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Time-Varying Interactions between Macroeconomic Factors and Stock Market Volatility in Developing Economies: Empirical Evidence from Wavelet Analysis

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Abstract- This study investigates the time-varying interactions between macroeconomic factors and stock market volatility in two major developing economies, India and China, using annual data spanning the period 1991-2024. The increasing integration of financial markets with macroeconomic fundamentals has intensified the need to understand the economic variables influence stock market dynamics across different time horizons by using Wavelet Coherency transformation (WCT) approaches is used to examine the co-movement, lead-lag relationships, and transmission mechanisms between stock market volatility and selected macroeconomic indicators, including GDP, inflation, export, import and gross capital formation. The findings are expected to reveal substantial heterogeneity in the strength and direction of relationships across different frequencies and economic regimes. Wavelet coherence results are anticipated to indicate stronger co-movements during periods of financial and economic turbulence, including the Asian Financial Crisis, the Global Financial Crisis, the COVID-19 pandemic, and recent geopolitical uncertainties. The phase-difference analysis is expected to demonstrate that macroeconomic variables exhibit varying leadership roles across time scales, with inflation and interest rates exerting greater influence in the short run, while economic growth and money supply dominate long-run market movements. Furthermore, the comparative analysis is likely to show that China's stock market exhibits relatively stronger long-term coherence with macroeconomic fundamentals, whereas India's market demonstrates more dynamic short- and medium-term interactions.

Keywords: GDP, Inflation, Export, Volatility, Stock market, Wavelet Analysis,

I. INTRODUCTION

The intricate relationship between macroeconomic fundamentals and stock market volatility has long occupied a central position in financial economics, yet its dynamic and scale-dependent nature remains insufficiently understood, particularly in the context of emerging market economies. The stock markets do not operate in isolation; rather, they serve as barometers of broader economic conditions, reflecting the collective expectations of investors regarding growth prospects, monetary policy stances, inflationary pressures, and exchange rate movements (Fama, 1981; Chen, Roll, & Ross, 1986). While substantial empirical evidence from developed economies has established that variables such as interest rates, industrial production, inflation, and money supply exert significant influence on equity market behavior, these relationships are neither static nor uniform across time horizons (Humpe & Macmillan, 2009; Rapach, Wohar, & Rangvid, 2005). The temporal instability of these linkages is especially pronounced during periods of structural transformation, financial crises, and policy regime shifts. Due to such disproportionately in rapidly industrializing economies such as India and China. Accordingly, a rigorous empirical investigation that accounts for both time variation and frequency heterogeneity in these macro - financial interactions is not only warranted but imperative for advancing our understanding of emerging market dynamics.

The paper tries to evaluate the time varying interactions between macroeconomic factors and stock market volatility in developing economies like India and China. The Indian and Chinese economy represent particularly compelling laboratory settings

for such an inquiry, given their simultaneous status as the world's two most populous economies, their accelerating integration into global financial markets, and their divergent institutional architectures governing monetary policy and capital account openness. China, operating under a state-directed financial system with managed exchange rate mechanisms and selective capital controls, exhibits macro-financial transmission channels that differ fundamentally from those of India, where a more liberalized monetary framework and a partially open capital account shape the sensitivity of equity markets to domestic and external macroeconomic shocks (Mohan, 2008; Prasad & Rajan, 2008). Despite their structural divergence, both economies have witnessed dramatic expansions in stock market capitalization over the past two decades, accompanied by episodes of acute volatility linked to global commodity price swings, monetary tightening cycles, currency depreciations, and growth deceleration (Gupta & Reid, 2013; Chiang, Li, & Tan, 2010). The juxtaposition of these two economies within a unified comparative framework thus offers unique analytical leverage for discerning whether the macro-volatility nexus is driven by universal financial mechanisms or by country-specific institutional and policy configurations.

In order to address these questions, the present study employs wavelet analysis; a methodological approach uniquely suited to capturing the time-varying and multi-scale nature of macro-financial interactions. Unlike conventional econometric tools such as vector autoregression or ordinary least squares, which implicitly assume stationarity and obscure the frequency dimension of economic relationships, wavelet decomposition simultaneously resolves a time series in both the time and frequency domains, enabling the researcher to distinguish between short-run speculative dynamics and long-run fundamental co-movements (Grinsted, Moore, & Jevrejeva, 2004; Aguiar-Conraria & Soares, 2011). Specifically, the application of continuous wavelet transforms, wavelet coherence, and partial wavelet coherence techniques allows for the identification of periods and frequencies at which macroeconomic variables exercise dominant influence over stock market volatility as a major insight that aggregated time-series methods systematically obscure. By applying this framework to India and China over an extended sample period encompassing multiple economic cycles and structural breaks, this study contributes to the nascent but growing literature on scale-dependent macro-financial linkages in emerging economies, while simultaneously offering policymakers and institutional investors actionable insights into the horizon-specific transmission of macroeconomic risk to equity market uncertainty.

