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Financial Stress Transmission from the United States to BRIC Markets: A Time-Varying Markov-Switching Approach (2019–2024)

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Abstract

The transmission of US financial stress to emerging markets is a key issue in a global environment characterized by the COVID-19 pandemic, monetary tightening, geopolitical tensions, and disruptions in commodity markets. This study aims to analyze the non-linear transmission of US financial stress to the stock markets of the BRIC countries (Brazil, Russia, India and China) and to examine whether this stress increases the probability of regime shifts in the volatility of these markets over the period 2019–2024. The analysis covers the four BRIC economies and uses daily data covering the period from 1 January 2019 to 31 July 2024. Using a Time-Varying Transition Probability Markov-Switching (TVTP-MS) model, we examine whether US financial stress, measured through global equity volatility, credit-risk indicators, dollar-liquidity conditions, and commodity-price movements, increases the likelihood of regime shifts in BRIC market volatility. The empirical results show that US equity volatility and USD-liquidity shocks constitute the dominant global transmission channels. The commodity-price channel is particularly strong for Brazil and Russia, while India and China exhibit greater resilience supported by domestic liquidity buffers and more stable sovereign-risk profiles. The filtered probabilities highlight three major episodes of synchronized bear-regime transitions across BRIC markets: the onset of COVID-19 (2020), the Fed's aggressive tightening combined with the war in Ukraine (2022), and the US banking-stress episode (2023). Theoretically, this study contributes to the understanding of the time-varying nature of financial stress transmission. Empirically, the findings for the BRIC stock markets underscore the significant role of global volatility and USD liquidity conditions in driving stock market regime shifts.

Keywords: U.S. financial stress; emerging BRIC countries; TVTP-MS model; contagion

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1. Introduction

The analysis of the international transmission of economic and financial cycles has become a central issue in contemporary literature, given the intensification of financial globalization. In this context, the United States plays a major role in global financial dynamics due to the international role of the US dollar, the depth of its financial markets, and the influence of Federal Reserve monetary policy. Numerous studies show that shocks originating in the United States can be widely transmitted to advanced economies and emerging markets, thereby contributing to the formation of a "global financial cycle" largely influenced by US financial conditions (Dees et al., 2007; Canova, 2005; Forbes & Rigobon, 2002; Rey, 2015; Miranda-Agrippino & Rey, 2020).

This transmission is particularly important for the emerging economies of the BRIC group (Brazil, Russia, India, and China), given their growing weight in the global economy and their increasing integration into international financial markets. However, their exposure to global turbulence remains heterogeneous due to differences in their financial structures, exchange-rate regimes, degrees of openness, and macro-financial vulnerabilities (Akin & Kose, 2007; Kose et al., 2003).

Recent crises have further reinforced the importance of this issue. The COVID-19 pandemic triggered exceptionally high market volatility in 2020 and significant capital outflows from emerging economies. Subsequently, global monetary tightening in 2022–2023, the war in Ukraine, geopolitical tensions, and disruptions in commodity markets altered international financial conditions. These episodes also highlighted differentiated responses across BRIC economies.

Against this background, this study examines the nonlinear transmission of US financial stress to the stock markets of Brazil, Russia, India, and China over the 2019–2024 period. The central research question is: to what extent, and through which mechanisms, is financial turbulence originating in the United States transmitted to BRIC markets, and how do these economies respond differently to episodes of financial stress?

This question is of two-fold interest. From an academic perspective, the study contributes to a deeper understanding of financial contagion dynamics and regime shifts in an environment characterized by successive global shocks. From an operational perspective, it helps identify the main transmission channels and differences in the exposure of emerging economies to financial stress.

The originality of this study lies in the use of a Markov-Switching Model with Time-Varying Transition Probabilities (MS-TVTP), which makes it possible to analyze the nonlinear dynamics of financial stress and identify differentiated transmission profiles across BRIC countries. The study considers market volatility, liquidity conditions, credit risk, and commodity-price movements as the main potential transmission channels.

The remainder of the article is organized as follows. Section 2 presents the theoretical framework related to financial stress and financial contagion. Section 3 provides a review of the literature on the transmission of international financial shocks and the role of the United States. Section 4 presents the methodology and data used. Section 5 discusses empirical results. Finally, Section 6 presents the conclusions and avenues for future research.

2. Theoretical Framework: Financial Stress and Financial Contagion

2.1. Financial Stress

Financial stress refers to a situation of widespread tensions simultaneously affecting financial markets, liquidity, and credit conditions, leading to increased uncertainty and a reduced ability of the financial system to efficiently provide financing to the economy. The literature approaches this phenomenon through various indicators of financial conditions and market stress (Hakkio & Keeton, 2009; Brave & Butters, 2011; Kliesen et al., 2012).

In this study, US financial stress is captured through several indicators reflecting market volatility, liquidity conditions, and credit risk. This operationalization makes it possible to examine how different dimensions of US financial stress may influence changes in the volatility regimes of BRIC markets.

2.2. Financial Contagion

Financial contagion generally refers to the rapid and excessive transmission of a shock from one market to another, beyond what can be explained by economic fundamentals (Forbes & Rigobon, 2002). The literature also distinguishes between two forms of contagion: "fundamental" contagion, related to trade and financial linkages between countries, and

"non-fundamental" contagion, which may arise from investor sentiment, risk aversion, and herding behavior (Kaminsky & Reinhart, 2000). This distinction is particularly important when analyzing relationships between the United States and emerging economies, as observed market movements may reflect both structural interdependencies and transmission mechanisms that become amplified during periods of crisis.

2.3. Main Transmission Channels

Several channels may explain the transmission of US financial shocks to emerging economies. The dollar channel, in particular, affects the cost of international financing and global liquidity conditions (Bruno & Shin, 2015; Avdjiev et al., 2019). The capital-flow channel reflects the sensitivity of international investors to changes in global risk aversion. Finally, the financial-market channel is based on interdependencies across equity, bond, and commodity markets (Kaminsky & Reinhart, 2000; Eichengreen & Gupta, 2015).

The intensity of these channels may nevertheless differ according to the structural characteristics of emerging economies, including their foreign-exchange reserves, macroprudential policies, exchange-rate regimes, and degree of financial openness.

2.4. Global Financial Cycle

The Global Financial Cycle framework emphasizes the role of the United States in the global synchronization of financial conditions. According to this approach, US monetary policy, dollar dynamics, and fluctuations in global risk aversion are important factors in transmitting financial conditions to emerging markets (Rey, 2015; Bruno & Shin, 2015; Miranda-Agrippino & Rey, 2020) (Table A1 in Appendix A).

This framework therefore helps explain why shocks originating in the United States can simultaneously affect economies with otherwise different economic and financial structures.

2.5. Interdependence, Contagion, and Regime Switching

An important distinction must be made between interdependence and genuine contagion. Forbes and Rigobon (1999, 2002) show that increased correlations between markets during crises may result from a general increase in volatility and do not necessarily indicate a structural change in the relationships between markets.

This distinction supports the use of approaches that identify changes in market dynamics rather than relying solely on changes in correlations. Markov-switching models make it possible to identify distinct volatility regimes, particularly relatively calm and stress periods (Hamilton, 1989). Introducing time-varying transition probabilities further makes it possible to examine the extent to which US financial factors influence the probability of moving from one regime to another.

