euro, and increases in U.S. corporate and Latin American government spreads (Figure 2). Moreover, these comovements between market movements in the United States and Latin America were quantitatively substantial. The next step is to investigate these patterns of correlation in greater detail.

Figure 2: Stock Market, Exchange Rates, and Spreads Before and During Turbulent Periods
(Day 0= first day of turbulent period; value on the first day of the turbulent period = 100)



Notes : See Appendix for data sources and definitions. The figure shows the average values across the 13 turbulent periods and Latin American countries of the stock market indices, exchange rates against the euro, Latin American sovereign spreads, and U.S. corporate spreads before and during the turbulent period. All series are normalized so that their values at the beginning of a turbulent period is equal to 100. Argentine sovereign spreads during the time of default are not included.

IV. Are Linkages Different in Tranquil and Turbulent times?

Our first question is whether linkages across the three markets we consider are different in turbulent and tranquil times. We address this question by first reporting a set of standard descriptive statistics and then by analyzing the dynamic responses of Latin American markets to shocks in the U.S. markets using simple vector autoregressive models. Finally, we examine the importance of U.S. market volatility for domestic market volatility.

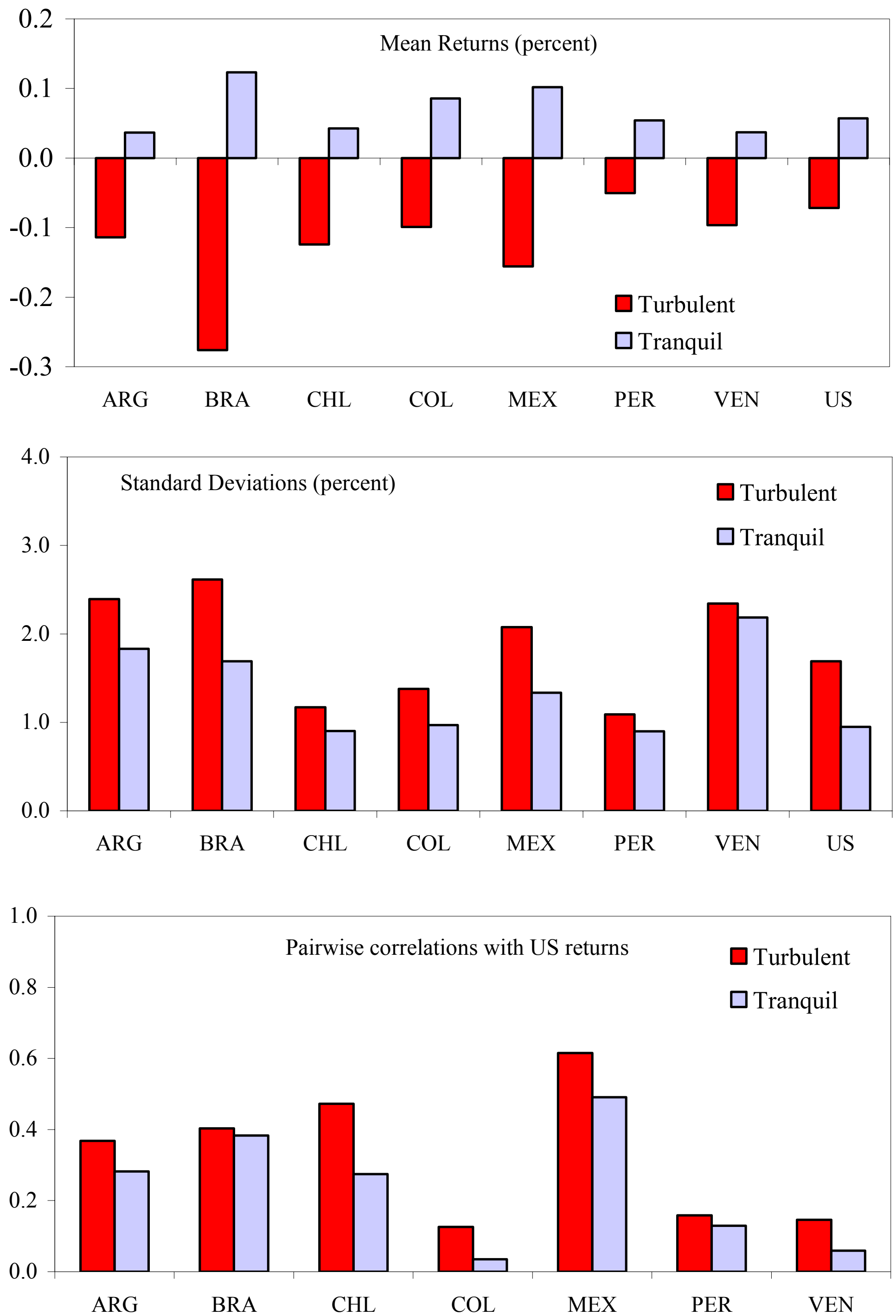
[12] Since exchange rates are based on the euro, our data is restricted and starts from 1999 onwards.

Descriptive Statistics

The change in market behavior across tranquil and turbulent periods is clearest for stock markets. In our sample, stock returns were negative on average and more volatile in both the United States and the Latin American countries during turbulent times (Figure 3 and panel A of Table 2). Moreover, the (unadjusted) pairwise correlations between the U.S. and the local markets increased, in line with previous evidence on stock market correlations (Sarkar and Patel (1998)). Finally, the correlations between the United States and domestic markets were larger for the largest Latin American economies (Argentina, Brazil and Mexico).

The picture is less clear-cut for exchange rates (panels B of Table 2). While some countries experienced, on average, larger depreciations during turbulent periods, this was not the case for all countries. As could have been expected, turbulent periods were associated with greater exchange rate volatility for all the countries, including the United States (Argentina being the only exception here), although the differences in volatilities were often small. The (unadjusted) correlations of Latin American exchange rates against the euro with the U.S. dollar-euro exchange rate were also generally large, but there was no pronounced tendency toward an increase or decrease of correlations during turbulent periods. The picture is even less clear-cut as regards sovereign spreads in Latin America and U.S. corporate spreads (Panel C), except for the volatility of spreads being greater and the (unadjusted) correlations of sovereign spreads with the U.S. corporate spreads increasing during turbulent periods (although these correlations were generally quite small).

Figure 3: Descriptive Statistics of Stock Market Returns in Normal v. Turbulent Times



Notes : See Appendix for data sources and definitions.

Table 2: Summary Descriptive Statistics

	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Venezuela	Latin America (average)	United States
A. Daily Stock Returns (percent)									
All sample									
Mean	0.01	0.05	0.01	0.06	0.06	0.04	0.03	0.04	0.03
Standard Deviation	1.93	1.89	0.96	1.06	1.51	0.93	3.07	1.62	1.12
Correlation with the U.S.	0.31	0.40	0.34	0.08	0.54	0.14	0.06	0.26	...
Observations	2737	2737	2737	2737	2737	2737	2737	2737	2737
Turbulent periods									
Mean	-0.11	-0.28	-0.12	-0.10	-0.16	-0.05	-0.10	-0.13	-0.07
Standard Deviation	2.39	2.62	1.17	1.38	2.08	1.09	2.34	1.87	1.69
Correlation with the U.S.	0.37	0.40	0.47	0.13	0.61	0.16	0.15	0.33	...
Observations	494	494	494	494	494	494	494	494	494
Tranquil periods									
Mean	0.04	0.12	0.04	0.09	0.10	0.05	0.04	0.07	0.06
Standard Deviation	1.83	1.69	0.90	0.97	1.34	0.90	2.19	1.40	0.95
Correlation with the U.S.	0.28	0.38	0.27	0.04	0.49	0.13	0.06	0.24	...
Observations	2243	2243	2243	2243	2243	2243	2243	2243	2243
B. Daily exchange rate changes (percent)									
All sample									
Mean	0.07	0.04	0.01	0.03	0.01	0.01	0.10	0.04	0.01
Standard Deviation	1.53	1.22	0.79	0.79	0.83	0.66	2.14	1.14	0.64
Correlation with the U.S.	0.30	0.45	0.51	0.55	0.57	0.69	0.07	0.45	...
Observations	1951	1951	1951	1951	1951	1951	1951	1951	1951
Turbulent periods									
Mean	0.00	0.10	0.03	0.07	0.02	-0.01	0.05	0.04	-0.01
Standard Deviation	1.25	1.49	0.91	0.84	0.96	0.70	2.18	1.19	0.66
Correlation with the U.S.	0.42	0.39	0.50	0.54	0.54	0.66	0.14	0.46	...
Observations	403	403	403	403	403	403	403	403	403
Tranquil periods									
Mean	0.09	0.03	0.01	0.02	0.01	0.01	0.12	0.04	0.01
Standard Deviation	1.61	1.15	0.77	0.77	0.80	0.66	2.16	1.13	0.64
Correlation with the U.S.	0.27	0.47	0.52	0.57	0.58	0.71	0.05	0.45	...
Observations	1548	1548	1548	1548	1548	1548	1548	1548	1548
C. Daily spread changes (basis points)									
All sample									
Mean	-0.33	-0.48	-0.06	-0.25	-0.38	-0.25	-0.51	-0.32	-0.08
Standard Deviation	283.38	28.57	5.31	12.00	11.85	12.97	25.37	16.01	8.65
Correlation with the U.S.	0.06	0.13	0.01	0.01	0.00	0.14	0.06	0.06	...
Observations	1856	1856	1856	1856	1856	1856	1856	1856	1856
Turbulent periods									
Mean	-19.61	-0.93	-0.12	0.52	-0.61	0.61	-1.55	-0.35	-0.85
Standard Deviation	477.52	50.40	5.42	15.21	11.07	14.66	24.13	20.15	10.89
Correlation with the U.S.	0.15	0.14	0.03	0.15	0.10	0.15	0.07	0.11	...
Observations	403	403	403	403	403	403	403	403	403
Tranquil periods									
Mean	5.02	-0.36	-0.04	-0.45	-0.31	-0.48	-0.23	-0.31	0.13
Standard Deviation	201.50	18.78	5.31	11.02	12.14	12.55	25.89	14.28	7.96
Correlation with the U.S.	-0.02	0.11	0.00	-0.03	-0.05	0.12	0.02	0.03	...
Observations	1453	1453	1453	1453	1453	1453	1453	1453	1453

Notes: See Appendix for data sources and definitions. "All sample" covers the period from January 1, 1997 through August 31, 2006. "Turbulent periods" correspond to the periods described in Section III (dates are reported in the Appendix). "Tranquil periods" correspond to the periods before turbulent periods. Latin America average of the daily spread changes does not include Argentina.

