Dynamic Connectedness across Equity, Currency, and Commodity Markets in South Asia: A Time- Varying Parameter Vector Autoregressive Approach

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ABSTRACT

This study examines the dynamic return spillovers among major South Asian financial markets, including equity indices from India (NIFTY50R), Pakistan (KSER), and Sri Lanka (SLASPIR), as well as key global commodities such as Brent crude oil (BrentR) and gold (GoldR), and the relevant exchange rates (USDINR, USDPKR, and USDLKR). Using the Time-Varying Parameter Vector Autoregressive (TVP-VAR) connectedness approach, the analysis covers the period from March 2, 2005, to February 29, 2024, providing insights into how financial shocks propagate across these interconnected markets over nearly two decades. The findings reveal that the Indian equity market (NIFTY50R) and the Indian Rupee exchange rate (USDINR) serve as significant transmitters of shocks within the South Asian region, influencing other regional markets. Conversely, the Sri Lankan (SLASPIR) and Pakistani (KSER) equity indices are identified as net receivers of shocks, indicating their vulnerability to external financial disturbances. The study also highlights the pivotal role of Brent crude oil prices (BrentR) in driving spillovers, particularly affecting the Indian financial markets. The study's findings have significant implications for understanding the complexities of market interconnectedness in South Asia, particularly in the context of global economic integration.

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1. Introduction

The increasing interconnectedness of global financial markets has prompted extensive research into the transmission of shocks and spillovers across various asset classes, including equity markets, currencies, commodities, and precious metals. This study focuses on analyzing return spillovers in major South Asian stock markets—specifically those of India, Pakistan, and Sri Lanka—as well as the relevant currencies in these countries, crude oil, and gold prices. By employing the Time-Varying Parameter Vector Autoregressive (TVP-VAR) connectedness approach, this paper aims to provide a comprehensive analysis of the dynamic spillover effects over the period from March 2, 2005, to February 29, 2024. This approach, as highlighted in the work of Antonakakis et al. (2020), is particularly suited for capturing the time-varying nature of connectedness without the limitations associated with rolling-window analyses, making it a robust framework for this study.

The research questions guiding this study are centered on the nature and extent of return spillovers between equity markets in India, Pakistan, and Sri Lanka, and their corresponding currencies. Additionally, this study seeks to understand the role of global commodities such as crude oil and gold in this interconnectedness. Given the volatility in global financial markets, particularly during periods of economic turmoil, it is crucial to examine whether these spillover effects exhibit significant temporal variations. Previous research, such as that by Tiwari et al. (2021), has shown that such spillovers can be both dynamic and volatile, suggesting that the nature of these connectedness relationships may change significantly over time.

The objectives of this paper are to quantify the extent of return spillovers among the selected financial markets and commodities, and to identify the primary transmitters and receivers of these spillovers over time. This study also aims to track the temporal evolution of connectedness in response to global and regional economic events, following the methodologies outlined in studies like those of Gabauer and Gupta (2018). Understanding these dynamics is essential for policymakers and investors, particularly in emerging markets, where the financial systems are often more vulnerable to external shocks.

The motivation for this research is grounded in the significant role that emerging markets play in the global financial system. South Asia, with its rapidly growing economies and increasing integration into global trade and finance, offers a unique context to study the dynamics of financial connectedness. The region's economic significance makes it imperative to understand how local and global factors interact within its financial markets. This study contributes to filling this gap in the literature by extending the analysis of financial connectedness to South Asia, an area that has been underrepresented in existing research. For instance, studies like those by Nong (2024) and Belcaid and El Ghini (2019) have explored connectedness in global markets, but they have not focused on this particular region.

Theoretically, this study builds on the foundational work of Diebold and Yilmaz (2012) on spillover indices, extending it by applying the TVP-VAR approach as enhanced by Antonakakis et al. (2020). This method is particularly effective in capturing the complexities of time-varying connectedness, which is a crucial feature of financial data characterized by volatility clustering and structural breaks. The methodological framework used in this study allows for a more nuanced understanding of the spillover dynamics between equity markets, currencies, and global commodities, similar to the approaches used in studies by Chen et al. (2022) and Pandey and Vipul (2018). Empirically, this study contributes to the existing literature by offering a detailed examination of spillover effects in South Asian markets, which are critical yet underexplored in current research. While previous studies have focused on developed markets, this paper provides new insights into how spillovers operate in emerging economies, with a specific focus on South Asia. This is particularly relevant given the region's growing importance in the global economy. The analysis also incorporates global commodities like crude oil and gold, which are essential to the economies of these countries, as shown in studies by Singhal et al. (2019) and Kumar et al. (2022).

Consequently, this paper seeks to make several contributions to the existing literature. First, it

provides a comprehensive analysis of return spillovers in South Asian equity markets, relevant currencies, and key global commodities using the TVP-VAR connectedness approach. Second, it identifies the dynamic evolution of spillovers, highlighting periods of increased connectedness during global financial crises and regional economic disturbances. Third, it offers insights into the role of global commodities, such as crude oil and gold, in the financial interconnectedness of South Asian markets. Finally, it contributes to the broader understanding of financial market integration in emerging economies, with implications for policy formulation and investment strategies. This study, therefore, fills a significant gap in the literature by focusing on a region of growing economic importance and by employing a methodological approach that captures the complexities of time-varying financial connectedness.