From this perspective, the MS-TVTP model used in this study provides a framework for jointly analyzing the dynamics of volatility regimes and the mechanisms through which US financial stress is transmitted to BRIC markets.

3. Literature Review

The international transmission of financial shocks has become a major issue in international finance, particularly since the global financial crisis of 2008. The literature emphasizes the central role of the United States in shaping global financial conditions through monetary policy, dollar movements, global risk aversion, capital flows, and financial market volatility. Emerging economies, including the BRIC countries, are particularly exposed to these external disturbances because of their increasing financial integration and dependence on international capital flows.

A fundamental distinction in this literature concerns the difference between financial contagion and normal market interdependence. Forbes and Rigobon (2002) show that the increase in market correlations observed during crises does not necessarily imply genuine contagion, since higher correlations may result from the increase in market volatility. Kaminsky and Reinhart (2000) further emphasize that crises can be transmitted through trade, banking, and financial linkages. These contributions suggest that international financial transmission is not necessarily constant over time and may intensify during periods of stress.

A second strand of literature focuses on the role of the United States in the Global Financial Cycle. Rey (2015) argues that global financial conditions are strongly influenced by US monetary policy, global risk appetite, capital flows, and asset prices. Miranda-Agrippino and Rey (2020) provide further evidence that US monetary policy shocks generate synchronized movements in international asset prices, credit conditions, risk aversion, and capital flows. Bruno and Shin (2015) identify an international banking and risk-taking channel through which US monetary conditions affect capital flows to emerging economies. S. Ahmed and Zlate (2014) similarly show that global factors, including US unconventional monetary policy, significantly influence capital flows to emerging markets. Together, these studies establish US financial conditions as an important source of external stress for emerging economies. Building on Rey (2015) and Miranda-Agrippino and Rey (2020), this study examines how US financial stress affects the probability of regime transitions across the four BRIC stock markets, while accounting for differences in their exposure to global financial conditions and commodity markets.

Empirical evidence also confirms that the transmission of US shocks to emerging and BRIC markets is heterogeneous and tends to strengthen during periods of financial turbulence. Aloui et al. (2011) document dynamic dependence between BRIC equity markets and international financial markets, while Bekaert et al. (2014) show that international financial dependence can increase substantially during crisis episodes. Country-specific studies further indicate that the sensitivity of BRIC markets differs according to their financial openness, exchange-rate arrangements, commodity dependence, and exposure to international capital flows. Such heterogeneity supports the use of an approach capable of distinguishing tranquil and stressed market conditions.

Complementary literature highlights the role of financial stress, liquidity, credit risk, and sovereign risk. Nguyen (2024), Dang (2024), and Pham et al. (2023) show that financial distress, information, and credit conditions can affect stock liquidity and market behavior. Wasi (2021) emphasizes the importance of non-pecuniary determinants in sovereign and bank rating changes, providing additional support for considering sovereign risk as an important component of financial stress. These studies are complementary to the international contagion literature, as they underline the channels through which financial distress can be amplified across markets.

Several econometric approaches have been employed to investigate international financial transmission. VAR and TVP-VAR models capture the dynamic responses of financial markets to external shocks, while GARCH and DCC-GARCH models are widely used to measure time-varying volatility and conditional correlations. Connectedness measures proposed by Diebold and Yilmaz (2009, 2012, 2014) quantify the direction and intensity of spillovers between financial markets.

However, these approaches primarily measure changes in dependence or spillovers and do not directly explain transitions between distinct market states. While Forbes and Rigobon (2002) and Diebold and Yilmaz (2009, 2012, 2014) examine changes in market dependence and financial spillovers, the present study focuses on the role of financial-stress indicators in determining the probability of transitions between market regimes.

Despite their contributions, these approaches leave room for further investigation into the determinants of financial regime transitions. Measuring volatility spillovers or time-varying correlations does not necessarily reveal which financial-stress indicators influence the probability of entering or remaining in a crisis regime. By incorporating observable financial-stress indicators into transition probabilities, the MS-TVTP framework provides a complementary perspective that focuses on the dynamics of market-state changes rather than solely on the intensity of cross-market dependence.

Markov-Switching models provide an alternative framework for identifying latent financial regimes. Following Hamilton (1989), these models allow financial relationships to differ between regimes, such as tranquil and crisis periods. The extension proposed by Filardo (1994) introduces time-varying transition probabilities, allowing observable financial variables to influence the probability of moving from one regime to another. This feature is particularly relevant for studying the transmission of US financial stress, since it allows external stress indicators to affect the probability of entering or remaining in a crisis regime.

Recent global disturbances, including the COVID-19 pandemic and the Russia-Ukraine war, further demonstrate the importance of regime-dependent financial transmission. These episodes were characterized by sharp increases in uncertainty, volatility, capital-flow reversals, and sovereign and market risk. The literature therefore increasingly emphasizes nonlinear and time-varying transmission mechanisms. Nevertheless, relatively limited attention has been devoted to explaining how US financial stress affects the probability of transitions between tranquil and crisis regimes in BRIC equity markets over a period simultaneously covering these major shocks. By covering the COVID-19 pandemic, the subsequent monetary tightening cycle, and the Russia–Ukraine war, the 2019–2024 period provides a common framework for examining whether the determinants of regime transitions differ across major global shocks and BRIC markets.

The distinctive contribution of the present study lies in the joint examination of the probability of regime transitions and the role of multiple financial-stress transmission channels across the four BRIC stock markets. Rather than treating the BRIC economies as a homogeneous group, the analysis considers differences in their exposure to global equity volatility, USD-liquidity conditions, credit risk, sovereign risk, and commodity-price movements. Furthermore, the 2019–2024 sample provides an opportunity to examine regime transitions across several major global disturbances within a common empirical framework, including the COVID-19 pandemic, the monetary tightening cycle, and the Russia–Ukraine war.

The present study addresses this gap by employing a Markov-Switching Model with Time-Varying Transition Probabilities (MS-TVTP) over the 2019–2024 period. The model allows us to identify different market regimes while examining whether US and global financial stress indicators influence the probability of regime transitions. By combining regime identification with time-varying transition probabilities, the study contributes to the literature by moving beyond conventional measures of correlation and spillovers and by providing a more direct assessment of how external financial stress contributes to the emergence and persistence of crisis regimes in BRIC markets.

4. Empirical Methodology

This study aims to analyze the transmission of financial stress from the United States to the stock markets of BRIC countries over the period 2019–2024. More specifically, it seeks to determine whether US financial stress affects the probability of BRIC markets shifting from a low-volatility regime to a high-volatility regime, to identify the main transmission factors, and to examine differences across the four economies. Particular attention is paid to episodes

of heightened instability, notably the COVID-19 pandemic, US monetary tightening, and geopolitical tensions related to the war in Ukraine.

Based on this framework, the following hypotheses were formulated:

H1. *US financial stress significantly increases the probability of BRIC markets transitioning to a high-volatility regime.*

H2. *US financial stress indicators significantly influence the transition probabilities of BRIC markets.*

H3. *The intensity of US financial stress transmission differs across Brazil, Russia, India, and China due to their distinct characteristics and differing exposure to international financial factors.*

H4. *The transmission of US financial stress varies across episodes of heightened financial and geopolitical instability observed during the study period.*

These hypotheses were subsequently tested using a Markov-Switching Model with Time-Varying Transition Probabilities (MS-TVTP), which makes it possible to directly assess the influence of financial stress factors on regime-transition probabilities.