Dynamic response to U.S. shocks

Our next exercise is to investigate the dynamic interdependence of financial markets using a vector autoregression (VAR) model. In particular, we split the sample into two sub-samples corresponding to tranquil and turbulent periods and we estimated bivariate VARs on the United States and each of the seven Latin American countries separately for each of the two sub-samples. Exogenous variables were also included in the models to control for other sources of correlation between the domestic and U.S. asset markets.

More specifically, we estimated the following model:

$$X_t = \beta\,(L)\,X_t + \delta\,(L)\,Z_t + \varepsilon_t \qquad (3)$$

$$X_t = \{x_t^{us}, x_t^{i}\}' \qquad (4)$$

$$Z_t = \{MSCI^{\text{non-latin}}, i_t^{us}, i_t^{i}\}, \qquad (5)$$

where X_t is a two-dimensional vector of asset returns in the United States (x_t^{us}) and in the respective Latin American country (x^i_t) in day *t*; Z_t is a vector of exogenous variables; ε_t is a two-dimensional vector of disturbances; and $\beta(L)$ and $\delta(L)$ are polynomial lags applied to the endogenous and exogenous variables, respectively. The number of lags for the endogenous variables was set to two or higher depending on the statistical significance of higher lags.[13] The model structure was identical for the three markets, except for the choice of the exogenous variables (that is, for the vector Z_t). For illustration purposes, equation (5) shows our choice of exogenous variables in the stock market case. In this case, the vector Z_t includes a non-Latin American emerging market stock index ($MSCI^{\text{non-latin}}$), and U.S and domestic interest rates ($i_t^{us}$and i_t^{i}, respectively). In the model for currency markets, the vector Z_t included domestic and U.S. interest rates, while in the model for the bond markets it also included the daily return on a non-Latin American emerging bond index (EMBI).[14]

Provided that structural shocks can be identified, impulse responses based on these bivariate VARs provide an insight on the dynamic linkages between the U.S. and Latin American markets. Since our interest lies in the response of small emerging market economies to shocks in a large economy (the United States), it is plausible to rely on a triangular Choleski decomposition of the model covariance matrix (with the U.S. variable coming first in the ordering of variables). Intuitively, this identification assumption implies that a shock to a U.S. market can have a contemporaneous (same-day) impact on a Latin American market, while a contemporaneous effect of a shock in a Latin American market on the U.S. market is ruled out a priori.

[13] The number of lags for the endogenous variables was generally found higher in tranquil period. Lags higher than one for the exogenous variables were generally not significant.

[14] Although interest rates are an imperfect measure of aggregate shocks, they are a good proxy for global shifts in real economic variables and/or policies that affect asset market performance. Forbes and Rigobon (2002) follow a similar approach.

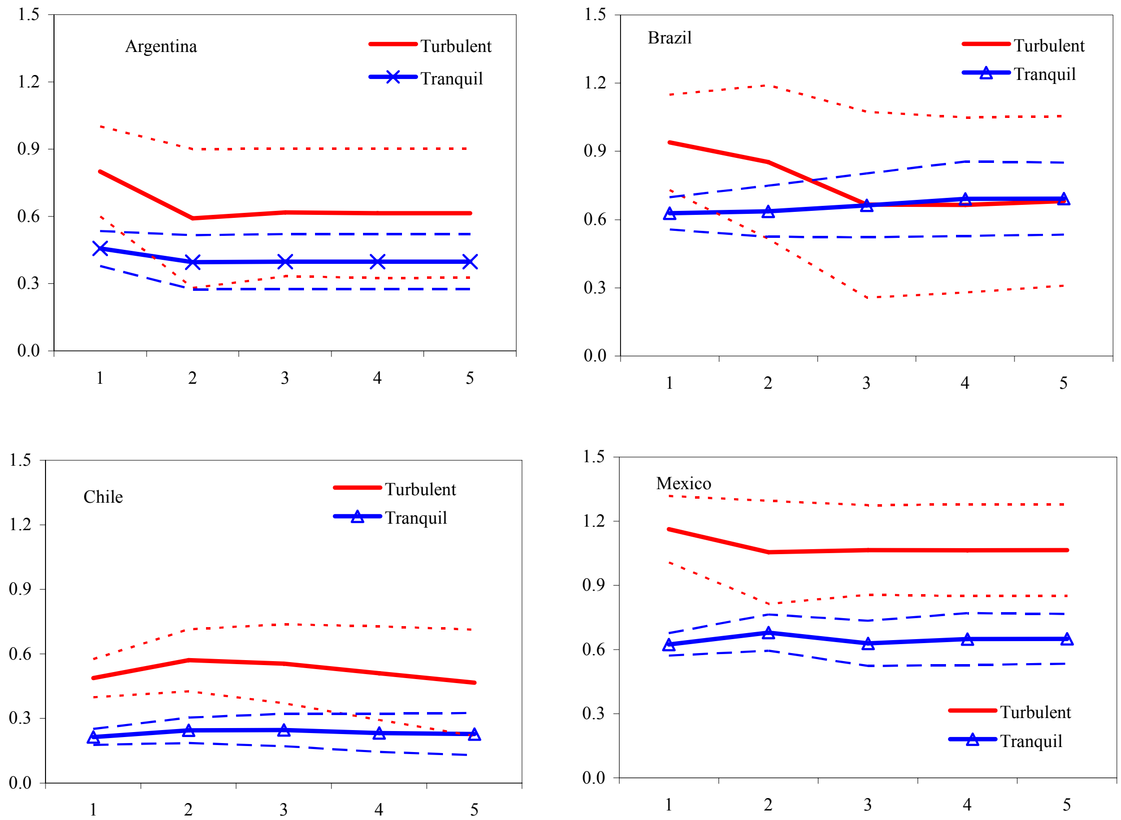
To compare the effect of shocks during periods characterized by different underlying volatilities, we need to define what constitutes a shock of the "same magnitude". This is because, in periods with high volatility, larger shocks tend to occur more frequently and thus it would be misleading to compare shocks of the same *nomina*l magnitude across turbulent and tranquil times. Instead, we chose to track the response of domestic asset markets to *one-standard deviation* shocks to U.S. returns, which controls for the fact that larger shocks are more likely in more turbulent times.

As before, we found that the stock market showed the most pronounced differences between turbulent and tranquil times. Figure 4 presents impulse response functions of domestic markets to a one-standard deviation shock in the U.S. stock market in both turbulent and tranquil times. For simplicity, only the four Latin American countries where, at least on impact, the stock market's response is stronger in turbulent than in tranquil times (Argentina, Brazil, Chile and Mexico) are shown. In these countries, the response to a U.S. shock in turbulent times lies above the response to a shock in tranquil times, especially in Chile and Mexico (by a factor of two). For these four countries, the differences between the responses are statistically significant for at least the first day when the shock hits (two days for Chile and more than five days for Mexico).[15] In the other three countries for which impulse responses are not reported (Colombia, Peru, and Venezuela), the impulse response functions were generally not statistically different across turbulent and tranquil periods, although their point estimates were qualitatively similar. It is worth noting that, both in tranquil and turbulent times, the effect of shocks is larger in the three largest countries (Argentina, Brazil, and Mexico)—in these countries, domestic markets also tend to overshoot in turbulent times.

Statistical results were less clear cut for currency and bond markets, although the pattern of the response of these markets to U.S. shocks were generally similar to that documented for the stock market. The point estimates of the impulse response functions for the currency market during turbulent times were generally found to be positive and lie above the impulse response functions estimated for tranquil times for the first three days for most countries—indicating stronger depreciation in turbulent times—although the differences were not statistically significant. In the case of the government bond market, the point estimates of the impulse response functions in turbulent times lied above those estimated in tranquil times for all countries except Venezuela.

[15] The failure to find more pronounced statistically significant differences is driven by the large standard errors found for the models estimated on turbulent times.