The remainder of the article is structured as follows: Section 2 reviews the relevant literature on financial market spillovers. Section 3 outlines the methodology, focusing on the TVP-VAR connectedness approach and data. Section 4 presents the analysis of the results, while Section 5 discusses the economic, academic, and policy implications. Finally, Section 6 concludes with a summary of findings, contributions, limitations, and future research directions.

2. Literature Review

The study of return and volatility spillovers across financial markets has been extensively explored in recent literature, with significant advancements in econometric methodologies enhancing our understanding of market interconnectedness. The Time-Varying Parameter Vector Autoregressive (TVP-VAR) model, introduced by Antonakakis et al. (2020), has been a pivotal tool in capturing the dynamic nature of spillovers, outperforming traditional rolling-window approaches. This model has been effectively applied to various financial markets, providing a more nuanced understanding of how market interactions evolve over time in response to economic and financial disturbances.

The importance of capturing dynamic spillovers has been emphasized by numerous studies. For instance, Yoon et al. (2019) and Mensi et al. (2023) expanded the scope of connectedness studies by applying network spillover methodologies to a range of asset classes, including equity, bond, currency, and commodity markets. These studies quantified net directional connectedness, offering insights into how shocks propagate across markets, which is critical for developing effective portfolio management strategies. Similarly, Kang and Lee (2019) utilized the DECO-FIGARCH model alongside Diebold and Yilmaz's spillover index to capture volatility spillovers between stock indices and commodity futures, particularly during financial crises. Their findings underscored the importance of identifying markets that act as net transmitters or receivers of volatility, a theme that resonates with the results of studies on market contagion during crises (Mensi et al., 2018; Bouri et al., 2021).

The exploration of spillover dynamics has not been limited to developed markets. Belcaid and El Ghini (2019) assessed return and volatility spillovers among Moroccan, U.S., and European stock markets, highlighting how the Global Financial Crisis significantly increased financial connectedness between these markets. This study aligns with the findings of Tiwari et al. (2021), who investigated the oil-stock return and volatility connectedness, revealing that spillover indices for WTI and Brent oil are particularly sensitive to economic shocks. Such findings emphasize the importance of including global commodities like crude oil in spillover analyses, as these commodities often serve as conduits for transmitting shocks across markets.

In addition to stock markets and commodities, the connectedness between financial indices and macroeconomic variables has been a subject of interest. Gabauer and Gupta (2018) introduced a novel extension of the dynamic directional connectedness approach, which decomposes spillovers into internal and external components. Their analysis of economic policy uncertainty spillovers between Japan and the U.S. demonstrated that monetary policy uncertainty is a significant driver of spillovers, a conclusion that is supported by other studies focusing on the impact of macroeconomic news and uncertainties on market connectedness (Nong, 2024; Mensi et al., 2018). The relationship between gold and oil prices and their spillover effects on equity markets has been extensively documented. Studies by Chen et

al. (2022) and Pandey and Vipul (2018) revealed that gold often acts as the ultimate recipient of volatility spillovers from crude oil and other markets, a finding consistent with the work of Fonseca and Ignatieva (2018), who examined the volatility spillovers in the U.S. credit default swap market during the Global Financial Crisis. These studies highlight the importance of including both gold and oil in spillover analyses, as these commodities are critical in understanding the transmission of shocks in global financial markets.

The interplay between equity markets, currencies, and commodities has been further explored by researchers like Singhal et al. (2019), who investigated the dynamic relationship among international oil prices, gold prices, exchange rates, and stock market indices. Their findings suggest that oil prices negatively affect stock prices, while gold prices have a positive influence, highlighting the complex and often asymmetric spillover effects that exist between these markets. This complexity is echoed in the work of Kumar et al. (2022), who analyzed volatility spillovers among crude oil, natural gas, exchange rates, gold, and stock markets in India, demonstrating that these spillovers are sensitive to both global and local factors.

The impact of financial crises on spillover dynamics has been a recurring theme in the literature. Nong (2024) found that the total connectedness index for 50 selected stock markets showed significant temporal variations, with the most substantial changes occurring during the onset of the COVID-19 pandemic. This finding is consistent with the work of Bouri et al. (2017) and Bassil et al. (2019), who documented that financial crisis intensify the interdependencies between markets, leading to increased spillovers. Similarly, studies by Beckmann et al. (2019) and Reboredo (2013) highlighted the role of gold as a safe haven during periods of economic turmoil, further emphasizing the importance of considering commodities in spillover analyses.

Moreover, the literature has also explored the spillover effects between different financial instruments, such as cryptocurrencies and traditional assets. Dahir et al. (2020) examined the dynamic connectedness between Bitcoin and equity market information in BRICS countries, finding that Bitcoin primarily acts as a receiver of volatility rather than a transmitter. This aligns with the findings of Shahzad et al. (2019, 2020), who compared the safe haven properties of Bitcoin and gold, concluding that while Bitcoin has gained popularity as a safe haven, gold remains a more reliable hedge against market volatility.