4.1. The Database

To examine the effects of financial crises on emerging-market financial markets, we study the evolution of the stock market indices of the BRIC countries during the period 1 January 2019 to 31 July 2024[1]. We use daily data to obtain a sufficient number of observations during the study period. Our sample covers the period from the subprime crisis that began in January 2019 and ended in July 2024, with the stability of the markets (Dooley & Hutchison, 2009; Khallouli & Sandretto, 2012).

The explanatory variables were constructed using daily financial data and aligned with the observation dates of the BRIC indices. Market volatility is derived from returns, calculated as the logarithmic change in prices and then transformed into a volatility measure. The explanatory variables were constructed using daily financial data and aligned with the observation dates of the BRIC indices. Particular attention was paid to missing observations and differences in trading calendars across markets. Missing observations corresponding to non-trading days were not artificially replaced; instead, the series were aligned using the common available dates. For financial variables, no systematic interpolation was applied in order to avoid artificially altering volatility. This procedure preserves data quality and ensures consistency between the explanatory variables and the transition probabilities estimated by the MS-TVTP model.

Several empirical studies support the methodological choices adopted in this study. Dufrénot et al. (2011) provides an important reference for the use of a Markov model with time-varying transition probabilities to analyze the transmission of financial stress to emerging markets. Other recent studies confirm the relevance of regime-switching models for analyzing financial volatility at a daily frequency, notably M. Y. Ahmed and Sarkodie (2021), who examine the effects of the pandemic and commodity markets, as well as Vukovic et al. (2022), who analyze CDS behavior using Markov-switching models. More recent studies applying TVP-VAR and Markov-switching approaches to financial markets during crisis periods also highlight the usefulness of models capable of accounting for regime changes and the time-varying nature of financial relationships. Finally, studies focusing on CDS, stock markets, and commodities confirm the relevance of using daily data to identify episodes of financial stress and contagion. These studies therefore provide empirical support for the use of an MS-TVTP model, daily data, and financial indicators designed to explain regime changes in BRIC markets.

Several dynamic models are used to analyze financial-stress transmission. GARCH and DCC-GARCH capture volatility and time-varying correlations, while VAR and TVP-VAR examine dynamic interactions between markets. Connectedness measures quantify financial spillovers, whereas Markov-Switching models identify distinct market regimes. The MS-TVTP model extends this analysis by allowing financial-stress indicators to influence regime-transition probabilities.

To explore whether volatility in emerging markets is driven by financial stress in the United States, we use changes in the volatility of these stock market indices as the endogenous variable. It is calculated as the squared stock-market return. Stock returns are calculated as follows:

The daily logarithmic return of the stock market index at date (t) is calculated as follows:

$$R_{i,t} = 100 \times ln\ ln \left(\frac{P_{i,t}}{P_{i,t-1}} \right)$$

where:

$R_{i,t}$: daily return of the stock market index (i) at date (t). $P_{i,t}$: closing value of the stock market index (i) at date (t). $P_{i,t-1}$: closing value of the stock market index (i) on the previous date.

The variable representing volatility is then calculated as the squared return: $V_{i,t} = R_{i,t}^2$.

For the exogenous variables, following Dufrénot et al. (2011), we consider the following proxies: ABCP spreads, which reflect financial conditions in the ABCP market; the spread between the three-month interbank rate and the US federal funds rate, indicating the liquidity of bank financing; the volatility of the S&P 500 index, which serves as a proxy for US stock-market volatility; CDS spreads, which reflect credit risk; and the spreads between two- and five-year US Treasury yields, representing the liquidity conditions in the US market. As for the variable "volatility" in other markets, we consider the volatility of the global stock-market index (excluding the United States) for the sample of regional indices, and the volatility of the regional index for each country will be considered as a transition variable for the BRIC countries. However, unlike Dufrénot et al. (2011), we add a proxy based on an overall commodity price index. This variable is an indicator of stress on independent emerging financial markets relative to the US market. We consider daily data covering the period from 1 January 2019 to 31 July 2024. Daily data provides a large number of observations, allowing us to better capture market dynamics during crisis periods. All data were obtained from the Datastream database and the MSCI website. The database summarizing the variables used in the model to analyze the transmission of US financial stress to emerging markets is presented in Tables A2 and A3 of Appendix A.

4.2. Markov-Switching Model

4.2.1. Hamilton's Markov-Switching Model

Markov-switching models were introduced by Quandt (1958), Goldfeld and Quandt (1973) and further developed by Hamilton (1990). These models define different regimes for the dynamics of the variable studied. The transition from one regime to another depends on an unobserved state variable "s_t" which follows a Markov chain of order one.

The Markov-switching model is specified as follows:

$$y_t = \phi_{01} + \phi_{11} y_{t-1} + \varepsilon_{1t},\ if\ s_t = 1;\ y_t = \phi_{02} + \phi_{12} y_{t-1} + \varepsilon_{2t},\ if\ s_t = 2. \quad (1)$$

where:

y_t endogenous variable; ϕ: the constant. s_t = i, with i = 1, 2.

s_t represents the state of the unobserved variable. It takes 1 in a period of crisis characterized by high volatility and 0 in a period of calm or non-crisis that is associated with low volatility.

Given that the state variable is unobservable, to estimate the model, we calculate the probability of transition from one regime to another. Hamilton (1990) defined it as follows:

$$p_{ij} = P(S_t = j \mid S_{t-1} = i) \tag{2}$$

S_t: represents the regime at time t.

S_{t-1}: represents the previous regime.

p_{ij}: the probability of transition from regime i at time t − 1 to regime j at time t, such as $p_{11} + p_{12} = 1$ and $p_{21} + p_{22} = 1$. A limitation of this model is that it assumes constant transition probabilities between regimes. However, in reality, for a given state, the duration is not fixed in time and is influenced by exogenous shocks. Diebold et al. (1994) and Filardo (1994) were the first to extend the basic model by introducing time-varying transition probabilities

4.2.2. Markov Switching Model with Time-Varying Probabilities

Diebold et al. (1994) and Filardo (1994) proposed a Markov switching model with time-varying probabilities between the two regimes (Time-Varying Transition Probabilities).

Unlike standard Markov-Switching models, which assume constant transition probabilities, the MS-TVTP model allows these probabilities to vary with observable financial indicators. This feature makes it suitable for examining how US financial stress influences transitions between low- and high-volatility regimes in BRIC stock markets. These probabilities are not constant; they are influenced by a vector of exogenous variables Z_t of dimension q*1. Thus, the probability matrix of a transition from one regime to another is as follows:

$$\mathrm{P}\left(S_t = \frac{i}{S_{t-1}} = j, Z_t\right) = p_{ij}\,(Z_t) = \begin{bmatrix} p(Z_t) & 1 - q(Z_t) \\ 1 - p(Z_t) & q(Z_t) \end{bmatrix}; i, j = 0,\ 1 \tag{3}$$

Filardo (1994) assumes that the transition probabilities follow the following logistic specification[2]:

$$\begin{aligned} P_{0,0}\,(Z_t) &= \frac{exp\left(p_0 + p_1\, z_{t-1}\right)}{1 + exp\left(p_0 + p_1\, z_{t-1}\right)} \\ P_{1,1}\,(Z_t) &= \frac{exp\left(q_0 + q_1\, z_{t-1}\right)}{1 + exp\left(q_0 + q_1\, z_{t-1}\right)} \end{aligned} \tag{4}$$

In this model, if $p_1 = q_1 = 0$, we find the constant probability model developed by Goldfeld and Quandt (1973) and Hamilton (1990).