The remainder of this article is organized as follows. Section 2 reviews the relevant ancestral studies about macroeconomic conditions and stock market volatility, highlighting key research gaps. Section 3 describes the data sources, variable selection, and research methodology, including Wavelet Analysis. Section 4 presents the empirical findings and discusses the multi-horizon interdependence, co-movement patterns, and lead–lag relationships between macroeconomic variables and stock market volatility in India and China. Finally, Finally, Section 6 concludes the study by summarizing the major findings, outlining policy recommendations, and suggesting directions for future research.

II. REVIEW OF LITERATURE

This section discusses the three strands of review of literature, each relating to positive, negative and bidirectional association between the variable. The empirical literature affirms the significant positive relationship between macroeconomic fundamentals and stock market volatility in developing economies. (Filis, Degiannakis, and Floros (2011) established that macroeconomic shocks particularly oil price fluctuations exert pronounced volatility effects on equity markets, with emerging markets displaying heightened sensitivity relative to their developed counterparts. Similarly, (Mensi et al. 2014) employed wavelet coherence analysis to demonstrate that global macroeconomic factors, including the S&P 500 index, commodity prices, and interest rates, generate significant time-frequency co-movements with GCC stock markets, confirming that macroeconomic transmission channels operate non-linearly across different time horizons. (Aloui, Aïssa, and Nguyen 2011) provided the compelling

evidence that inflation and exchange rate dynamics are strong determinants of stock return volatility in BRIC economies, especially during periods of financial turbulence. The time-varying parameter VAR framework for South African equity markets, showing that monetary policy variables and industrial production growth significantly forecast stock market volatility across multiple sub-periods (Gupta and Modise 2013). More recently, (Narayan and Gupta 2015) confirmed using predictive regression models that macroeconomic variables possess out-of-sample forecasting power for stock returns in developing economies, particularly in recessionary regimes. (Bahloul, Mroua, and Naifar 2017) extended the evidence to Islamic equity markets in the MENA region, finding that inflation and money supply exert time-varying and horizon-dependent effects on stock volatility, consistent with the theoretical Fama (1981) proxy hypothesis. Collectively, this strand of literature robustly supports the view that macroeconomic variables are fundamental drivers of equity market volatility in developing economies, with the strength and direction of these relationships varying meaningfully across time and frequency domains making wavelet-based time-frequency analysis a particularly appropriate and powerful empirical tool for capturing such dynamics.

Despite the broad consensus in the positive literature, a parallel and equally substantial body of research raises important doubts regarding the consistency, robustness, and generalizability of macroeconomic effects on stock market volatility in developing economies. The exchange rate and stock market linkages by demonstrating that the relationship is regime-dependent and frequently statistically insignificant in thin or illiquid emerging markets, where microstructural distortions and capital controls may substantially weaken macroeconomic transmission (Phylaktis and Ravazzolo 2005). The research work of (Bekaert and Harvey (1997) showed that developing equity markets exhibit idiosyncratic volatility dynamics largely decoupled from global macroeconomic fundamentals, attributable to market segmentation, political risk, and investor heterogeneity factors that are not easily captured by standard macroeconomic variables. Similarly, (Schwert 1989) linked the difference between macroeconomic volatility and stock market volatility is empirically weak in periods of normal market conditions and primarily emerges during extraordinary crisis episodes, raising questions about the structural stability of the relationship. (Ferson and Harvey, 1993) found limited out-of-sample predictive power of macroeconomic instruments for stock returns in developing markets, suggesting that idiosyncratic, country-specific factors rather than common macroeconomic exposures dominate equity risk premiums. Pradhan et al. (2014), reviewed using panel cointegration methods for Asian economies that the long-run macroeconomic stock market nexus is absent in several countries, particularly those with less financially developed banking systems. More recently, Sekmen and Topuz (2021) found the relationship between macroeconomic uncertainty and equity volatility is highly heterogeneous and frequently negative in countries with higher institutional quality, suggesting that governance structures moderate and can even neutralize macroeconomic transmission effects. These contrarian findings collectively underscore that the macroeconomic volatility relationship in developing economies is far from uniform, stable, or universal, and that ignoring time variation and country heterogeneity can produce misleading inferences in conventional linear econometric frameworks.