The literature on return and volatility spillovers is rich and diverse, with significant contributions that have enhanced our understanding of market interconnectedness. The use of econometric models, such as the TVP-VAR, has allowed researchers to capture the dynamic nature of spillovers more effectively, providing valuable insights into how shocks are transmitted across different asset classes and markets. This study builds on these insights by applying the TVP-VAR connectedness approach to analyze return spillovers in South Asian markets, focusing on the interactions between regional equity markets, relevant currencies, crude oil, and gold prices. By doing so, it aims to contribute to the broader understanding of financial market integration in emerging economies, with implications for both policymakers and investors.

3. Methodology

3.1. Data and Sample

The study focuses on analyzing return spillovers in major South Asian stock markets, relevant currencies, crude oil, and gold prices using the Time-Varying Parameter Vector Autoregressive (TVP-VAR) connectedness approach. The analysis covers the period from March 2, 2005, to February 29, 2024, allowing for an extensive examination of spillover dynamics over nearly two decades, including periods of significant financial and economic disturbances.

The data set includes daily closing prices for the following variables: the NIFTY50 index representing the Indian equity market, the KSE index representing the Pakistani equity market, and the ASPI index representing the Sri Lankan equity market. In addition to these equity indices, the study incorporates the COMEX Gold Composite Commodity Futures to represent gold prices, the ICE Europe Brent crude oil futures to represent crude oil prices, and spot exchange rates for USD/INR, USD/LKR, and USD/PKR, representing the exchange rates of the U.S. dollar against the Indian rupee, Sri Lankan rupee, and

Pakistani rupee, respectively. All data were collected from Bloomberg, ensuring accuracy and consistency across the different financial instruments.

After obtaining the daily closing prices, the daily return series for each variable was calculated. The return series, which represent the percentage change in the price from one day to the next, are essential for capturing the dynamic interactions and spillover effects among the markets being studied.

The variables included in the analysis are detailed in Table 1 below:

Table 01
Variables Used

Variable	Description	Symbol Used*
India-equity index	NIFTY50 index	NIFTY50R
Gold	COMEX Gold Composite Commodity Futures	GoldR
Karachi (Pakistan Stock Exchange) - equity	KSE index	KSER
Sri Lanka ASPI equity	ASPI Index	ASPIR
Crude oil	ICE Europe Brent crude oil futures	BrentR
USD/INR exchange rate	Spot rate	USDINR
USD/LKR (Sri Lankan rupee) exchange rate	Spot rate	USDLKR
USD/PKR (Pakistani rupee) exchange rate	Spot rate	USDPKR

**Return Series*

The choice of these variables is motivated by their relevance to the South Asian financial markets and their significance in global economic contexts. The NIFTY50, KSE, and ASPI indices are key indicators of the equity market performance in their respective countries, while gold and crude oil are essential commodities with significant influence on global and regional economies. The exchange rates provide additional insight into the currency market dynamics, which are crucial for understanding the broader financial interconnectedness in the region.

The use of daily data and the corresponding return series allows for a detailed analysis of the return spillovers, capturing the short-term dynamics and variations in connectedness across different market conditions.

3.2. TVP-VAR Connectedness Approach for Return Spillovers

The TVP-VAR-based dynamic connectedness approach, initially proposed by Diebold and Yılmaz (2009, 2012, 2014), is a commonly used framework for tracing and evaluating spillovers within a predefined network. This approach is valued for its ability to conduct both static and dynamic analyses of time series networks. The static analysis utilizes a vector autoregressive model (VAR) on the entire dataset, while the dynamic analysis employs a rolling-window VAR to capture time-varying spillovers. Antonakakis et al. (2020) advanced this methodology by introducing a time-varying parameter vector autoregressive (TVP-VAR) model, which addresses several of the limitations associated with the traditional rolling-window VAR approach.

The TVP-VAR model offers several distinct advantages: it is less sensitive to outliers due to the use of the Kalman filter, it eliminates the need for arbitrary selection of rolling-window size, it avoids the loss of observations, and it is well-suited for application to low-frequency datasets. This study follows the methodology described by Antonakakis et al. (2018), Gabauer and Gupta (2018), and Bouri et al. (2021), estimating a TVP-VAR (1) model as determined by the Bayesian Information Criterion (BIC). The specification of the TVP-VAR model in this study is as follows:

$$Z_t = B_t Z_{t-1} + U_t \qquad U_t \sim N(0, S_t) \qquad (1)$$

$$vec(B_t) = vec(B_{t-1}) + v_t \qquad v_t \sim N(0, R_t) \qquad (2)$$

where Z_t and Z_{t-1} , are $k \times 1$ dimensional vectors, and B_t and S_t are $k \times k$ dimensional matrices. $vec(B_t)$ and v_t are $k^2 \times 1$ dimensional vectors, and R_t is a $k^2 \times k^2$ dimensional matrix. Subsequently, the H-step ahead generalized forecast error variance decomposition (GFEVD) introduced by Koop et al. (1996) and Pesaran and Shin (1998) is calculated. Unlike the orthogonalized forecast error variance

decomposition, the GFEVD is invariant to the ordering of variables (Diebold & Yılmaz, 2009). The GFEVD is normalized such that each row sums to unity, representing the influence of variable j on variable i in terms of its forecast error variance share, defined as the pairwise directional connectedness from j to i:

$$\phi_{ij,t}^{g}(H) = \frac{S_{ii}^{-1}\sum_{t=1}^{H-1}(e_i' A_t S_t e_j)^2}{\sum_{j=1}^{k}\sum_{t=1}^{H-1}(e_i' A_t S_t e_j)} \quad (3)$$

$$\tilde{\phi}_{ij,t}^{g}(H) = \frac{\phi_{ij,t}^{g}(H)}{\sum_{j=1}^{k}\phi_{ij,t}^{g}(H)} \quad (4)$$

where e_i is a selection vector with unity in the i^{th} position and zeros elsewhere.