$p_{00}(z_t)$ can be interpreted as the conditional probability and represents the probability of being in the first regime knowing that we were already in the first regime.

$(1 - p_{00}\,(z_t))$ is interpreted as the probability of moving to the second regime knowing we were in the first regime.

$p_{11}(z_t)$ is the conditional probability of being in the second regime knowing that we were already in the second regime.

$(1 - p_{11}(z_t))$ is interpreted as the probability of passing the first plan knowing we were in the second regime. These two probabilities, $p_{00}(z_t)$ and $p_{11}(z_t)$, are used for analyzing the persistence of the regime. More specifically, the type of information contained in z_t influences the sign of the latter and has the same sign as that contained in q_1 and p_1 in Equation (4), for example, if $\hat{q_1} > 0$ and $\hat{p_1} < 0$, after an increase in z_t, this variation may be interpreted through the fact that the probability of remaining in the high regime $(p_{11}(z_t))$ increased and the transition probability of the low regime $(1 - p_{00}(z_t))$ has also increased. A bull market (low volatility) could provide increased probabilities $1 - p_{11}(z_t)$ and $p_{00}(z_t)$ and therefore would be observed as $\hat{p_1} > 0$ and $\hat{q_1} < 0$.

The influence of zt is measured by p1 and q1 variables that must be of opposite signs. It should be noted that Filardo (1994) assumed in this work only the average depends

on the state of the economy. For our study, we will assume that the autoregressive and variance terms are different between the regimes[3]. To estimate the model parameters, maximum likelihood estimation under a Gaussian distribution is used with the EM algorithm[4] ((Expectation-Maximization) programmed by GAUSS 7.0.

Before estimating our model, we must first ensure the stationarity of our series summarizes the results of tests of ADF and KPSS stationarity for all variables in the model. To prove statistically inability autoregressive models, reflect the asymmetry in the volatility stock market indices, we use the likelihood ratio test (LR). This test verifies the robustness of using Switch Markov model over to a non-linear model of regime change. However, Switch Markov models do not have standard asymptotic distributions. To overcome this problem, we use the standard asymptotic distribution undeveloped analytically by Garcia (1998) for certain specifications of Markov models for regime change in two states. The LR statistic is calculated using the following formula:

$$LR = 2 \times |ln\ ln\ (L_{MS})\ - ln\ ln\ (L_{linear})|$$

The results of the LR test under the null hypothesis of linearity stock market volatility represented by the AR (1). The values of this test are much greater than the critical value, confirming the rejection of the null hypothesis. They show that linear models cannot consider the structural changes in the volatility of the stock index caused mainly by international shocks. In our case, this test may be evidence that emerging stock markets have experienced a period of "bull market" and a period of "bear market". The Markov-switching model is therefore more appropriate for identifying these regime changes.

5. Estimation Results

This section presents the estimation results of the Markov-Switching Model with Time-Varying Transition Probabilities (MS-TVTP) applied to the BRIC equity markets over the 2019–2024 period. The analysis aims to identify the different market regimes and examine how US financial stress and other financial conditions affect the dynamics and transitions between these regimes. The results are presented first for the overall regime structure and then discussed separately for Brazil, Russia, India, and China.

5.1. Brazil[5]: Exposure to Global Financial Stress and Commodity-Market Conditions

The estimation results for Brazil (Table 1) reveal two distinct volatility regimes over the 2019–2024 period. Regime 0 is characterized by relatively low volatility, with variance ranging from 4.60 to 5.10 across the different specifications, whereas Regime 1 is associated with substantially higher volatility, with variance ranging from 43.50 to 48.20. This large difference confirms the existence of a clear regime-dependent structure in the Brazilian equity market, with periods of financial stress characterized by considerably higher uncertainty than normal market conditions.

The significance of the Hamilton LR test provides further support for the relevance of the two-regime specification. The LR statistics are significant for US volatility (6.01 **), S&P 500 volatility (7.23 **), commodity-market conditions (6.87 **), and regional volatility (6.87 **). These results indicate that the regime-switching specification captures relevant changes in the dynamics of the Brazilian stock market when these dimensions of financial stress are considered. By contrast, the non-significant LR statistics associated with the ABCP spread, interbank spread, and CDS spread suggest that these specifications provide weaker evidence of regime differentiation for Brazil over the sample period.

The estimates also show that the dynamics of the market differ across regimes. The autoregressive coefficients are between −0.41 and −0.49 in Regime 0, while they range from −0.50 to −0.63 in Regime 1. The larger absolute values observed in the crisis regime

indicate stronger dependence in the dynamics of market volatility during periods of stress. Combined with the much higher variance of Regime 1, this result suggests that once the Brazilian market is characterized by adverse market conditions, fluctuations become substantially more pronounced than in the low-volatility regime.

Table 1. Estimation results (TVP-MS) for the case of Brazil: (2019–2024).

	US Volatility Stock Index S&P 500	Commodity Index	Regional Volatility	ABCP Spread	Interbank Spread	CDS Spread
μ_0	−0.210	−0.180	−0.195	−0.240	−0.230	−0.220
μ_1	0.680	0.720	0.705	0.690	0.670	0.640
Φ_0	−0.48 **	−0.47 **	−0.49 **	−0.41 *	−0.45 **	−0.39
Φ_1	−0.62 **	−0.63 **	−0.61 **	−0.55 **	−0.59 **	−0.50 *
Var_0	4.90 **	4.60 **	4.72 **	5.10 **	4.87 **	5.02 **
Var_1	43.5 **	45.7 **	44.9 **	47.1 **	46.9 **	48.2 **
p_1	−0.12 **	−0.18 **	−0.20 **	−0.05	−0.07	0.01
q_1	0.29 **	0.41 **	0.38 **	0.09	0.03	0.02
LR-test (Hamilton)	6.01 **	7.23 **	6.87 **	1.01	0.98	0.77

Note: *, **,indicate the significance of the estimated coefficients at a level of 10%, 5% respectively.

Regarding the transmission of US financial stress, the significant results obtained for US volatility and S&P 500 volatility indicate that conditions prevailing in US financial markets are relevant to the regime dynamics of the Brazilian equity market. This finding is consistent with the role of the US market as a major source of global financial conditions.

In particular, changes in US market uncertainty can affect international investor sentiment, risk appetite, capital flows, and financing conditions in emerging markets. The Brazilian market is therefore not isolated from global financial disturbances, and US financial stress constitutes an important dimension of its regime-dependent dynamics.

The results also highlight the relevance of commodity-market conditions. The significant LR statistic associated with the commodity index (6.87 **) indicates that the specification incorporating commodity-market conditions provides evidence of distinct volatility regimes for Brazil. This result is economically consistent with the important role of commodity-related activities in the Brazilian economy. Changes in international commodity prices can affect export revenues, corporate earnings, growth expectations, and investor sentiment, thereby influencing stock-market conditions. However, the results should be interpreted as evidence of the importance of commodity-market conditions for regime dynamics, rather than as proof that commodity volatility is the single or dominant determinant of crisis transitions.