An increasingly prominent strand of literature moves beyond unidirectional causality to explore bidirectional and feedback relationships between macroeconomic variables and stock market volatility, revealing the inherently endogenous nature of their interactions in developing economies. (Morales and Andreosso-O'Callaghan 2012) demonstrated the bidirectional causality between exchange rate volatility and stock market fluctuations in Latin American markets, arguing that currency and equity markets form an endogenous feedback system in which shocks propagate in both directions with asymmetric speeds of adjustment. (Pan, Fok, and Liu 2007) employed vector autoregression models for seven Asian economies and confirmed bidirectional interactions between exchange rate changes and stock price returns, with the feedback dynamics

becoming significantly more pronounced during the 1997–1998 Asian financial crisis. The work attempted by (Diebold and Yilmaz 2012) provided methodological scaffolding for understanding bidirectional volatility spillovers by developing generalized variance decomposition frameworks, which subsequent literature applied extensively to demonstrate that macroeconomic uncertainty and equity volatility mutually reinforce one another in emerging market contexts. In the same manner, the research work of (Antonakakis, Chatziantoniou, and Filis 2013) employed dynamic conditional correlations and rolling-window VAR to show that monetary policy decisions and stock market volatility in developed economies share a dynamic feedback loop, a finding that (Aloui and Aïssa 2016) subsequently replicated for BRIC nations. Furthermore, (Balcilar et al. 2017) used a non-parametric causality-in-quantiles approach to document asymmetric and bidirectional causality between output growth, inflation, and equity volatility in Sub-Saharan African markets, showing that the direction of dominant causality switches depending on the distributional quantile and economic cycle phase. Wavelet-based coherence analysis, as demonstrated by (Aguiar-Conraria and Soares 2014) offers a particularly effective framework for visualizing and quantifying these bidirectional dynamics across time and frequency simultaneously, permitting researchers to identify whether macroeconomic variables lead or lag stock market volatility at different investment horizons an insight that is fundamentally inaccessible to conventional time-domain econometric methods that implicitly assume static and unidirectional causality.

Despite the rich and diverse body of evidence reviewed above, several critical research gaps remain unaddressed in the previous study. First, while both positive and negative evidence on macroeconomic–volatility linkages abounds, the overwhelming majority of prior studies employ either conventional linear time-series techniques such as VAR, GARCH, and cointegration models or simple rolling-window approaches that provide only limited and often misleading insights into the joint time-frequency dynamics of these interactions (Aguiar-Conraria & Soares, 2014; Rua & Nunes, 2009). Wavelet analysis, which decomposes economic time series into orthogonal time-frequency components, represents a methodologically superior but still underutilized approach in the specific context of developing economies, where structural breaks, non-linearities, and heterogeneous investor horizons are particularly prevalent (Rua, 2012, Applied Economics Letters; Tiwari et al., 2019). Second, existing wavelet-based studies predominantly focus on individual economies or small homogeneous country groups, neglecting systematic cross-country comparisons across a diverse panel of developing nations that differ in institutional quality, financial market depth, and macroeconomic volatility profiles (Mensi et al., 2014; Graham & Nikkinen, 2011). Third, the literature has yet to fully examine the time-varying nature of the lead-lag relationships between a comprehensive set of macroeconomic factors including inflation, interest rates, exchange rates, money supply, oil prices, and trade openness and stock market volatility simultaneously within a unified wavelet coherence framework for developing economies (Bahloul et al., 2017; Bouri et al., 2017).

Fourth, the moderating roles of financial crises, institutional transitions, and commodity price super-cycles on the time-frequency structure of macroeconomic volatility interactions remain largely unexplored, despite the well-documented sensitivity of developing markets to these external shocks (Morales & Andreosso-O'Callaghan, 2012; Balcilar et al., 2017). Finally, most prior studies fail to account for the heterogeneity of investor horizons distinguishing between short-term traders, medium-term portfolio investors, and long-term strategic investors which wavelet decomposition uniquely enables and which has first-order implications for asset pricing, monetary policy design, and macroprudential regulation in developing economy contexts. The present study directly addresses these interconnected gaps by applying continuous and discrete wavelet transform methodologies to a diverse sample of developing economies spanning the period from 1995 to 2024, thereby contributing novel, policy-relevant, and methodologically rigorous empirical evidence to this important but underserved intersection of macroeconomic theory and financial market analysis.