Figure 4: Cumulative Response of Daily Stock Returns to a One-Standard Shock to US Stock Returns
(Tranquil v. Turbulent Periods; in percent) 1/

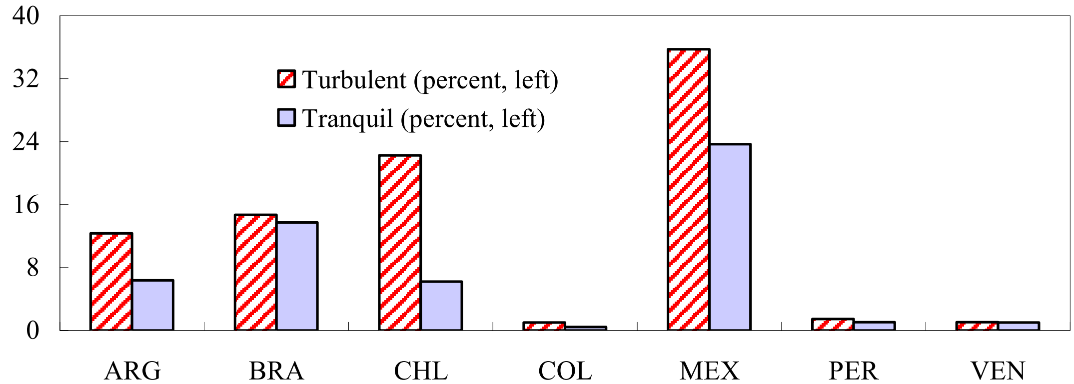


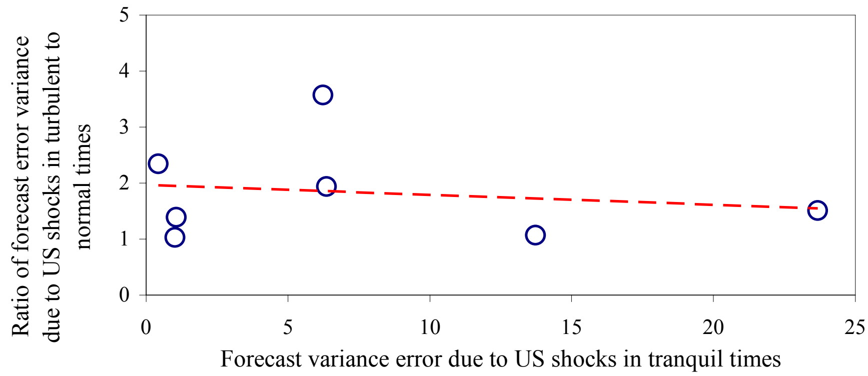
Notes : See Appendix for data sources and definitions.

Importance of U.S. market volatility for domestic market volatility

Understanding what contributes to forecast error variance helps understand the source of market movements. Intuitively, the forecast error variance decomposition in a bivariate model describes the proportion of the movements in an economic variable that is explained by its own (structural) shocks rather than by shocks to the other variable in the system. Thus, a variance decomposition exercise provides a different angle to look at cross-country linkages of asset markets, because it provides a calculation of expected volatility in a market in terms of domestic vs. foreign sources of shocks.

Figure 5: Forecast Error Variance of Stock Returns Due to US Stock Return Shocks

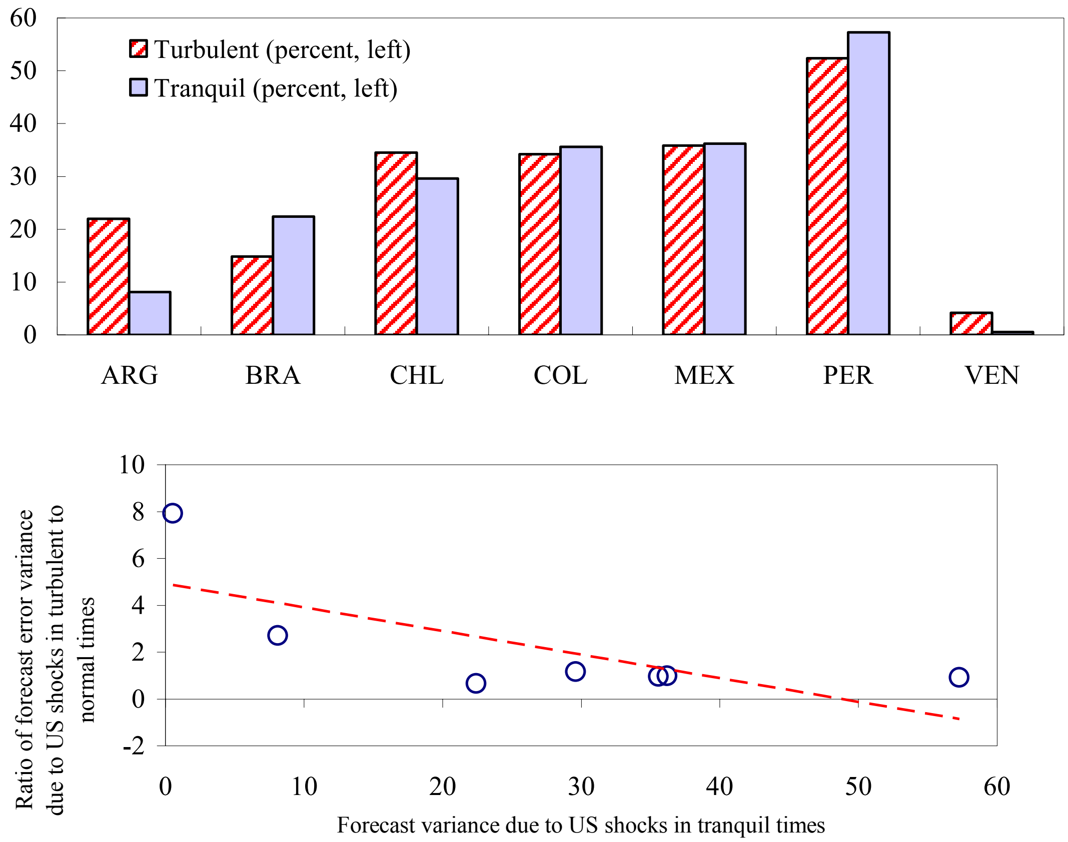




Notes: See Appendix for data sources and definitions. The top panel shows the share of the forecast variance (at a 10 days horizon) that is due to U.S. shocks in both tranquil and turbulent times. The bottom panel plots the share of the forecast error variance due to U.S. shocks in normal times (on the horizontal axis) against the ratio of the forecast error variance due to U.S. shocks in turbulent times to the forecast error variance due to U.S. shocks in tranquil times (on the vertical axis).

Starting from the stock markets (Figure 5), the importance of U.S. shocks for domestic market volatility varied considerably across countries. The share of forecast error variance of stock returns that can be explained by U.S. stock return in tranquil times varied considerably, from almost nothing in Peru and Venezuela to around 25 percent in Mexico, the country where U.S. stock market volatility mattered most in both tranquil and turbulent times. In the four countries where U.S. stock market volatility played a non negligible role (Argentina, Brazil, Chile and Mexico), the importance of U.S. stock market volatility also increased during turbulent times, with Chile being the country where the increase was highest (by a factor of almost four. It is worth pointing out, however, that countries that were more sensitive to U.S. shocks during tranquil time were not necessarily those that experienced a greater increase in sensitivity to U.S. shocks in turbulent times.

Figure 6: Forecast Error Variance of Exchange Rate Changes to US Exchange Rate Shocks



Notes: See Appendix for data sources and definitions. The top panel shows the share of the forecast variance (at a 10 days horizon) that is due to U.S. shocks in both tranquil and turbulent times. The bottom panel plots the share of the forecast error variance due to U.S. shocks in normal times (on the horizontal axis) against the ratio of the forecast error variance due to U.S. shocks in turbulent times to the forecast error variance due to U.S. shocks in tranquil times (on the vertical axis).

As for exchange rates, the role of U.S. exchange rate shocks was generally important for the volatility of Latin American currencies, both in tranquil and turbulent times (Figure 6). Barring Venezuela (where the official exchange rate was pegged against the U.S. dollar for most of the sample period), the share of forecast error variance due to U.S. shocks in tranquil times was at least 10 percent for all countries and 20 percent for all countries other than Argentina (this share is highest for Peru at over 50 percent). The share of forecast error variances due to U.S. shocks was also generally high in turbulent times, although it increased for only three countries (Argentina, Chile, and Venezuela—the latter from very low levels). While the number of countries in our sample is too small to justify broad generalizations, it suggests the existence of an inverse relationship between the share of forecast error variances that is explained by U.S. exchange rate shocks in tranquil times and the *increase* in the share of forecast error variance due to U.S. shocks in turbulent times. This would suggest that countries whose exchange rates are relatively more affected by U.S. exchange rate shocks in tranquil times are also less exposed to increases in U.S. exchange rate volatility in turbulent times.

Finally, it is perhaps somewhat surprisingly that the share of forecast error variance of sovereign spreads that was explained by U.S. corporate spread shocks was generally fairly small, suggesting that, despite some similarities between these asset classes, linkages among them were not strong in our sample.

To summarize our results so far, we have noted that, for the three assets under consideration, U.S. shocks explained a larger proportion of volatility of Latin American assets during turbulent times as opposed to tranquil times. Table 3 summarizes our findings from the descriptive statistics, impulse response functions and variance decompositions. These results are generally consistent with previous findings in the literature that financial linkages between the U.S. and Latin American markets are indeed different in "tranquil" and "turbulent" times, with U.S. shocks having a larger impact on Latin American markets during turbulent times.