Based on the GFEVD, Diebold and Yılmaz (2012, 2014) derived several connectedness measures.

Total directional connectedness to others:

$$TO_{jt} = \sum_{i=1,i\neq j}^{k}\tilde{\phi}_{ij,t}^{g}(H) \quad (5)$$

Total directional connectedness from others:

$$FROM_{jt} = \sum_{i=1,i\neq j}^{k}\tilde{\phi}_{ji,t}^{g}(H) \quad (6)$$

Net total directional connectedness:

$$NET_{jt} = TO_{jt} - FROM_{jt} \quad (7)$$

Total connectedness index:

$$TCI_t = \frac{1}{k}\sum_{j=1}^{k} TO_{jt} = \frac{1}{k}\sum_{j=1}^{k} FROM_{jt} \quad (8)$$

Net pairwise directional connectedness:

$$NPDC_{ij,t} = \tilde{\phi}_{ij,t}^{g}(H) - \tilde{\phi}_{ji,t}^{g}(H) \quad (9)$$

These measures provide detailed insights into the interconnectedness within the network, highlighting whether a variable acts as a net transmitter or receiver of shocks. The total directional connectedness to others (TO) quantifies the impact a specific variable has on all other variables within the network, while the total directional connectedness from others (FROM) measures the influence that all other variables exert on a particular variable. The net total directional connectedness (NET) is calculated by subtracting FROM from TO, indicating whether a variable is predominantly a net transmitter or receiver of shocks. The total connectedness index (TCI) offers an assessment of overall market risk, with higher values suggesting greater interconnectedness and, consequently, higher market risk. Lastly, the net pairwise directional connectedness (NPDC) focuses on the bilateral relationship between two variables, determining which variable is driving or being driven by the other.

4. Analysis

4.1. Descriptive Statistics

The descriptive statistics of the financial variables under study are summarized in Table 2. The analysis utilizes several key statistical measures to evaluate the properties of the return series, providing a foundation for understanding the behavior of these variables in the context of the TVP-VAR model.

Firstly, the skewness and excess kurtosis of the return series are assessed using the tests proposed by D'Agostino (1970) and Anscombe and Glynn (1983), respectively. The results indicate significant skewness and excess kurtosis across all return series, with skewness values showing that most series are either right- or left-skewed, and kurtosis values significantly exceeding the benchmark for normal distributions. This suggests that the return distributions are asymmetric and exhibit fat tails, indicating departures from normality.

The Jarque-Bera test, as developed by Jarque and Bera (1980), further confirms the non-normality of all return series. The test results show highly significant departures from normality, rejecting the null hypothesis at the 1% significance level for all variables. This finding underscores the importance of using models that can accommodate non-normality in the return distributions.

The stationarity of the return series is evaluated using the ERS unit-root test, as proposed by Elliott et al. (1996). The results from this test indicate that all return series are stationary, with the null hypothesis of a unit root being rejected at the 1% significance level. This stationarity is a critical assumption for the TVP-VAR model, ensuring that the dynamic relationships between variables can be reliably analyzed.

Furthermore, the presence of autoregressive conditional heteroskedasticity (ARCH) effects is examined using the Q(20) and Q2(20) statistics, developed by Fisher and Gallagher (2012). The results indicate significant ARCH effects in all return series at the 1% significance level, suggesting the presence of volatility clustering. This highlights the necessity of accounting for time-varying volatility when modeling these return series, which is well-suited to the TVP-VAR approach.

Table 3 presents the unconditional correlations among the return series, providing insights into the relationships between different markets. The correlations reveal significant relationships between the variables, which are essential for understanding the interconnectedness and potential spillover effects among the South Asian stock markets, relevant currencies, crude oil, and gold prices. The descriptive statistics provide a comprehensive overview of the key characteristics of the financial return series, laying the groundwork for the TVP-VAR analysis. The significant skewness, excess kurtosis, non-normality, stationarity, and presence of ARCH effects underscore the complexity of the data and justify the use of advanced econometric modeling techniques like the TVP-VAR to capture the dynamic spillover effects accurately.

4.2. TVP-VAR Connectedness Results

The Time-Varying Parameter Vector Autoregressive (TVP-VAR) connectedness analysis provides a detailed examination of return spillovers among the selected financial variables, including equity indices, exchange rates, crude oil, and gold. This analysis sheds light on the interconnectedness and dynamic spillover effects between these markets, offering insights that are essential for understanding their roles within the broader financial system.

The results from the connectedness table (Table 4) indicate that certain markets exhibit significant levels of self-connectedness, which is the extent to which a variable's own shocks explain its variance. Notably, the Sri Lankan Rupee (USDLKR) and the Pakistani Rupee (USDPKR) demonstrate the highest levels of self-connectedness, at 84.64% and 85.95% respectively. This suggests that these exchange rates are heavily influenced by internal factors, which may include country-specific economic policies or domestic market conditions. Such findings are consistent with previous studies that have highlighted the relative insulation of certain emerging market currencies from external shocks, as observed in the connectedness analysis of other regional financial markets (Mensi et al., 2018; Bouri et al., 2021).