Regional financial conditions also appear relevant, as indicated by the significant LR statistic associated with regional volatility (6.87 **). This suggests that the dynamics of the Brazilian equity market are influenced not only by global financial conditions but also by developments in the broader regional market environment. Regional volatility may reinforce the transmission of international shocks through common investor sentiment, capital flows, and financial linkages.

These findings are particularly relevant for the objective of the study, which is to examine the transmission of US financial stress to emerging-market equity markets. The Brazilian case indicates that this transmission operates within a broader international environment in which US market volatility interacts with regional financial conditions and

commodity-market developments. The results therefore support the existence of heterogeneous transmission channels, rather than a uniform response to global financial stress.

The 2019–2024 period provides an appropriate context for observing these dynamics, as it includes several major episodes of international financial stress, notably the COVID-19 pandemic, the subsequent inflationary and commodity-price shocks, the tightening of US monetary policy, and the banking stress of 2023. These episodes do not, by themselves, establish a causal effect for each specific variable, but they provide an economic context consistent with the regime-dependent behavior identified by the model.

Overall, the Brazilian results suggest that the country's equity market is particularly exposed to global financial and commodity-market conditions, while the two-regime structure indicates that the intensity of this exposure varies according to market conditions. The evidence therefore supports the main objective of the study by showing that US financial stress is relevant to the dynamics of the Brazilian equity market, but that its transmission should be understood jointly with regional and commodity-market conditions.

5.2. Russia: Geopolitical and Sovereign Risk Channels

The estimation results for Russia (Table 2) reveal a particularly pronounced distinction between the two market regimes. Regime 0 is characterized by relatively low volatility, with variance ranging from 3.92 to 4.72, whereas Regime 1 exhibits extremely high volatility, with variance ranging from 115.0 to 128.4. This substantial gap indicates that periods of financial stress are associated with a pronounced increase in uncertainty in the Russian equity market.

Table 2. The estimation results (TVP-MS) for the case of Russia (2019–2024).

	CDS Spread	Interbank Spread	US Volatility Stock Index S&P 500	Commodity Index	Regional Index	ABCP Spread
μ_0	−0.260 **	−0.245 **	−0.210	−0.240	−0.220	−0.205
μ_1	0.720 **	0.640	0.590	0.705 **	0.630 *	0.540
Φ_0	−0.25 **	−0.27 **	−0.52 ***	−0.24 **	−0.25 **	−0.22
Φ_1	−0.57 ***	−0.55 ***	−0.53 ***	−0.51 ***	−0.49 **	−0.50 **
Var_0	4.55 **	4.72 **	3.92 **	4.44 **	4.32 **	4.70 **
Var_1	125.2 ***	120.8 ***	115.0 ***	128.4 ***	126.3 ***	118.7 ***
p_1	−0.02	0.19	0.01	−0.03	0.08	−0.04
q_1	3.10 *	0.88	0.52	3.22 *	0.41	−0.12
LR-test (Hamilton)	16.80 ***	6.10 **	14.70 ***	6.90 **	7.45 **	0.80

Note: *, **, *** indicate the significance of the estimated coefficients at a level of 10%, 5% and 1% respectively.

The Hamilton LR test is significant for the CDS (16.80 ***), US volatility (14.70 ***), commodity index (6.90 **), regional volatility (7.45 **), and interbank spread (6.10 *), confirming the relevance of the two-regime specification for these variables. Only the ABCP spread produces a non-significant LR statistic (0.80). These results suggest that several dimensions of global and domestic financial conditions are relevant to the regime-dependent dynamics of the Russian market.

The CDS specification provides the strongest LR statistic (16.80 ***), highlighting the particular importance of sovereign credit risk in distinguishing the market regimes. This result is economically consistent with the sharp deterioration in Russia's financial and geopolitical conditions following the outbreak of the Russia–Ukraine war in 2022. The

significant role of the interbank spread also indicates that funding and liquidity conditions contributed to the dynamics of the Russian market, while the significance of the commodity index reflects the importance of commodity-market conditions for an economy strongly exposed to energy exports.

The significance of US volatility (LR = 14.70 ***) is particularly relevant to the objective of this study. It indicates that US financial conditions are associated with distinct volatility regimes in the Russian equity market. However, the Russian case also shows that the transmission of US financial stress cannot be considered independently of country-specific factors. Sovereign risk, commodity-market conditions, regional volatility, and interbank liquidity appear to interact with international financial conditions in shaping the observed market dynamics.

The autoregressive coefficients are also larger in absolute value in Regime 1, ranging from (−0.49) to (−0.57), compared with (−0.22) to (−0.52) in Regime 0. Together with the much higher variance in Regime 1, this indicates that market dynamics become considerably more pronounced during periods of stress. The particularly high variance of the crisis regime reflects the exceptional magnitude of volatility experienced by the Russian market during the sample period.

Overall, the results for Russia indicate a strong and heterogeneous transmission of financial stress, with US market conditions playing an important role alongside significant sovereign, geopolitical, commodity, and liquidity channels. The evidence therefore suggests that the transmission of US financial stress to Russia is strongly conditioned by country-specific shocks, especially those associated with the geopolitical and sovereign-risk environment after 2022.

5.3. India: US Financial Integration and Heterogeneous Transmission of Financial Stress

During the 2019–2024 period, the Indian equity market exhibits two clearly differentiated volatility regimes. Regime 0 is characterized by relatively low volatility, with variance ranging from (2.08) to (2.26), whereas Regime 1 displays substantially higher volatility, with variance ranging from (17.88) to (18.50). The large difference between the two regimes confirms the presence of distinct market conditions and indicates a significant amplification of uncertainty during periods of financial stress. The estimation results are reported in Table 3.

Table 3. The estimation (TVP-MS) for the case of India (2019–2024).

	US Volatility Stock Index S&P 500	**Regional Index**	**Interbank Spread**	**CDS Spread**	**Commodity Index**	**ABCP Spread**
μ_0	−0.19	−0.17	−0.21	−0.20	−0.18	−0.16
μ_1	0.52 **	0.48 **	0.46 **	0.43	0.44	0.40
Φ_0	−0.42 ***	−0.44 ***	−0.53 ***	−0.52 ***	−0.50 ***	−0.49 ***
Φ_1	−0.54 ***	−0.52 ***	−0.50 ***	−0.51 ***	−0.50 ***	−0.49 ***
Var_0	2.26 **	2.15 **	2.14 **	2.12 **	2.08 **	2.17 **
Var_1	18.50 **	18.20 **	18.10 **	17.90 **	17.88 **	18.05 **
p_1	−0.03	−0.01	−2.82 **	−0.02	−0.01	−0.01
q_1	0.30 *	0.33 **	3.91	−0.03	0.08	0.12
LR-test (Hamilton)	5.22 **	6.12 **	7.01 **	0.61	1.44	0.95

Note: *, **, *** indicate the significance of the estimated coefficients at a level of 10%, 5% and 1% respectively.

The Hamilton LR test is significant for US volatility (5.22 **), regional volatility (6.12 **), and the interbank spread (7.01 **), while the CDS, commodity index, and ABCP spread specifications are not statistically significant. Among the significant variables, the interbank spread produces the highest LR statistic, suggesting that liquidity and funding conditions are particularly relevant to the distinction between the two market regimes. The significance of US volatility nevertheless provides direct support for the central objective of this study, indicating that US financial conditions are associated with regime-dependent dynamics in the Indian equity market.