Table 3: Tranquil vs. Turbulent Times (Summary of Results)

	A: Descriptive statistics during turbulent times		
Assets	Average changes	Volatility	Correlations (Unadjusted)
Stocks	negative	higher	higher
Currencies	mixed	higher	lower
Bonds	mixed	higher	higher
	B: Response to US shocks during turbulent times		
Stocks	greater		
Currencies	greater		
Bonds	greater		
	C: Share of market volatility explained by US shocks during turbulent times		
Stocks	increases		
Currencies	increases		
Bonds	increases (but remains small)		

V. HAVE LINKAGES SHIFTED OVER TIME?

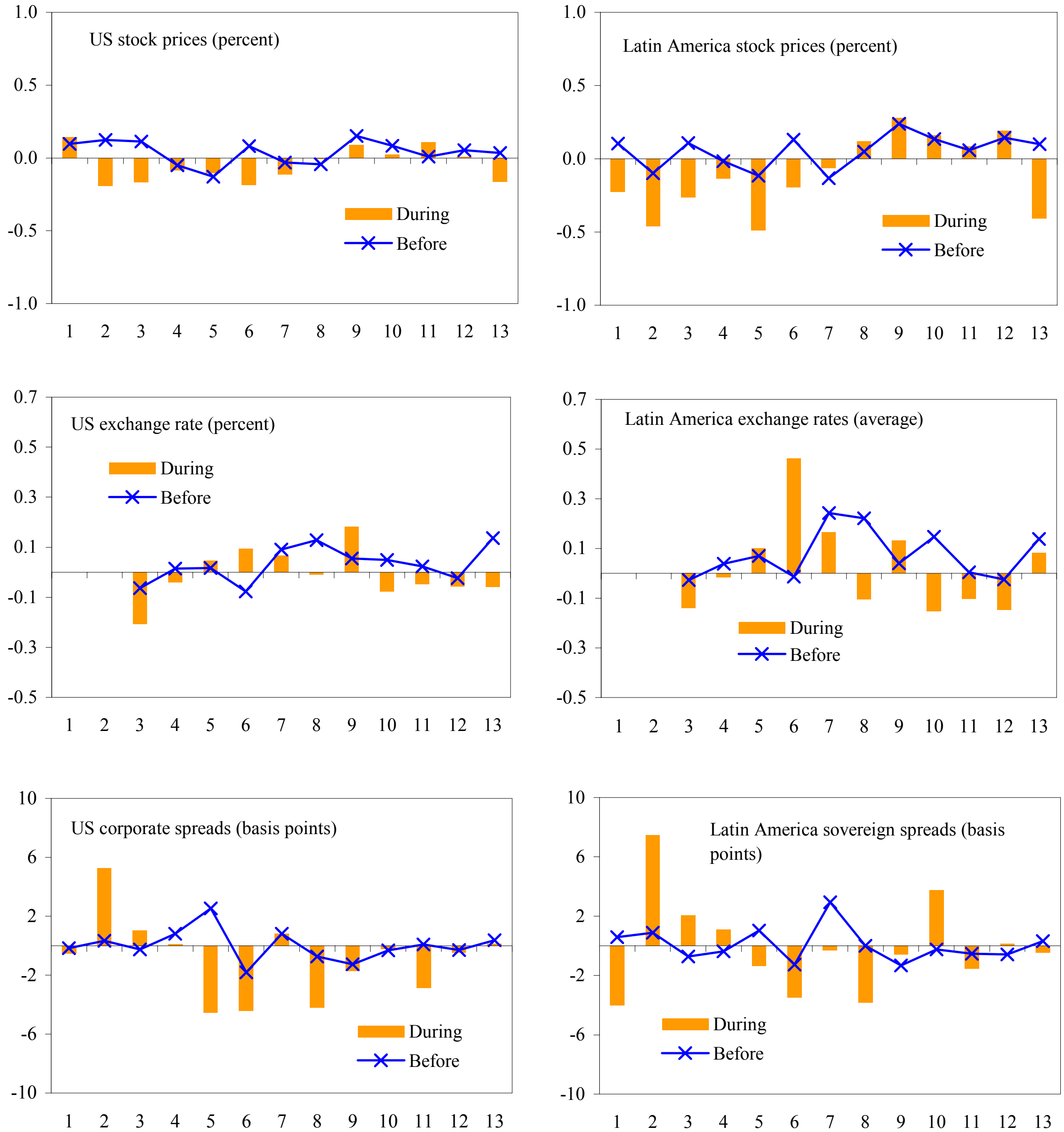
Our next objective is to study whether linkages have changed over time. To address this question, we first examine average returns and their volatility over subsequent tranquil and turbulent episodes. This provides preliminary evidence on whether there has any been any clear shift in the behavior of asset markets during tranquil and turbulent episodes. Next, we return to the issue of measuring changes in correlations between the U.S. and Latin American asset markets. As mentioned earlier, the correlations between asset returns during turbulent periods need to be adjusted to overcome the problem that correlations may be biased as a result of changes in underlying asset volatilities, as pointed out by Forbes-Rigobon (2002).

Figures 7 and 8 show average returns and volatilities for the U.S. and Latin American financial markets for each of the tranquil and turbulent periods in our sample. Starting from stock prices, the figures show that the gap between average stock returns in turbulent and tranquil periods narrowed after 2003 (corresponding to the eighth turbulent period). A similar pattern seems to hold for stock price volatilities as well. This could suggest that the linkages between the two regions have weakened over time, although this trend appears to have reversed in the latest turbulent period in our sample (May-June 2006)—when average stock returns became negative and volatilities increased compared with the preceding tranquil period.

Turning to exchange rates, Latin American exchange rates over the last few years tended to appreciate against the euro during both periods of tranquility and turbulence. By contrast, the last episode saw both depreciations and increases in volatilities. Similar to the behavior of stock markets, movements of exchange rates tend to be larger in Latin America than in the U.S., in line with evidence provided by Ganguly and Breuer (2007) showing that nominal exchange rate volatility tends to be more than three times as large in developing countries than in developed countries, even after controlling for fundamentals and different horizons.

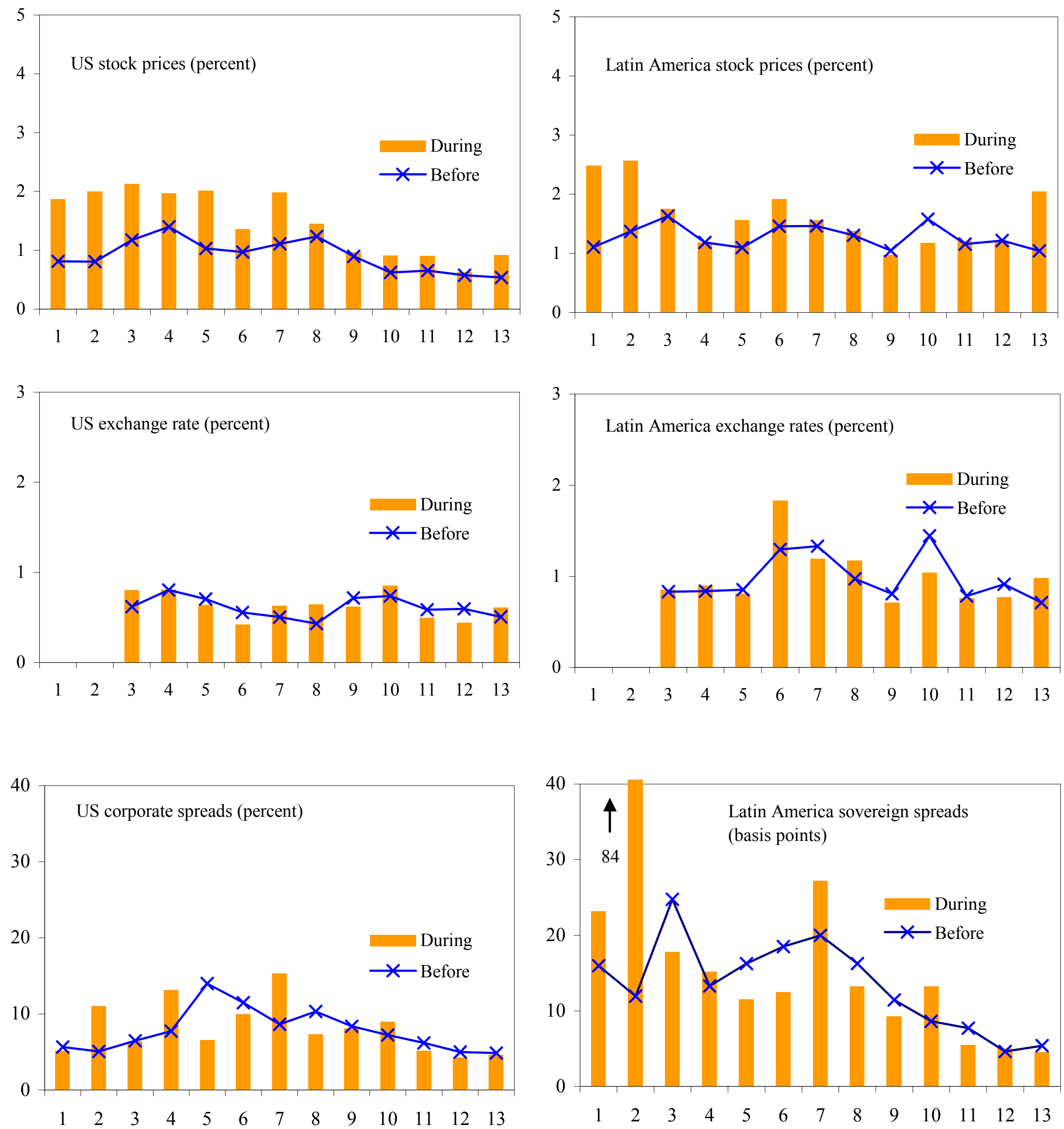
Finally, the bond markets in Latin America were far less volatile in more recent years (see also IMF (2006)). Moreover, there was no specific pattern in their co-movements with the U.S. corporate bond market.

Figure 7: Asset Price Changes Before and During Turbulent Periods



Notes: The charts show average daily changes in stock prices (in percent), in exchange rates against the euro (in percent), and in bond spreads (in basis points) for the United States and Latin America (calculated as the average across the seven included Latin American countries) for each of the thirteen turbulent periods ("During") and each of the tranquil periods preceding the turbulent periods ("Before").

Figure 8: Asset Price Volatilities Before and During Turbulent Periods



Notes: The charts show standard deviations of daily changes in stock prices (in percent), in exchange rates against the euro (in percent), and in bond spreads (in basis points) for the United States and Latin America (calculated as the average across the seven included Latin American countries) for each of the thirteen turbulent periods ("During") and each of the tranquil periods preceding the turbulent periods ("Before").