The analysis also reveals significant cross-variable connectedness, particularly between Brent crude oil prices (BrentR) and other financial markets such as the Indian Rupee (USDINR) and the Indian equity market (NIFTY50R). BrentR contributes notably to the spillovers received by USDINR and NIFTY50R, underscoring the crucial role that crude oil plays in influencing financial market dynamics, especially in energy-dependent emerging economies. This finding aligns with the literature that has documented the interconnectedness between commodity prices and financial markets, where fluctuations in crude oil prices can have far-reaching effects on exchange rates and equity markets (Antonakakis et al., 2020; Kang and Lee, 2019).

The total directional connectedness "TO" values provide further insights into how each market transmits shocks to others. The NIFTY50R, for instance, emerges as a major transmitter with a TO value of 28.4%, highlighting its significant influence on other financial markets in the South Asian region. This finding is supported by studies that have shown the pivotal role of large equity indices in transmitting financial shocks across different markets, particularly in emerging economies where equity markets are often closely linked to macroeconomic indicators (Yoon et al., 2019; Mensi et al., 2023). In terms of net directional connectedness, the NIFTY50R exhibits a positive NET value, indicating that it is a net

Table 02
Summary Statistics

	NIFTY50R	USDINR	BrentR	GoldR	USDLKR	USDPKR	KSER	SLASPIR
Mean	0.001***	0.000**	0.000	0.000	0.000***	0.000***	0.000**	0.000***
	(0.008)	(0.036)	(0.578)	(0.428)	(0.001)	0.000	(0.047)	(0.007)
Variance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Skewness	(0.003)	0.109***	-0.259***	-0.259***	10.472***	1.229***	-0.376***	-0.794***
	(0.935)	(0.009)	0.000	0.000	0.000	0.000	0.000	0.000
Ex. Kurtosis	12.806***	7.526***	2.890***	5.205***	266.370***	46.893***	3.396***	11.341***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
JB	23616.260***	8162.270***	1241.589***	3940.315***	10280371.459***	317524.560***	1742.408***	18883.714***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ERS	(22.593)	(22.159)	(9.734)	(27.202)	(23.214)	(22.222)	(5.766)	(14.848)
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Q(20)	19.293**	13.890	17.665**	16.627*	329.731***	29.271***	58.616***	156.963***
	(0.023)	(0.176)	(0.045)	(0.067)	0.000	0.000	0.000	0.000
Q^2(20)	673.049***	1160.451***	1096.052***	473.202***	965.019***	108.523***	2018.306***	999.759***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

*Notes: Mean: Indicates the average daily return. Statistical significance levels: ***p<0.01, **p<0.05, *p<0.10. Variance: Represents the variability of the returns, although zero values may indicate summary data. Skewness: Measures the asymmetry of the return distribution. Positive values indicate a right-skewed distribution, and negative values indicate a left-skewed distribution (D'Agostino, 1970). Excess Kurtosis: Measures the "tailedness" of the distribution. High positive values indicate heavy tails (Anscombe & Glynn, 1983). JB (Jarque-Bera test): The Jarque-Bera test statistic for normality. Higher values suggest departures from normality (Jarque & Bera, 1980). ERS: Refers to the Elliott, Rothenberg, and Stock test for unit roots (Elliott et al., 1996). Q (20): The Ljung-Box test for autocorrelation in the return series up to lag 20. Q2(20): The Ljung-Box test for autocorrelation in the squared return series, which is related to volatility clustering (Fisher & Gallagher, 2012).*

Table 03
Unconditional Correlations

	NIFTY50R	USDINR	BrentR	GoldR	USDLKR	USDPKR	KSER	SLASPIR
NIFTY50R	1.000***	-0.231***	0.105***	0.046***	0.009	0.009	0.068***	0.053***
USDINR	-0.231***	1.000***	-0.113***	-0.139***	0.015	0.016	-0.038***	-0.039***
BrentR	0.105***	-0.113***	1.000***	0.137***	-0.004	-0.003	0.013	0.017
GoldR	0.046***	-0.139***	0.137***	1.000***	0.006	0.009	-0.003	0.034***
USDLKR	0.009	0.015	-0.004	0.006	1.000***	0.030***	-0.025**	-0.002
USDPKR	0.009	0.016	-0.003	0.009	0.030***	1.000***	-0.039***	-0.012
KSER	0.068***	-0.038***	0.013	-0.003	-0.025**	-0.039***	1.000***	0.042***
SLASPIR	0.053***	-0.039***	0.017	0.034***	-0.002	-0.012	0.042***	1.000***