The significance of regional volatility (LR = 6.12 **) further indicates that Indian market dynamics are also influenced by financial conditions within the broader Asian and regional environment. This result is consistent with India's increasing integration into international financial markets, through which global and regional shocks can be transmitted to domestic equity markets. In contrast, the non-significance of the CDS and commodity-index specifications suggests that sovereign credit risk and commodity-market conditions do not play the same role in distinguishing the Indian regimes as they do in the Russian or Brazilian cases.

The COVID-19 pandemic provides an important context for interpreting the high-volatility regime observed during the sample period. The sharp increase in global uncertainty and financial-market volatility during 2020 is consistent with the substantial difference between the low- and high-volatility regimes identified by the model. The significance of US and regional volatility also suggests that the Indian market was exposed to the international financial stress associated with this global episode. However, since the model does not include a specific COVID-19 dummy variable, the results should be interpreted as evidence of regime-dependent market stress during the sample period rather than as a direct estimate of the pandemic's causal effect.

The Russia-Ukraine war in 2022 constitutes another major source of international financial uncertainty during the sample period. Its potential effects on India are likely to have operated mainly through global financial conditions, regional volatility, and international liquidity rather than through a direct sovereign-risk or commodity channel, given the non-significance of the CDS and commodity-index specifications. The significant US volatility and regional volatility variables therefore indicate that international financial conditions remained relevant during a period characterized by heightened global uncertainty following the outbreak of the war.

The autoregressive coefficients are significant in both regimes and are generally slightly larger in absolute value in Regime 1, ranging from (-0.49) to (-0.54), compared with (-0.42) to (-0.53) in Regime 0. Combined with the much higher variance of Regime 1, these estimates indicate that market dynamics become more pronounced under stressful conditions. The significant transition parameters associated with the interbank spread also reinforce the importance of liquidity conditions in the time-varying regime dynamics, although the exact direction of the change in transition probabilities depends on the specification of the transition equation.

Overall, the Indian results point to a heterogeneous transmission of financial stress in which US and regional financial conditions are significant, while liquidity and funding conditions appear particularly important. The evidence from the COVID-19 pandemic and the Russia–Ukraine war indicates that the Indian market is sensitive to major global stress episodes. However, financial stress appears to be transmitted mainly through international financial and liquidity channels rather than through sovereign-risk or commodity-market channels. This distinguishes India from Brazil and Russia and highlights the country-specific nature of US financial-stress transmission across BRIC equity markets.

5.4. China: External Financial Transmission and Domestic Vulnerabilities

During the 2019–2024 period, the Chinese equity market exhibits two clearly differentiated volatility regimes. Regime 0 is characterized by relatively moderate volatility, with variance ranging from 6.90 to 7.15, whereas Regime 1 displays substantially higher volatility, with variance ranging from 49.10 to 50.40. The large difference between the two regimes confirms the presence of distinct market conditions and indicates a significant amplification of uncertainty during periods of financial stress. The estimation results are reported in Table 4.

Table 4. The estimation (TVP-MS) for the case of China (2019–2024).

	US Volatility Stock Index S&P 500	**Regional Index**	**CDS Spread**	**Interbank Spread**	**Commodity Index**	**ABCP Spread**
μ_0	−0.31	−0.21	−0.19	−0.10	−0.18	−0.11
μ_1	0.58	0.57	0.56	0.55	0.56	0.54
Φ_0	−0.49 **	−0.50 **	−0.48 **	−0.47 **	−0.49 **	−0.46 **
Φ_1	−0.60 **	−0.59 **	−0.60 **	−0.58 **	−0.59 **	−0.58 **
Var_0	6.90 **	7.05 **	7.00 **	7.11 **	7.10 **	7.15 **
Var_1	49.10 **	50.40 **	49.50 **	49.70 **	49.30 **	49.90 **
p_1	−0.02	−0.03	0.06	0.01	−0.11	−0.03
q_1	0.19	0.41	−0.05	−0.02	−0.13	0.09
LR-test (Hamilton)	6.22 **	4.70 *	6.90 **	0.35	−0.50	1.05

Note: *, **, indicate the significance of the estimated coefficients at a level of 10%, 5%, respectively.

The Hamilton LR test is significant for US volatility (6.22 **), regional volatility (4.70 *), and sovereign CDS (6.90 **), whereas the interbank spread (0.35), commodity index (−0.50), and ABCP spread (1.05) are not statistically significant. These results indicate that the Chinese market is particularly sensitive to international financial conditions, regional market developments, and sovereign-risk conditions, while liquidity and commodity-market variables do not significantly improve the distinction between the two regimes.

The significance of US volatility (LR = 6.22 **) provides direct support for the central objective of the study. It indicates that US financial conditions are associated with regime-dependent dynamics in the Chinese equity market. This finding is consistent with the strong financial and economic integration between China and global markets. It is also particularly relevant during the major stress episodes covered by the sample, including the COVID-19 pandemic, the subsequent global monetary tightening cycle, and the period of heightened US–China economic and technological tensions. However, since the model does not include a specific variable measuring US–China geopolitical tensions, these events should be considered as economic contexts for the observed transmission rather than as directly estimated causal effects.

Regional volatility is also significant at the 10% level (LR = 4.70 *), indicating that regional financial conditions contribute to the regime-dependent dynamics of the Chinese market. This result is consistent with China's strong integration into Asian production, trade, and financial networks. The significance of both US and regional volatility therefore suggests that external financial conditions operate through both global and regional channels.

The CDS specification produces the highest LR statistic (6.90 **), highlighting the particular relevance of sovereign-risk conditions in distinguishing the Chinese market regimes. This result is especially important in the context of the deterioration of the Chinese real estate sector from 2021 onward, including the financial difficulties of major developers

and the associated increase in concerns about domestic financial stability. The CDS results therefore provide evidence that changes in perceived credit risk were associated with the regime-dependent dynamics of the Chinese equity market. Nevertheless, the model does not directly identify the real estate crisis as a causal determinant, since no specific real estate variable is included.

The COVID-19 pandemic represents another important context for interpreting the Chinese results. As the pandemic originated in China and was followed by strict containment measures and substantial disruptions to economic activity and global supply chains, it coincided with a period of exceptionally high international uncertainty. The large difference between the two estimated volatility regimes is consistent with the presence of such episodes of elevated market stress. The subsequent reopening of the Chinese economy and the normalization of global activity were also accompanied by important changes in financial and macroeconomic conditions. However, as with the other BRIC markets, the absence of a specific COVID-19 dummy prevents the model from isolating a direct pandemic effect.

The Russia–Ukraine war also forms part of the external environment during the latter part of the sample. Its implications for China were transmitted mainly through global uncertainty, international financial conditions, and regional economic channels. The significance of US and regional volatility is therefore consistent with the continued exposure of the Chinese market to international financial conditions during this period. By contrast, the non-significance of the commodity-index specification suggests that commodity-market conditions did not constitute a principal factor distinguishing the Chinese volatility regimes over the full sample period.

The autoregressive coefficients are significant in both regimes and are systematically larger in absolute value in Regime 1, ranging from (-0.58) to (-0.60), compared with (-0.46) to (-0.50) in Regime 0. Together with the substantially higher variance of Regime 1, this indicates that market dynamics become more pronounced under stressful conditions. The persistence of market dynamics is therefore stronger when the Chinese equity market is in the high-volatility regime.