To better understand co-movements over time between the Latin American and U.S. markets, we turn to a more formal analysis of correlations. We rely on the Forbes-Rigobon (2002) methodology to correct for the fact that standard correlation coefficients are conditional on the actual value of market volatility, and thus may be biased. More specifically, this methodology adjusts the correlation between two asset returns during the turbulent period to overcome the problem that simple sample correlations may increase simply as a result of increases in the volatilities of the underlying variables. Since turbulent periods are typically characterized by increased volatility, "the conditional correlation coefficient (the unadjusted correlation coefficient) will tend to increase after a crisis, even if the unconditional correlation coefficient (the underlying cross-market relationship) is the same as during more stable periods" (Forbes and Rigobon, p. 11). Therefore, a test based on the unadjusted correlation may be biased upward, that is, it may show a spurious increase in correlations. Without adjusting for this bias, it is not possible to deduce if increases in unadjusted correlation represent increases in correlations or instead increases in market volatility.

The first step to properly measure correlations is to estimate bivariate VARs for two sub-samples corresponding to turbulent and tranquil periods. We use the same VAR models as in Section IV. Specifically, for each of the three markets under consideration, a model is estimated for the U.S. variable and the corresponding variable in the domestic Latin American market. These models provide estimates of the variance-covariance matrices of the structural residuals during the tranquil and turbulent period. The variance-covariance matrices are in turn used to calculate the adjusted cross-market correlation coefficients for each set of countries and periods. Forbes and Rigobon show that, if there is an increase in volatility in the U.S. asset returns during the turbulent period (measured by the variance of the structural shocks in the VAR model), that is, $\sigma^2_{H,\,US} > \sigma^2_{L,\,US}$, there can be an increase in the calculated sample correlations between the U.S. and domestic returns. To adjust for this bias Forbes and Rigobon propose an "unconditional" (adjusted) correlation, calculated as follows:[16]

$$\rho_t = \frac{\rho_t^c}{\sqrt{1 + \delta_t \left[1 - (\rho_t^c)^2\right]}} \tag{6}$$

where ρ is the adjusted correlation coefficient, ρ^c is the conditional (unadjusted) correlation coefficient, and δ is the relative increase in the variance of U.S. asset,

$$\delta = (\sigma^2_{H,\,1} / \sigma^2_{L,\,1}) - 1 \tag{7}$$

After transforming the adjusted correlations coefficients with a Fisher transformation (to ensure that they are normally distributed), standard tests can be used to examine whether during turbulent periods the adjusted correlations changed significantly compared to the tranquil period. More specifically, we can test the null hypothesis

$$H_0:\ \rho_H = \rho_L, \tag{8}$$

against the alternative hypothesis

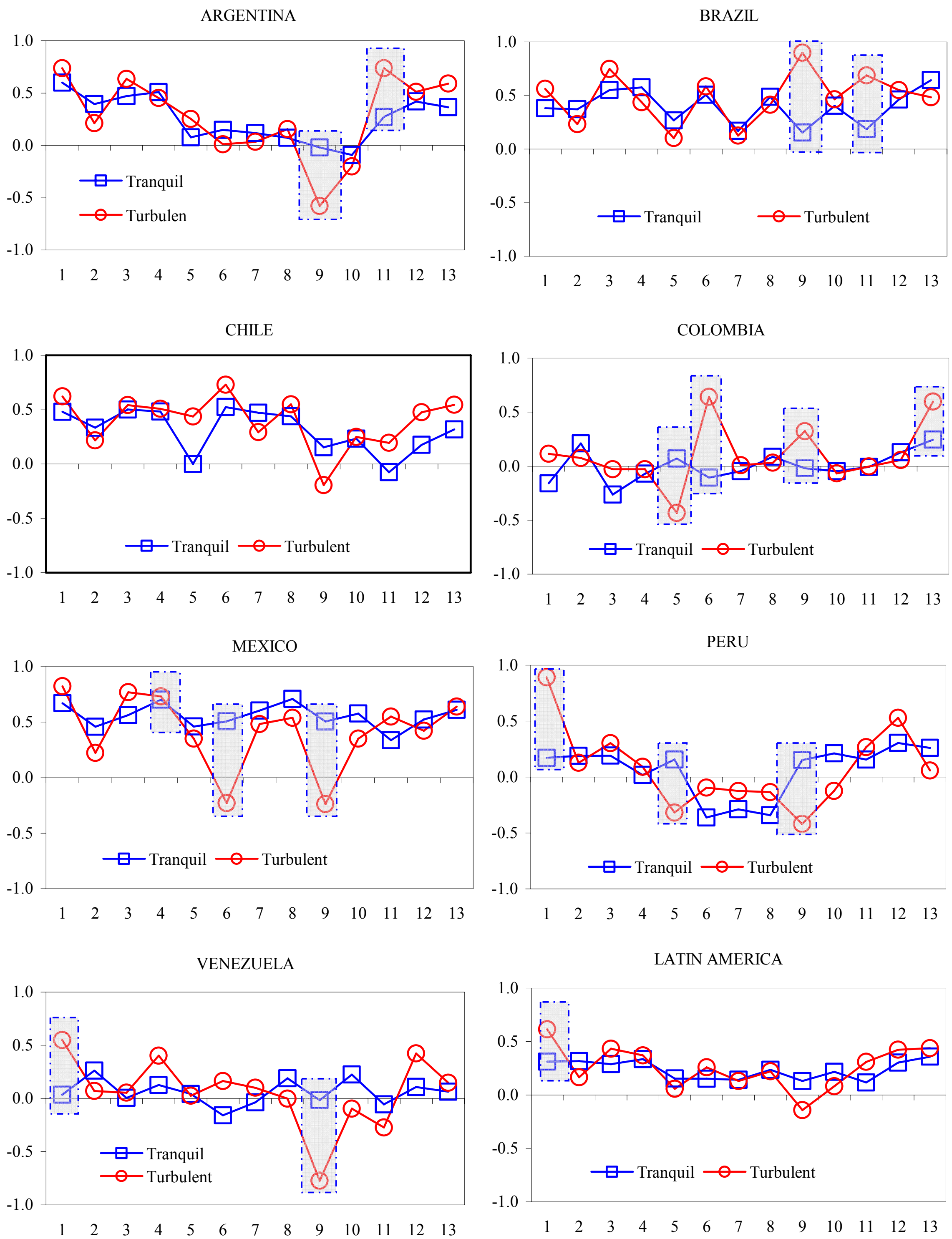
$$H_1:\ \rho_H \neq \rho_L \tag{9}$$

[16] Equation (6) assumes that there is no endogeneity or omitted-variable bias.

Rejection of the null hypothesis indicates that there is a significant change in cross-market linkages.

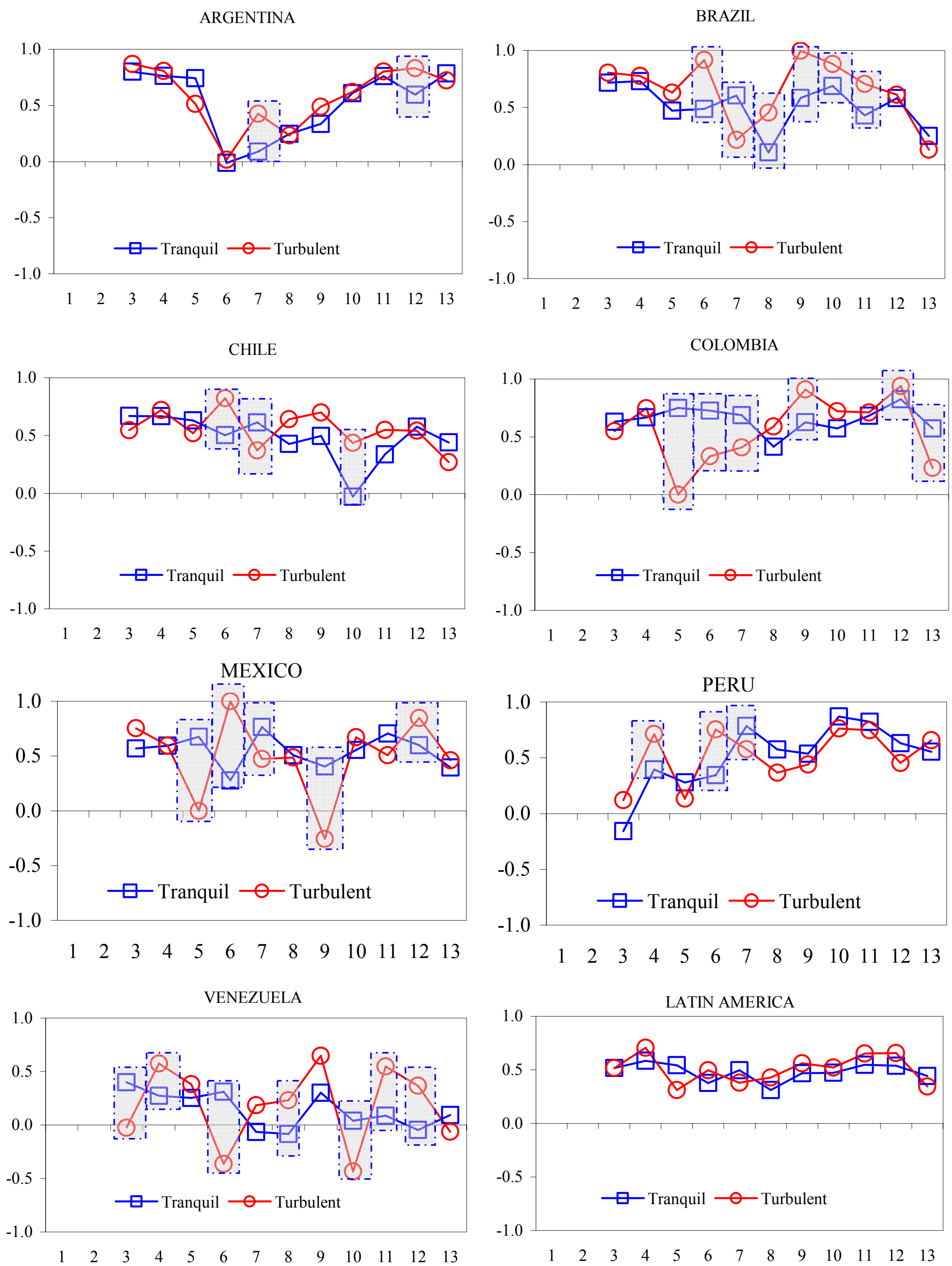
Adjusted correlations (see Figures 9-11) confirm that stock, currency and bond markets have distinctive features. Starting from stock markets, while correlations between the U.S. and Latin American stock markets declined over time during the earlier part of our sample period, they increased during recent turbulent episodes (and especially during the last one). It is currency markets, however, that reveal the clearest changes in cross-market linkages during turbulent episodes, with correlations increasing in many (but not all) instances during turbulent times. It is thus interesting that during the market turbulence in May-June 2006 there was a marked departure from the earlier pattern of strong correlations in both tranquil and turbulent periods, as correlations declined in most cases (both during tranquil and turbulent periods), which is consistent with higher exchange rate flexibility in the region. Finally, no significant pattern emerges for bond markets, as correlations were generally low over time and across countries (with some exceptions).