****p<0.01, **p<0.05, *p<0.1.*

Table 04
Average Connectedness Table – TVP-VAR

	NIFTY50R	USDINR	BrentR	GoldR	USDLKR	USDPKR	KSER	SLASPIR	FROM
NIFTY50R	72.70	10.86	4.1	3.41	1.93	1.88	2.99	2.14	27.3
USDINR	10.23	70.42	4.78	6.34	1.91	2.17	2.47	1.69	29.58
BrentR	4.23	4.94	76.02	6.43	2.08	1.74	2.28	2.29	23.98
GoldR	3.23	6.81	6.52	76.31	1.93	1.66	1.94	1.60	23.69
USDLKR	2.13	2.39	2.07	2.25	84.64	2.11	1.98	2.44	15.36
USDPKR	2.03	2.35	1.94	1.73	2.20	85.95	2.19	1.61	14.05
KSER	3.86	3.02	3.00	2.30	2.42	2.63	80.44	2.33	19.56
SLASPIR	2.70	2.33	2.24	1.94	2.48	1.71	2.34	84.26	15.74
TO	28.40	32.70	24.65	24.39	14.96	13.89	16.18	14.09	169.26
Inc.Own	101.10	103.12	100.67	100.7	99.60	99.84	96.62	98.35	cTCI/TCI
NET	1.10	3.12	0.67	0.70	-0.400	-0.16	-3.38	-1.65	24.18/21.16
NPT	5.00	7.00	3.00	5.00	4.00	2.00	1.00	1.00	

Notes: The results are derived from a TVP-VAR model with a lag length of one, as determined by the Bayesian Information Criterion (BIC), and a 20-step-ahead generalized forecast error variance decomposition.

transmitter of shocks. This contrasts with indices like the Sri Lankan All Share Price Index (SLASPIR) and the Karachi Stock Exchange Index (KSER), which show negative NET values, identifying them as net receivers of shocks. The status of NIFTY50R as a net transmitter suggests that it plays a crucial role in the regional financial ecosystem, potentially driving spillovers that affect other markets. Conversely, the net receiver status of SLASPIR and KSER implies their vulnerability to external shocks, a characteristic that has been noted in studies focusing on the susceptibility of smaller, less liquid markets to global financial disturbances (Belcaid and Ghini, 2019).

The dynamic nature of connectedness is further illustrated in the figures provided. Figure 1, which depicts the dynamic total connectedness, shows significant fluctuations over time, particularly during periods of global financial stress such as the 2008 financial crisis and the COVID-19 pandemic. These spikes in connectedness reflect the heightened integration of markets during times of economic uncertainty, a phenomenon well-documented in the literature on financial contagion and the increased interdependence of global markets during crises (Diebold and Yilmaz, 2012; Gabauer and Gupta, 2018).

Figures 2 and 3, which show directional return spillovers "FROM" and "TO" others, respectively, reinforce the central role of NIFTY50R and USDINR as significant transmitters of shocks. The substantial spillovers from these markets to others in the region are indicative of their influence on regional financial stability. This is consistent with the findings of earlier studies that have highlighted the importance of monitoring key equity indices and exchange rates for early signs of financial instability in interconnected markets (Antonakakis et al., 2020; Gabauer, 2021).

The net total directional connectedness depicted in Figure 4 further clarifies the roles of various markets as either transmitters or receivers of shocks. The consistent position of NIFTY50R and USDINR as net transmitters underscores their importance in shaping regional financial dynamics. These findings are in line with studies that have emphasized the critical role of major financial markets in propagating shocks across the global financial system (Diebold and Yilmaz, 2014; Koop and Korobilis, 2014).

Finally, the network plot in Figure 5 visually represents the complex web of relationships between the markets. The plot highlights NIFTY50R, USDINR, and BrentR as central nodes, signifying their dominant positions within the network. The numerous outgoing connections from these nodes indicate their significant influence on other markets, reinforcing their roles as key transmitters of shocks. This visualization aids in understanding the broader implications of interconnectedness in financial markets, where central markets can act as conduits for the rapid transmission of shocks, affecting global financial stability (Barunik et al., 2016; Bouri et al., 2021).

The TVP-VAR connectedness analysis provides a comprehensive understanding of the dynamic spillover effects among key financial markets in South Asia. The findings highlight the critical roles of certain markets, such as NIFTY50R and USDINR, as major transmitters of shocks, while also identifying more vulnerable markets like SLASPIR and KSER as net receivers. These insights are valuable for both policymakers and investors, as they underscore the importance of monitoring these markets to manage risks and maintain financial stability in the region. The dynamic nature of connectedness further suggests that risk management strategies must be adaptable to changing market conditions, particularly during periods of global financial uncertainty.

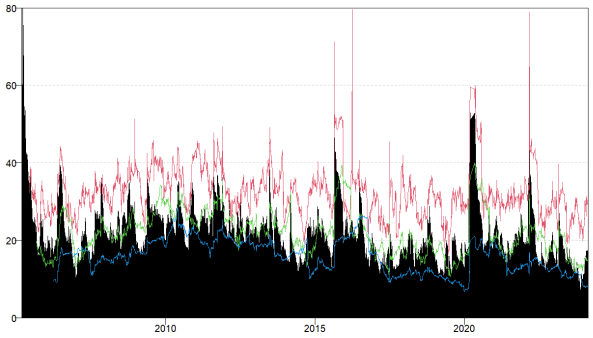

Figure 1: Dynamic Total Connectedness

Analyzed using a TVP-VAR model with a lag length of order one, determined by BIC, and a 20-step-ahead generalized forecast error variance decomposition. Additionally, the red line illustrates the results from the original Diebold and Yilmaz (2012) approach, which employs a 200-day rolling-window VAR with a lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

5. Discussion

The discussion of this study's findings carries significant economic, academic, and policy implications, contributing to the broader discourse on financial market interconnectedness. The application of the Time-Varying Parameter Vector Autoregressive (TVP-VAR) model in analyzing return spillovers among South Asian financial markets, including equity indices, exchange rates, crude oil, and gold, offers nuanced insights that are relevant across multiple domains.