Overall, the Chinese results reveal a combination of external financial transmission and domestic risk conditions. US financial volatility and regional market volatility are significant, supporting the role of international financial integration, while the CDS results point to the importance of sovereign and domestic credit-risk conditions. The COVID-19 pandemic, the post-pandemic adjustment, the US–China tensions, and the Russia-Ukraine war provide important contexts for the observed volatility regimes, although their individual effects cannot be separately identified by the model. Compared with Brazil and Russia, where commodity and geopolitical channels are particularly prominent, the Chinese market appears to be characterized by a combination of global financial exposure, regional integration, and domestic credit-risk conditions.

5.5. Summary of the Discussion of the Results

The results of the MS-TVTP model show that the transmission of US financial stress to the stock markets of BRIC countries is nonlinear, heterogeneous, and regime-dependent. Two distinct regimes are identified: a low-volatility regime and a high-volatility regime. The main episodes of international financial stress, including the COVID-19 pandemic, US monetary tightening, the Russia-Ukraine war, and the banking tensions of 2023, coincide with periods of heightened market stress and increased volatility. These results highlight the significant role of US financial conditions in shaping the dynamics of emerging markets. The analysis also highlights substantial heterogeneity across BRIC countries. Brazil is particularly sensitive to commodity-market fluctuations, while Russia stands out for the importance of CDS, interbank spreads, and commodity-market conditions, with a marked

change after 2022 in the context of geopolitical tensions and sanctions. In India, US and regional market volatility represent important transmission channels. China exhibits a more hybrid profile, in which external factors interact with domestic vulnerabilities, particularly real-estate pressures and the economic slowdown.

Overall, these findings are consistent with the existing literature on the global financial cycle, financial spillovers, and international interdependencies. They confirm the central role of the United States, the asymmetric nature of shock transmission, and the importance of country-specific characteristics. The originality of this study lies in the use of the MS-TVTP model, which makes it possible to identify volatility regimes while examining the factors associated with regime-switching probabilities, and to analyze the four BRIC economies within a homogeneous empirical framework over a period characterized by successive global crises.

Finally, the study shows that crisis episodes may be associated with greater persistence of financial stress and changes in market dynamics. The main contribution is therefore to show that the transmission of US financial stress is not uniform but depends on productive structure, exposure to commodity markets, financial integration, sovereign and banking risk, and domestic vulnerabilities. The MS-TVTP model thus provides a perspective complementary to those offered by traditional approaches based on correlations, VAR models, or GARCH models.

The detailed database and the definitions of the variables used in the analysis are presented in Appendix A, Table A2.

6. Conclusions and Recommendations

6.1. Main Findings and Contributions

This study analyzed the transmission of US financial stress to the stock markets of Brazil, Russia, India, and China over the 2019–2024 period using a Markov-Switching Model with Time-Varying Transition Probabilities (MS-TVTP). The results reveal two distinct volatility regimes across the four economies, as well as substantial heterogeneity in the transmission mechanisms.

The filtered probabilities identify three major episodes associated with shifts toward the high-volatility regime: the COVID-19 pandemic in 2020, the US monetary tightening associated with the war in Ukraine in 2022, and the international banking tensions in 2023. A gradual stabilization is observed during 2023–2024 in most economies, although international financial and geopolitical conditions remained sources of vulnerability.

The results highlight four main transmission channels: global equity-market volatility, commodity markets, sovereign and banking risk, and dollar liquidity conditions. Their relative importance varies across countries: Brazil is more exposed to commodity markets and global volatility; Russia is more exposed to sovereign and banking risks, as well as energy-related shocks; India is more exposed to US and international financial conditions; while China exhibits a profile combining external factors with domestic vulnerabilities.

Overall, the findings confirm the continuing role of the US financial cycle in emerging markets while highlighting the differentiated nature of financial-stress transmission. They therefore do not support the hypothesis of complete decoupling of BRIC markets from the US financial cycle. From a scientific perspective, the study contributes to the literature by considering a succession of recent global shocks, applying a nonlinear MS-TVTP framework, and identifying differentiated transmission profiles across the BRIC economies (Table A4 in Appendix A).

6.2. Policy Implications and Recommendations

The results indicate the need to strengthen the monitoring of key international financial-stress indicators, particularly market volatility, dollar liquidity conditions, credit spreads, sovereign risk, and commodity prices. The findings also support the implementation of macroprudential policies tailored to the specific vulnerabilities of each economy. Prudent management of international reserves, monitoring capital flows, and the use of countercyclical macroprudential instruments may help strengthen the capacity of emerging economies to absorb external shocks. For investors, the findings also emphasize the importance of incorporating international financial-stress indicators into portfolio construction, promoting international diversification across markets with different risk exposures, and adapting approaches to risk management to changing market conditions. Finally, greater regional financial cooperation, particularly in terms of risk monitoring, information sharing, and emergency liquidity mechanisms, could contribute to strengthening the stability of emerging economies in the face of international shocks.

6.3. Limitations of the Study

This study has several limitations. First, the analysis period, from January 2019 to July 2024, remains relatively short and is characterized by an exceptional succession of global shocks. The sample, which is limited to the four BRIC economies, also limits the generalizability of the findings to emerging markets as a whole.

Furthermore, the selected variables represent indicators of the different transmission channels and do not capture all of the underlying institutional, trade, and financial mechanisms, including the herding behavior of international investors. Finally, although the MS-TVTP model is capable of capturing nonlinear dynamics and regime changes, it does not allow for a complete structural causal interpretation of the relationship between US financial-stress indicators and BRIC market volatility. Future research could incorporate additional variables, such as international investor herding behavior and foreign portfolio flows, and employ advanced empirical methods, such as DCC-GARCH and TVP-VAR models, to provide further insights into the dynamics of financial-stress transmission across BRIC stock markets.

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Conflicts of Interest: The author declares no conflict of interest.

Appendix A

Table A1. Summary of the main studies on international financial transmission.

Study	Objective	Importance	Data/Period	Sample	Methodology	Main Result
Rey (2015)	To examine the Global Financial Cycle and the role of US monetary policy in global financial conditions.	Establishes the central role of the US in the synchronization of global financial conditions.	Capital flows, asset prices, credit, and global financial indicators.	Advanced and emerging economies.	Global factor analysis.	US monetary tightening is associated with higher global risk aversion, dollar appreciation and lower capital flows to emerging economies.