Figure 9: Adjusted Correlations between Stock Price Changes



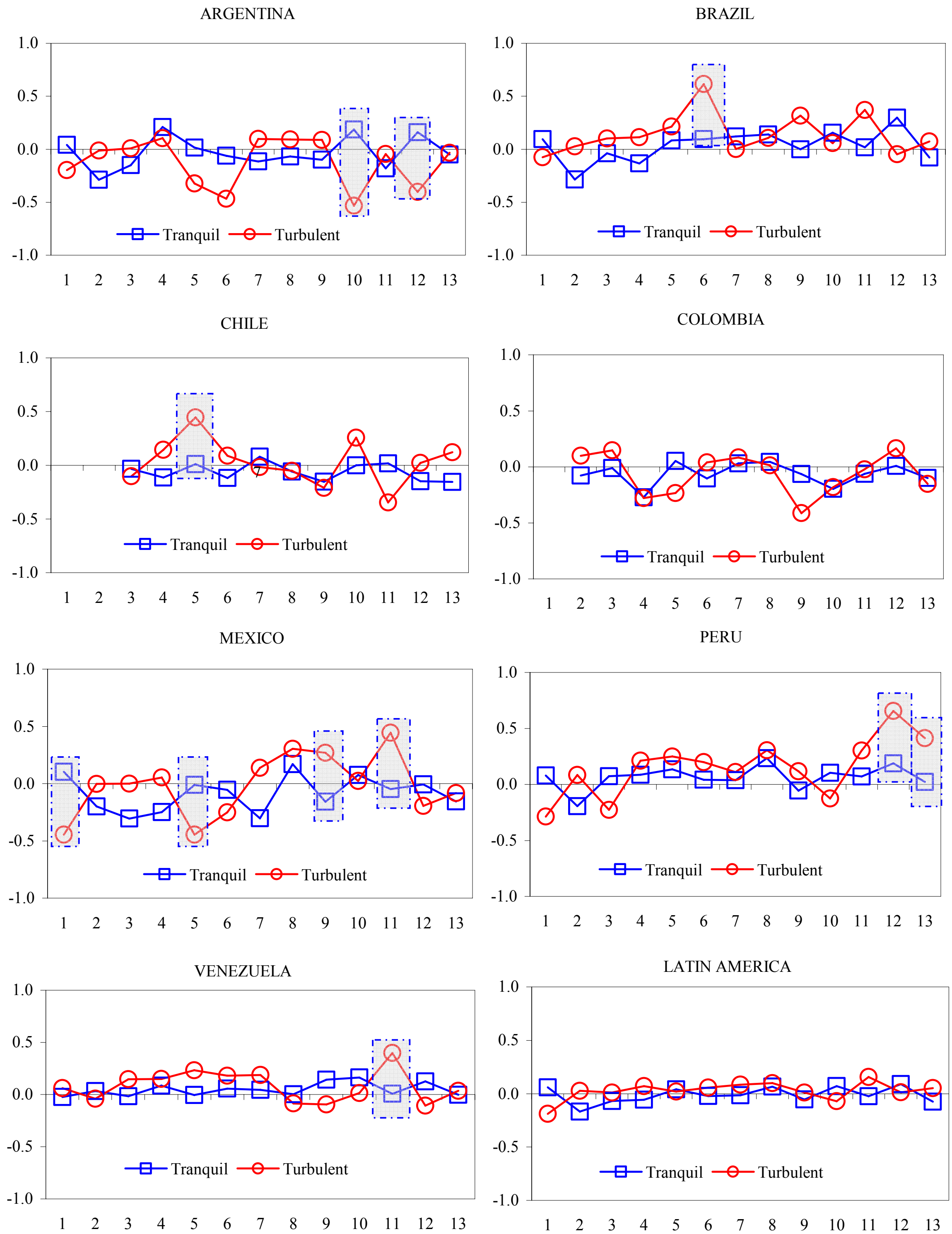
Notes : The charts show the adjusted correlations between daily price changes in the US and each Latin American country during each turbulent period and the tranquil period preceding each turbulent period. The adjustment is made according to the Forbes-Rigobon (2002) methodology. The shaded boxes indicate statistically different correlations. For Latin America, averages of the seven countries are reported.

Figure 10: Adjusted Correlations between Exchange Rate Changes



Notes : The charts show the adjusted correlations between daily changes in exchange rates against the euro for the US and each Latin American country during each turbulent period and the tranquil period preceding each turbulent period. The adjustment is made according to the Forbes-Rigobon (2002) methodology. The shaded boxes indicate statistically different correlations. For Latin America, averages of the seven countries are reported.

Figure 11: Adjusted Correlations between Bond Spreads



Notes : The charts show the adjusted correlations between daily changes in bond spreads the US and each Latin American country during each turbulent period and the tranquil period preceding each turbulent period. The adjustment is made according to the Forbes-Rigobon (2002) methodology. The shaded boxes indicate statistically different correlations. For Latin America, averages of the seven countries are reported.

This evidence leads us to tackle more directly the initial question which motivated this paper, namely whether recent episodes of market turbulence was abnormal in light of previous market behavior and thus suggests a shift in the pattern of cross-country financial linkages. . More specifically, we compare the sensitivity of Latin American markets to the U.S. market during the May-June 2006 episode of turbulence with the twelve previous episodes of turbulence. This is done by estimating the following equation for two samples, one covering the first twelve turbulent episodes and 2006 episode only:

$$Y_t = \alpha + \beta\, Y_{t-1} + \gamma\, US_t + \eta\, US_t * DUM + \mu\, X_t + \lambda\, X_t * DUM + \nu_t \qquad (10)$$

This equation was estimated for each of the seven Latin American countries and for each of the three assets under consideration. The dependent variable, Y_t, represents the daily percentage change in domestic stock prices, the daily percentage change in the domestic exchange rate against the euro, and the change in domestic sovereign spreads, depending on the market under consideration. The dependent variable is regressed on its lagged value, the percentage change in the corresponding U.S. variable (in the case of the bond markets, the change in U.S. corporate spreads is used), and a variable X_t that captures other potentially relevant factors that can affect asset price changes, such as the percentage change in non-Latin MSCI stock market indices for the stock market case; domestic and U.S. interest rate differential for the currency market case; and the change in non-Latin government spreads for the bond market. Finally, to test whether the behavior of domestic markets changes during turbulent times, the coefficients on the right-hand side variables (other than the lagged endogenous variable) are interacted with a dummy variable that takes a value of one during turbulent times and zero otherwise. Equation (10) is estimated using White heteroskedasticity-consistent standard errors and covariance.

Estimation results are presented in Tables 4-6. The main findings can be summarized as follows:

- While the sensitivity of Latin American stock markets to the U.S. stock market was higher in turbulent periods than in preceding tranquil periods throughout the sample (Panel A of Table 4), during the last episode of market turbulence such an increase was generally much more pronounced (Panel B). It is also interesting that there is evidence that, after controlling for the U.S. market, the direct linkages between Latin and non-Latin emerging markets did not display a similar tendency to shifting during turbulent times (both in the first twelve episodes and in the last episode).

- As for the exchange rate markets, there is less evidence of changes in the strength of linkages with the U.S. dollars during turbulent times (Table 5). In this sense, the last episode did not stand out significantly from previous episodes. However, in some countries (Brazil, Chile, and Mexico), the estimated coefficient on the U.S. exchange rate movements decreased somewhat during the last episode.

- Despite of the fact that sovereign spreads in Latin America were hardly correlated with U.S. corporate spreads in tranquil times, their sensitivity to U.S. corporate spreads tended to increase during turbulent times (Table 6). This pattern was also observed during the last turbulent period, although estimates are generally imprecise. On the other hand, there was no clear-cut pattern in the correlations between Latin and non-Latin emerging market spreads. However, compared with previous episodes, sovereign spreads in Latin America were more sensitive to changes in non-Latin emerging spreads during the most recent episode in our sample.