Economically, the findings emphasize the importance of understanding market interdependencies in an increasingly globalized financial environment. The identification of NIFTY50R and USDINR as significant transmitters of shocks within the South Asian region highlights their roles as pivotal financial indicators. This underscores the need for both domestic and international investors to closely monitor these markets, as disturbances originating here could propagate across the regional financial landscape, affecting asset valuations and investment strategies. The significant self-connectedness observed in currencies like USDLKR and USDPKR suggests that these markets are more influenced by domestic factors, which might include country-specific policies, economic performance, and political stability. Such insights are crucial for multinational corporations and investors who are exposed to currency risks in these emerging markets, as they need to develop hedging strategies that account for both global and local economic conditions (Yoon et al., 2019; Belcaid and El Ghini, 2019).

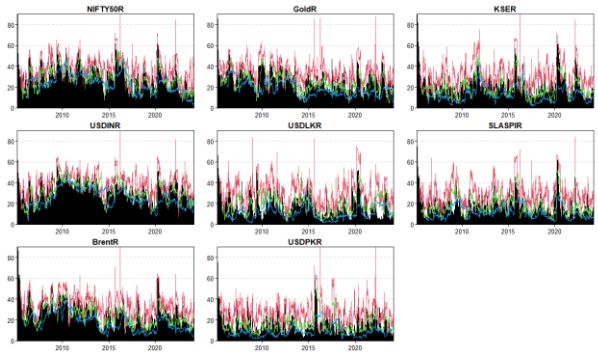

Figure 2: Directional Return Spillovers, FROM 8 Variables

Analyzed using a TVP-VAR model with a lag length of order one, determined by BIC, and a 20-step-ahead generalized forecast error variance decomposition. Additionally, the red line illustrates the results from the original Diebold and Yilmaz (2012) approach, which employs a 200-day rolling-window VAR with a lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

Moreover, the interconnectedness between crude oil prices and financial markets, particularly in energy-dependent economies like India, reinforces the critical role of commodities in financial market dynamics. The significant spillovers from BrentR to NIFTY50R and USDINR suggest that fluctuations in global oil prices can have direct implications for inflation, exchange rates, and

equity market performance in the region. This aligns with the findings of Tiwari et al. (2021) and Pandey and Vipul (2018), who demonstrated the sensitivity of financial markets to commodity price shocks. For policymakers, these insights highlight the need for careful monitoring of global commodity markets, as well as the formulation of policies that mitigate the adverse effects of volatile oil prices on the domestic economy.

From an academic perspective, this study contributes to the growing body of literature on financial market spillovers, particularly within emerging economies. The use of the TVP-VAR model allows for a dynamic analysis of market interactions, providing a more detailed understanding of how these relationships evolve over time. This methodological approach, as highlighted by Antonakakis et al. (2020) and Gabauer and Gupta (2018), offers a significant advancement over traditional models, enabling researchers to capture the complexities of market connectedness in a more robust manner. The study's focus on South Asian markets fills a gap in the literature, which has traditionally been centered on developed markets or broader global analyses. By providing empirical evidence from an emerging market context, this research adds to the discourse on how regional factors and global economic conditions interplay in shaping financial market dynamics.

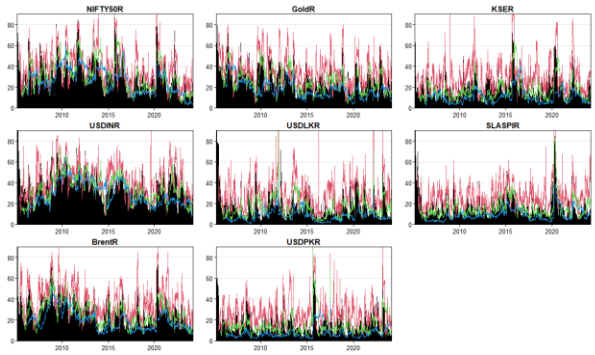

Figure 3: Directional Return Spillovers, TO 8 Variables

Analyzed using a TVP-VAR model with a lag length of order one, determined by BIC, and a 20-step-ahead generalized forecast error variance decomposition. Additionally, the red line illustrates the results from the original Diebold and Yilmaz (2012) approach, which employs a 200-day rolling-window VAR with a lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

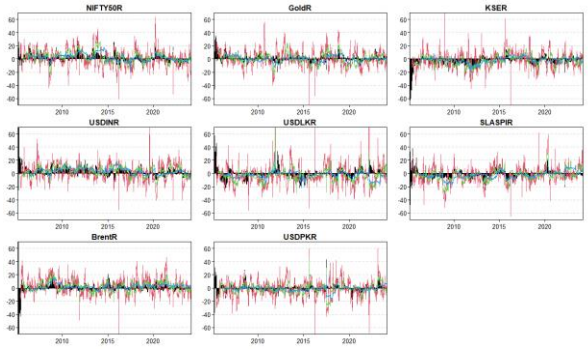

Figure 4: Net Total Directional Connectedness

Analyzed using a TVP-VAR model with a lag length of order one, determined by BIC, and a 20-step-ahead generalized forecast error variance decomposition. Additionally, the red line illustrates the results from the original Diebold and Yilmaz (2012) approach, which employs a 200-day rolling-window VAR with a lag length of order one (BIC) and a 20-step-ahead generalized forecast error variance decomposition.