Table A1. *Cont.*

Study	Objective	Importance	Data/Period	Sample	Methodology	Main Result
Bruno and Shin (2015)	To investigate the international banking and risk-taking channels of US monetary policy.	Explains how US monetary conditions affect international liquidity and capital flows.	US interest rates, bank leverage, credit and international capital flows.	US and emerging economies.	Theoretical model and empirical analysis.	Accommodative US monetary policy increases bank leverage and capital flows to emerging economies, while tightening has the opposite effect.
Aloui et al. (2011)	To examine the dynamic dependence between BRIC equity markets and international financial markets.	Provides evidence of changing BRIC exposure to international financial conditions.	Equity returns and volatility.	BRIC countries and international markets.	DCC-GARCH.	Market interdependence increases significantly during periods of financial stress.
Bekaert et al. (2014)	To investigate international equity-market contagion during financial crises.	Distinguishes changes in market dependence from crisis-related contagion.	Equity returns and international financial factors.	International equity markets.	Contagion models and factor analysis.	Financial contagion and cross-market dependence increase during crisis episodes.
Gurdgiev and O'Riordan (2021)	To examine the dynamic relationships between BRIC and advanced-economy equity markets across different time horizons.	Highlights the time-varying and frequency-dependent nature of financial integration.	Equity-market data, 2000–2016.	BRIC and advanced economies.	Wavelet transform analysis.	Market relationships vary across time horizons and change significantly during periods of stress.
Kangogo and Volkov (2022)	To investigate volatility spillovers across different market regimes.	Supports the importance of regime-dependent financial transmission.	Realized volatility, 1999–2017.	Global financial markets.	Markov-switching VAR.	Spillovers are substantially stronger during turbulent regimes than during tranquil periods.
Ouyang et al. (2023)	To examine financial contagion across different frequency domains.	Shows that financial transmission cannot be fully captured by aggregate measures alone.	Financial-risk indicators and connectedness measures.	Global equity markets.	Multilayer and frequency-domain connectedness.	Contagion mechanisms differ across frequencies and investment horizons.
Zhai et al. (2024)	To investigate interactions between market and sovereign risk during COVID-19.	Highlights the role of sovereign credit risk in the transmission of financial stress.	Equity and CDS data during COVID-19.	32 equity and CDS markets.	Time-frequency spillover analysis.	Short-term spillovers between equity and CDS markets increased sharply during the pandemic.

Table A1. *Cont.*

Study	Objective	Importance	Data/Period	Sample	Methodology	Main Result
Maurya et al. (2024)	To examine changes in global financial connectedness during recent crises.	Provides evidence of intensified financial transmission during major global shocks.	Volatility indices, 2014–2023.	13 G20 countries.	TVP-VAR and connectedness analysis.	Financial connectedness increased significantly during COVID-19 and the Russia-Ukraine war.
Nguyen (2024)	To examine the dynamic effects of debtor bankruptcy on creditors' stock liquidity.	Highlights the role of credit distress in transmitting financial stress through liquidity.	Bankruptcy and stock-liquidity data.	Firms and unsecured creditors.	Dynamic empirical analysis.	Debtor bankruptcy significantly affects the stock liquidity of exposed creditors.
Dang (2024)	To investigate informed trading around corporate bankruptcies.	Emphasizes the role of information asymmetry during periods of financial distress.	Trading activity around bankruptcy announcements.	Listed firms.	Empirical analysis of informed trading.	Corporate bankruptcy significantly affects investor trading behavior and information-related trading activity.
Pham et al. (2023)	To examine the impact of bank-loan announcements on stock liquidity.	Links banking-financing conditions to equity-market liquidity.	Bank-loan announcements and stock-liquidity measures.	Listed firms.	Empirical/ event-based analysis.	Bank-loan announcements significantly affect stock liquidity.
Wasi (2021)	To identify non-pecuniary determinants of sovereign and bank rating changes.	Highlights the importance of broader risk perceptions in sovereign and banking risk assessment.	Sovereign and bank rating data.	Countries and financial institutions.	Empirical analysis of rating changes.	Rating changes are influenced by factors beyond conventional financial fundamentals.
Present study	To examine the effect of US financial stress on transitions between market regimes in BRIC equity markets.	Directly links US financial stress to the probability and persistence of crisis regimes.	Equity-market returns/volatility and US financial-stress variables, 2019–2024.	Brazil, Russia, India and China.	MS-TVTP (Markov-Switching Model with Time-Varying Transition Probabilities).	Identifies distinct market regimes and evaluates whether US financial stress affects the probability of entering, exiting, and remaining in a crisis regime.

Table A2. Definition, Use, Measurement, and Data Sources of Variables.

Variables	Proxy/Indicator	Use in the Model	Calculation or Measurement	Data Source
Emerging market volatility	Squared stock returns of regional emerging market indices and BRIC indices	Endogenous variable	r_{it}^2, where r_{it} is the return of the index	Datastream, MSCI

Table A2. *Cont.*

Variables	Proxy/Indicator	Use in the Model	Calculation or Measurement	Data Source
ABCP market stress	ABCP spread	Exogenous explanatory variable	Difference between the ABCP rate and a comparable benchmark rate	Datastream
Bank funding liquidity	3-month interbank spread—Fed Funds rate	Exogenous explanatory variable	Difference between the 3-month interbank rate and the US Federal Funds rate	Datastream
US market volatility	S&P 500 index volatility	Exogenous explanatory variable	Squared return of the S&P 500, or the volatility measure available in the database	Datastream
Bank default risk	CDS spreads	Exogenous explanatory variable	Difference between the CDS rate and the corresponding risk-free benchmark rate	Datastream
US market liquidity	Spread between 2-year and 5-year US Treasury bonds	Exogenous explanatory variable	Yield spread between the 2-year and 5-year maturities, according to the convention adopted	Datastream
Commodity market stress	Global commodity price index	Additional exogenous variable	Change in or level of the global commodity price index	Datastream
Global market volatility excluding the US	Volatility of the global stock market index excluding the US	Transition variable for regional emerging market indices	Squared return of the global ex-US index, or the selected volatility measure	Datastream, MSCI
Regional market volatility	Volatility of the corresponding regional index	Transition variable for BRIC countries	Squared return of the associated regional index	Datastream, MSCI

Table A3. Transition Variables.

Sample	Transition Variable	Role	Calculation	Source
Regional emerging market indices	Volatility of the global stock market index excluding the US	Influences the transition probabilities between volatility regimes	r_t^2	Datastream, MSCI
BRIC countries	Volatility of the corresponding regional index for each country	Captures the influence of regional financial conditions on transition probabilities	r_t^2	Datastream, MSCI

Table A4. Country-Specific Financial Stress Transmission Channels and Key Shocks.

Country	Main Identified Channel	Complementary Factors	Particularly Important Episode/Shock	Interpretation
Brazil	Commodity markets	US volatility, regional volatility	COVID-19 and the 2021–2023 commodity price shock	High exposure to the commodity cycle
Russia	CDS/sovereign risk	Commodity markets, interbank spread	Russia-Ukraine war, 2022	Geopolitical disruption and high stress persistence
India	US volatility	Regional volatility, interbank liquidity	US monetary tightening	Significant financial transmission, but relatively limited amplification
China	US and regional volatility	CDS, real estate vulnerabilities	US-China tensions and the real estate crisis	Interaction between external shocks and domestic vulnerabilities

Notes

[1] The COVID-19 pandemic (2020–2021), followed by supply-chain disruptions, rising geopolitical tensions, the Russia-Ukraine conflict (from 2022), and the most aggressive monetary-policy tightening by the US Federal Reserve since the 1980s (2022–2024), generated exceptional volatility across global financial markets.

[2] Kim et al. (2008) introduced a model in which probability varied over time using a transition probability in the probit function.

[3] This is to take account of a larger asymmetry in the series. In fact, the variance in the phase of returns "crisis" is greater than the variance in the phase of returns "normal" type stage (Black, 1976; Christie, 1982). With this difference, it is interesting to assume that the average returns and the variance differ between the different regimes. Kähler and Marnet (1992) demonstrate empirically that the variance is different in recession than in expansion for four countries.

[4] Filardo and Gordon (1998) use the Gibbs sampler to estimate these parameters.

[5] Brazil is part of the BRIC group (Brazil, Russia, India, China) because, at the time the concept was introduced, it met a set of economic and geopolitical criteria that placed it among the major emerging powers capable of influencing the global economy in the twenty-first century.

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