It therefore appears that the most recent episode of market turbulence in our sample stood out from preceding ones in the sense that Latin American stock markets showed increased sensitivity to U.S stock market shocks, and this reversed a trend of weakening linkages. On the other hand, currency markets in Latin America exhibited a decrease in cross-market linkages with the United States over our sample, in line greater exchange rate flexibility.[17] Compared with other financial markets, the sovereign bond market in Latin America were weakly linked with U.S corporate bonds, while there was an increase in sensitivity to movements in other emerging market bond markets, which could signal the increasing consolidation of emerging markets as an asset class of its own clearly separated from U.S. corporate bond markets. Increased market integration across financial markets and a move toward increased exchange rate flexibility (often in the context of inflation targeting regimes) suggests that these features of market response under stress may be observed in future episodes of market turbulence. Indeed, the behavior of global financial markets during February-March 2007—and subsequently during June-August, although these episodes were still unfolding at the time of writing—would seem broadly consistent with this hypothesis (see IMF (2007) for a review of events during February-March 2007)).

[17] This result is consistent with our earlier findings using the adjusted correlations analysis and is consistent with results presented in Box 1 of the Regional Economic Outlook, IMF (November, 2006)

Table 4: Stock Market Sensitivity to US and Other Emerging Markets in Normal and Turbulent Times

	Dependent variable: Stock price index (percentage change)							
	(1) Argentina	(2) Brazil	(3) Chile	(4) Colombia	(5) Mexico	(6) Peru	(7) Venezuela	(8) Average
	A: First twelve episodes							
Lagged dependent variable	0.08 **	0.13 ***	0.15 ***	0.26 ***	0.07 ***	0.08 ***	0.07	0.13
US stock price (% change)	0.37 ***	0.56 ***	0.23 ***	0.02	0.60 ***	0.05 ***	0.08 **	0.32
US stock price (% change) × Turbulence Dummy	0.43 ***	0.21 *	0.09 *	0.02	0.23 **	0.16 **	0.14	0.22
Non-Latin MSCI Index (% change)	0.28 ***	0.34 ***	0.26 ***	0.06 **	0.30 ***	0.13 ***	0.19 ***	0.22
Non-Latin MSCI Index (% change) × Turbulence Dummy	-0.23 *	-0.10	-0.08	0.08 *	0.02	0.08	0.17	-0.07
Constant	-0.01	0.02	0.01	0.05 ***	0.03	0.03	-0.02	0.05
R-squared	0.13	0.21	0.23	0.08	0.36	0.07	0.03	...
Durbin-Watson stat	1.965	1.96	2.00	2.01	1.97	2.01	2.01	...
Observations	2520	2520	2520	2520	2520	2520	2520	...
	B: Last Episode							
Lagged dependent variable	0.07	-0.03	-0.08	-0.12 *	0.10	-0.09	-0.03	-0.12
US stock price (% change)	0.28 *	1.45	0.41 ***	0.41	0.82 ***	0.46	-0.31	0.50
US stock price (% change) × Turbulence Dummy	0.91 ***	0.35	0.54 ***	2.16 ***	1.19 ***	-0.45	0.43	1.20
Non-Latin MSCI Index (% change)	0.33 **	0.89	0.40 **	0.09	0.44 **	0.08	1.19 ***	0.59
Non-Latin MSCI Index (% change) × Turbulence Dummy	0.03	-0.01	0.04	1.63 ***	-0.20	0.15	-0.79 *	0.42
Constant	-0.02	0.01	-0.03	0.00	-0.01	0.10	0.02	...
R-squared	0.58	0.55	0.64	0.73	0.63	0.14	0.16	...
Durbin-Watson stat	2.09	2.26	2.19	1.97	2.18	1.93	1.89	...
Observations	88	88	88	88	88	88	88	...

Notes : See Appendix for data sources and definitions. Panel A includes the first ten tranquil and turbulent periods; Panel B includes the last tranquil and turbulent period only. All equations are estimated by least squares. *, **, and *** denote significance at the 10, 5, and 1 percent levels based on White heteroskedasticity-consistent standard errors. The turbulence dummy takes value 1 during turbulent times and 0 otherwise. The average in column (8) is based only on the coefficients that are statistically significant at the 10 percent (or lower) level.

Table 5: Exchange Rate Sensitivity to US Exchange Rate Movements and Interest Rate Differentials in Normal and Turbulent Times

	Dependent variable: Exchange rate against the euro (percentage change)							
	(1) Argentina	(2) Brazil	(3) Chile	(4) Colombia	(5) Mexico	(6) Peru	(7) Venezuela	(8) Average
	A: First twelve episodes							
Lagged exchange rate change	0.08	0.12 ***	0.01	0.06 **	-0.01	0.02	-0.07	0.09
Dollar-euro exchange rate (percent change)	0.67 ***	0.86 ***	0.63 ***	0.68 ***	0.72 ***	0.72 ***	0.20 ***	0.64
Dollar-euro exchange rate (percent change) × Turbulence Dummy	0.13	0.04	0.08	0.02	0.06	-0.02	0.31 *	0.31
Interest rate differential	0.00	0.00	-0.01	0.00	-0.01	0.00	0.01	...
Interest rate differential × Turbulence Dummy	0.00	0.00	-0.01	0.01	0.00	0.00	0.00	...
Constant	0.00	0.10	-0.02	0.00	0.06	0.00	0.06	...
R-squared	0.12	0.22	0.27	0.32	0.33	0.48	0.01	...
Durbin-Watson stat	2.03	1.94	2.25	2.28	2.33	2.63	2.00	...
Observations	1863	1862	1863	1863	1863	1863	1863	...
	B: Last Episode							
Lagged exchange rate change	-0.01	-0.11	0.11	-0.14	-0.05	-0.07	-0.14	...
Dollar-euro exchange rate (percent change)	0.78 ***	0.44 **	0.45 ***	0.77 ***	0.42 ***	0.87 ***	0.20	0.62
Dollar-euro exchange rate (percent change) × Turbulence Dummy	-0.09	0.47	0.09	-0.20	0.35	-0.08	0.27	...
Interest rate differential	-0.01	0.27	0.45	-0.04	0.16	-0.63	0.03	...
Interest rate differential × Turbulence Dummy	0.01	0.05	-0.04	0.16	0.02	-0.02	0.19	...
Constant	0.03	-3.11	1.91	0.19	-0.28	-0.88	0.11	...
R-squared	0.64	0.12	0.22	0.24	0.24	0.52	0.05	...
Durbin-Watson stat	2.45	1.95	2.00	1.99	2.13	2.33	2.11	...
Observations	88	88	88	88	88	88	88	...

Notes : See Appendix for data sources and definitions. Panel A includes the first ten tranquil and turbulent periods; Panel B includes the last tranquil and turbulent period only. All equations are estimated by least squares. *, **, and *** denote significance at the 10, 5, and 1 percent levels based on White heteroskedasticity-consistent standard errors. The turbulence dummy takes value 1 during turbulent times and 0 otherwise. The average in column (8) is based only on the coefficients that are statistically significant at the 10 percent (or lower) level.

Table 6: Sovereign Spread Sensitivity to US Corporate Spreads and Non-Latin Emerging Market Spreads in Normal and Turbulent Times

	Dependent variable: Sovereign bond spreads (basis points, daily change)							
	(1) Argentina	(2) Brazil	(3) Chile	(4) Colombia	(5) Mexico	(6) Peru	(7) Venezuela	(8) Average
	A: First twelve episodes							
Lagged spread change	-0.09 *	0.13 **	-0.19 ***	0.09 **	0.02	0.00	-0.01	-0.02
US corporate spread (basis pointchange)	-0.29	0.13	0.01	-0.01	-0.10	0.18 ***	0.07	0.18
US corporate spread (basis pointchange) × Turbulence Dummy	6.79	0.41	0.01	0.28 **	0.37 **	0.10	0.44	0.32
Non-Latin emerging market spreads	0.01	0.00	0.00	0.00	0.00	0.00	0.00	...
Non-Latin emerging market spreads × Turbulence Dummy	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	...
Constant	-3.17	-0.45	-0.15	-0.71	-0.14	-0.20	-0.19	...
R-squared	0.02	0.03	0.04	0.03	0.01	0.02	0.00	...
Durbin-Watson stat	2.00	1.99	2.01	2.00	2.00	2.00	1.99	...
Observations	2385	2385	1767	2129	2385	2281	2385	...
	B: Last episode							
Lagged spread change	-0.04	-0.17	-0.15	0.07	-0.19	-0.05	-0.16	...
US corporate spread (basis pointchange)	-0.10	-0.25	-0.05	-0.22	-0.08	0.02	-0.03	...
US corporate spread (basis pointchange) × Turbulence Dummy	0.58	0.65 **	0.09	0.19	0.16	0.23	0.36	0.65
Non-Latin emerging market spreads	0.08	0.06	0.01	0.09	0.05 *	0.05	0.12 **	0.08
Non-Latin emerging market spreads × Turbulence Dummy	-0.02	-0.02 **	0.00 *	-0.02	-0.02 ***	-0.01	-0.03 **	-0.02
Constant	-12.40	-9.05	-1.86	-14.04	-6.94 *	-7.70	-18.50 **	-12.72
R-squared	0.05	0.10	0.08	0.04	0.10	0.03	0.08	...
Durbin-Watson stat	1.92	1.84	2.07	2.02	1.88	1.97	1.86	...
Observations	88	88	88	88	88	88	88	...

Notes : See Appendix for data sources and definitions. Panel A includes the first ten tranquil and turbulent periods; Panel B includes the last tranquil and turbulent period only. All equations are estimated by least squares. *, **, and *** denote significance at the 10, 5, and 1 percent levels based on White heteroskedasticity-consistent standard errors. The turbulence dummy takes value 1 during turbulent times and 0 otherwise. The average in column (8) is based only on the coefficients that are statistically significant at the 10 percent (or lower) level.