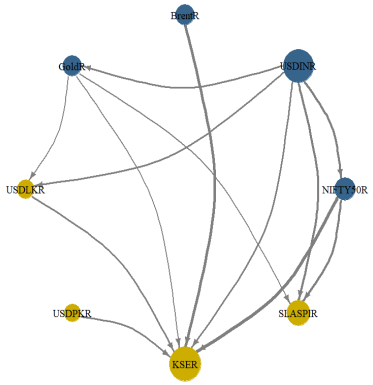

Figure 5: Network Plot of Return Spillovers among 8 Variables using TVPVAR Approach

The identification of key transmitter and receiver markets within the region also has implications for future research. Scholars could build on these findings by exploring the underlying factors that drive these spillovers, such as macroeconomic policies, geopolitical events, or investor sentiment. Additionally, the strong interdependencies observed during periods of global financial stress, such as the COVID-19 pandemic, suggest that further research could focus on the role of financial crises in altering market connectedness. This aligns with the work of Bouri et al. (2017) and Beckmann et al. (2019), who emphasized the heightened interdependencies during such periods, thereby

enriching our understanding of financial contagion and market stability.

For policymakers, the results of this study have several important implications. The significant interconnectedness observed among South Asian markets suggests that domestic economic policies cannot be formulated in isolation. Policymakers need to consider the potential spillover effects of their decisions on neighboring economies and financial markets. For example, monetary policy adjustments in India, as indicated by the influence of USDINR on other regional markets, could have ripple effects across the region, necessitating a coordinated approach to economic governance.

The study also highlights the importance of monitoring and managing financial risks that arise from global market integration. The interconnectedness between crude oil prices and regional financial markets underscores the need for robust energy policies and the development of alternative energy sources to reduce dependency on global oil markets. Additionally, the findings suggest that financial regulators should enhance their surveillance of key markets like NIFTY50R and USDINR, which serve as barometers for regional financial stability. In line with the recommendations of Gabauer and Gupta (2018), policymakers could benefit from adopting dynamic connectedness measures in their risk assessment frameworks, allowing for more proactive and informed decision-making.

6. Conclusion

This study provides a comprehensive analysis of return spillovers among major South Asian financial markets, including equity indices, relevant currencies, crude oil, and gold prices, using the Time-Varying Parameter Vector Autoregressive (TVP-VAR) connectedness approach. The dynamic nature of market interconnectedness is thoroughly examined, revealing critical insights into how financial shocks are transmitted across these markets over time.

The empirical findings indicate that key financial markets, such as the Indian equity market (NIFTY50R) and the Indian Rupee (USDINR), play significant roles as transmitters of shocks within the South Asian region. These markets exhibit substantial spillover effects on other regional markets, underscoring their centrality in the financial system of South Asia. In contrast, markets like the Sri Lankan All Share Price Index (SLASPIR) and the Karachi Stock Exchange Index (KSER) are identified as net receivers of shocks, highlighting their vulnerability to external disturbances. The interconnectedness between crude oil prices and these financial markets is particularly notable, with Brent crude oil prices (BrentR) significantly influencing the Indian equity and currency markets, which underscores the critical role of global commodities in the region's financial dynamics.

This study makes several important contributions to the literature on financial market spillovers. First, it extends the application of the TVP-VAR model to South Asian markets, a region that has been underrepresented in existing research. The study's focus on emerging markets provides new insights into how these markets interact with global economic forces, particularly through key commodities like crude oil and gold. Second, by employing a dynamic connectedness approach, this research captures the evolving nature of market spillovers, offering a more nuanced understanding of financial interconnectedness over time. This methodological contribution is significant, as it enhances the ability of researchers and policymakers to analyze the temporal variations in market dynamics, especially during periods of financial stress.

Despite its contributions, this study has several limitations. The analysis is confined to a specific set of markets within the South Asian region, which may not capture the full spectrum of financial interconnectedness, particularly with markets outside the region. Additionally, while the TVP-VAR model is effective in capturing time-varying connectedness, it does not account for structural breaks or regime changes that may occur during the sample period. Future research could address these limitations by expanding the analysis to include a broader set of financial markets, both within and outside South Asia, to provide a more comprehensive understanding of global financial interconnectedness. Incorporating models that account for structural breaks or regime shifts could enhance the robustness of the findings. Finally, investigating the role of financial technology and innovation, such as the impact of cryptocurrencies

on traditional financial markets, could provide valuable contributions to the evolving landscape of financial interconnectedness.

Overall, this study advances our understanding of the dynamic spillover effects in South Asian financial markets, highlighting the critical roles of key markets and commodities in shaping regional financial stability. The findings have important implications for both policymakers and investors, particularly in emerging markets, where managing interconnected financial risks is crucial for sustaining economic growth and stability.

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