VI. CONCLUSIONS

This paper has investigated the linkages between the United States and Latin America for the stock, currency and bond markets from 1997-2006. We proceeded in four steps. First, we identified periods of volatility in the United States based on a criterion linked to implied stock market volatility in the United States, which is generally considered a good measure of global market turbulence. Second, impulse response functions and variance decompositions allowed us to examine whether the sensitivity of Latin American financial markets to U.S. shocks changed during turbulent periods. Third, after documenting that cross-country linkages seemed indeed to differ in tranquil times and turbulent times, we investigated financial linkages between the United States and Latin American countries over time using correlation coefficients that were adjusted for changing volatility (heteroskedasticity) of returns. Finally, we compared the last sample episode of volatility in the United States (the one during May-June 2006) with previous episodes, and analyzed whether the last bout of turbulence was "abnormal".

We singled out 13 episodes of market turbulence. We found evidence that, during turbulent times, market behavior was generally different than during tranquil times. In particular, there was increased sensitivity of financial markets in Latin America to shocks in the United States. In stock markets, the amount of volatility in Latin American markets explained by U.S. market volatility increased by two times on average during turbulent times as opposed to tranquil time. For currency and bond markets we also observed an inverse relationship between the share of volatility explained by U.S. shocks in tranquil times and the increase in the share of volatility explained during turbulent times.

The examination of adjusted pairwise correlations, using the Forbes-Rigobon methodology, showed that currency markets were more prone than other asset markets to experiencing shifts in linkages with U.S. markets during periods of turbulence. Moreover, the last two episodes of market turbulence stood out from preceding ones as they were characterized by increased sensitivity of Latin American stock markets to U.S stock market shocks, in contrast to previous episodes that had shown a trend of weakening linkages. On the other hand, currency markets in Latin America exhibited a decrease in linkages with the United States, which could be consistent with greater exchange rate flexibility in the region than in the earlier part of the sample. Compared with other financial markets, the sovereign bond market in Latin America appeared only weakly linked with U.S corporate bonds, while they appear to have recently increased their sensitivity to movements in other emerging market bond markets.

The evidence in this paper suggests that financial linkages between the U.S and Latin America were different during periods of financial volatility in the United States. A natural extension and an avenue for future research is to identify potential transmission channels for these spillovers and to analyze if these channels have changed in importance over time.

Appendix I: Data Sources and Definitions

Countries: Argentina, Brazil, Chile, Colombia, Mexico, Peru, United States and Venezuela.

Table: List and Definition of Variables

Variable Name	**Definition**	**Source**
Stock market returns	Daily percentage changes of each country's aggregate stock market index, adjusting for weekends and holidays; daily returns are based on U.S dollars	Datastream
Exchange Rate	Daily nominal exchange rates for the U.S. and Latin American currencies are quoted relative to the euro; daily percentage changes are calculated based on the daily exchange rates	Datastream
U.S. corporate bond spreads	Daily U.S. corporate bond spreads (in basis points) are computed as the difference between (effective) high-yield of the Merrill Lynch High Yield Master II Index (which is a broad based index consisting of all U.S.-dollar denominated high-yield bonds) and five-year U.S. treasury bonds	Bloomberg
Latin American bond spreads	Daily stripped sovereign spreads in basis points on the EMBI Plus index (for Chile and Colombia, we used the EMBI Global index) constructed by JPMorgan. The sovereign spreads are differenced and are U.S. dollar denominated	J.P.Morgan
MSCI (non-Latin)	Daily percentage changes of non-Latin emerging country's aggregate MSCI stock market index, adjusting for weekends and holidays; daily returns are based on U.S dollars	Datastream
EMBI (non-Latin)	Daily stripped sovereign spreads in basis points on the non-Latin EMBI Plus index constructed by JPMorgan. The sovereign spreads are differenced and are U.S. dollar denominated	J.P.Morgan
Interest rates (U.S. and domestic)	Short-term interest rates	Datastream

Appendix II: Turbulent Episode Dates

1 : from 10/27/1997 to 12/03/1997

2 : from 07/21/1998 to 10/15/1998

3 : from 04/04/2000 to 05/17/2000

4 : from 02/20/2001 to 04/19/2001

5 : from 09/12/2001 to 10/07/2001

6 : from 01/29/2002 to 02/15/2002

7 : from 06/03/2002 to 11/15/2002

8 : from 01/24/2003 to 04/07/2003

9 : from 09/22/2003 to 10/14/2003

10 : from 03/10/2004 to 04/12/2004

11 : from 04/15/2005 to 05/19/2005

12 : from 01/20/2006 to 02/23/2006

13 : from 05/12/2006 to 06/27/2006

References

Arora, Vivek, and Martin Cerisola, 2001, "How does U.S. Monetary Policy Influence Economic Conditions in Emerging Markets?" *IMF Staff Papers*, Vol. 48 (3) (Washington: International Monetary Fund).

Caballero, Ricardo and Stavros Pangeas, 2004, "Contingent Reserves Management: an Applied fGramework," Working Papers 05-02, Federal Reserve Bank of Boston.

Calvo, Guillermo, Leonardo Leiderman, and Carmen M. Reinhart, 1993, "Capital Inflows to Latin America: the Role of External Factors," *IMF Staff Papers*, Vol. 40, pp. 108–151 (Washington: Iternational Monetary Fund).

Canova, Fabio, 2005, "The Transmission of U.S. Shocks to Latin America," *Journal of Applied Econometrics*, Vol. 20, pp. 229–251.

Chakrabarti, Rajesh, and Richard Roll, 2002, "East Asia and Europe during the 1997 Asian Collapse: a Clinical Study of a Financial Crisis," *Journal of Financial Markets*, Vol. 5, pp.1–30.

Chan-Lau, Jorge, and Iryna Ivaschenko, 2003, "Asian Flu or Wall Street Wirus? Price and Wolatility Spillovers of the Tech and Non-Tech Sectors in the United States and Asia," *Journal of Multinational Financial Management,* Vol. 13 (4–5), pp.302–322.

Chen, Gong-meng, Michael Firth, and Oliver Meng Rui, 2002, "Stock Market Linkages: Evidence from Latin America," *Journal of Banking and Finance*, Vol. 26, pp. 1113–1141.

Claessens, Stijn, Rudiger Dornbusch, and Yung Chul Park, 2001, "Contagion: Why Crises Spread and How this Can be Stopped," in Stijn Claessens, and Kristin J.Forbes, eds.: *International Financial Contagion* (Kluwer Academic Publishers, Norwell, MA).

Diebold, Francis, and Kamil Yilmaz, 2006, "Volatility Contagion," (mimeo; Koc University).

Enders, Walter, 1995, "Applied Econometric Time Series," Wiley Series in Probability and Mathematical Statistics.

Edwards, Sebastian, Biscarri, Javier Gomez, and Perez de Gracia, 2003, "Stock Market Cycles, Financial Liberalization and Volatility," *Journal of International Money and Finance*, Vol. 22 (7), pp. 925–955.

Eun, C.S., and S.Shin, 1989, "International Transmission of Stock Market Movements," *Journal of Financial and Quantitative Analysis,* 24, pp. 241–256.

Fernandez-Serrano, Jose, and Simon Sosvilla-Rivero, 2003, "Modelling the Linkages Between the U.S. and Latin American Stock Markets," *Applied Economics*, Vol.35 (12), pp.1423–1434.

Forbes, Kristin, and Roberto Rigobon, 2002, "No Contagion, Only Interdependence: Measuring Stock Market Comovements," *The Journal of Finance*, Vol.57, No.5, (Oct., 2002), pp.2223–2261

Garrett, Ian, Stuart Hyde, and Jose Varas, 2004, "The Interaction Between Latin American Stock Markets and the U.S.," (mimeo; University of Manchester).

Ganguly, Srideep, and Janice Boucher Breuer, 2007, "Nominal Exchange Rate Volatility, Relative Price Volatility, and the Real Exchange Rate," (mimeo; University of South Carolina).

Gelos, Gaston, and Ratna Sahay, 2001, "Financial Market Spillovers in Transition Economies," Economies of Transition, Vol. 9 (1), pp.53–86.

Hamao, Y., R.W.Maulis, and V.Ng, 1991, "The Effect of the 1987 Stock Crash on International Financial Integration," Ziemba, W., Bailey, W., Hamao, Y. (eds.), *Japanese Financial Market Research*, Elsevier, Amsterdam, pp. 483–502.

International Monetary Fund, 2006, *Global Financial Stability Report*, April (Washington).

———, 2006, *Global Financial Stability Report,* September (Washington).

———, 2006, *Regional Economic Outlook:Western Hemisphere*, November (Washington).

———, 2007, *Global Financial Stability Report*, April (Washington).

King, M.A., and S.Wadhwani, 1990, "Transmission of Volatility Between Stock Markets," *The Review of Financial Studies*, Vol. 3, pp. 5–33.

Masson, Paul, 1998, "Contagion: Monsoon Effects, Spillovers, and Jumps Between Multiple Equilibria," (unpublished; Washington: International Monetary Fund).

Ng, Angela, 2000, "Volatility Spillover Effects from Japan and the U.S. to the Pacific-Basin," *Journal of International Money and Finance*, 19, pp.207–233.

Pagan, Jose, and Gokce Soydemir, 2000, "On the Linkages Between Equity Markets in Latin America," *Applied Economic Letters*, 7, pp. 207–210.

Sarkar, Asani, and Sandeep A. Patel, 1998, "Stock Market Crises in Developed and Emerging Markets," Available via the Internet: http://ssrn.com/abstract=76168.

Wongswan, Jon, 2005, "The Response of Global Equity Indexes to U.S. Monetary Policy Announcements," International Finance Discussion Papers, No. 844.