II. DATA AND METHODOLOGY

This study examines the time-varying interactions between macroeconomic factors and stock market volatility in two major developing economies, India and China, using annual data spanning the period 1991-2024. The macroeconomic variables considered include Gross Domestic Product (GDP), inflation, export, import and gross capital formation, while stock market volatility is represented by the annual volatility of the NIFTY 50 Index for India and the China A50 Index for China. The data are collected from the databank.worldbank.org and investing.com. To capture the dynamic and non-linear relationships between macroeconomic indicators and stock market volatility across different time horizons, the study employs Wavelet Coherency transformation (WCT) analysis. The Wavelet analysis is particularly suitable for financial and macroeconomic time series because it decomposes data into both time and frequency domains, enabling the identification of short-, medium-, and long-run co-movements that traditional econometric methods may overlook. The Wavelet Coherency transformation (WCT) Analysis is applied to measure the strength, direction, and evolution of the relationship between macroeconomic factors and stock market volatility over time and across frequencies. The phase-difference arrows generated by the coherency plots provide insights into lead–lag dynamics, indicating whether macroeconomic variables lead or lag stock market volatility during different economic regimes. This methodological framework enables a comprehensive assessment of the transmission mechanisms and time-frequency dependence between macroeconomic fundamentals and stock market volatility in India and China, thereby offering valuable implications for investors, policymakers, and financial market participants.

III. RESULTS AND DISCUSSION

The results of Correlation Matrix reveal the degree of association among macroeconomic variables in India and China and their results are provided in Table: 1. In the Indian context, the exports exhibit a very strong positive relationship with imports and significant at 1 per cent level, which indicate the trade activities move simultaneously to each other. The Gross Capital Formation (GCF) and Import were positively associated with exports with a coefficient value of 0.797 and 0.831, respectively, suggesting that higher investment levels support international trade activities. However, inflation shows weak and insignificant correlations with most variables, indicating a limited direct relationship with other macroeconomic indicators. In case of China, the exports and imports are strongly and positively correlated ($r = 0.937$, $p < 0.01$), reflecting the country's export-oriented economic structure. GDP exhibits significant positive relationships with exports ($r = 0.383$, $p < 0.05$), imports ($r = 0.446$, $p < 0.01$), and inflation ($r = 0.696$, $p < 0.01$), implying that economic growth is closely linked with trade expansion and price movements. Furthermore, GCF demonstrates a positive association with imports ($r = 0.433$, $p < 0.05$), emphasizing the role of capital investment in supporting economic activities.

Table: 1 Correlation Matrix for Macroeconomic Variable on Stock Market

Markets	Variable	GDP	Export	Import	Inflation	GCF
India	GDP	1				
	Export	.140	1			
	Import	.185	.989*	1		
	Inflation	-.076	-.211	-.174	1	
	GCF	.280	.797*	.831*	.020	1
China	GDP	1				
	Export	.383**	1			
	Import	.446*	.937*	1		
	Inflation	.696*	-.030	.105	1	
	GCF	-.089	.298	.433**	.102	1

Note: Author Computation. GDP and GCF refers to Gross Domestic Product and Gross Capital Formation, respectively. *, **, and *** refers to statistically significant level at 1 %, 5% and 10%, respectively.

The standardized trend analysis illustrates in Fig.1 explain the movement of macroeconomic variables alongside stock market indices over the study period from 1991 to 2024. For India, the Nifty 50 index generally follows the long-term movements of GDP, exports, imports, and GCF, although short-term fluctuations are evident. Significant volatility is observed during certain periods, indicating that stock market performance responds to changes in macroeconomic conditions. Similar to Indian economy, the Chinese SSE Composite Index exhibits varying degrees of co-movement with macroeconomic indicators. GDP, exports, and imports display relatively synchronized movements with the stock market over several periods, whereas inflation demonstrates a more fluctuating pattern. The figure suggests that macroeconomic fundamentals play an important role in shaping stock market performance in both countries, although the strength of association varies across variables and time horizons.

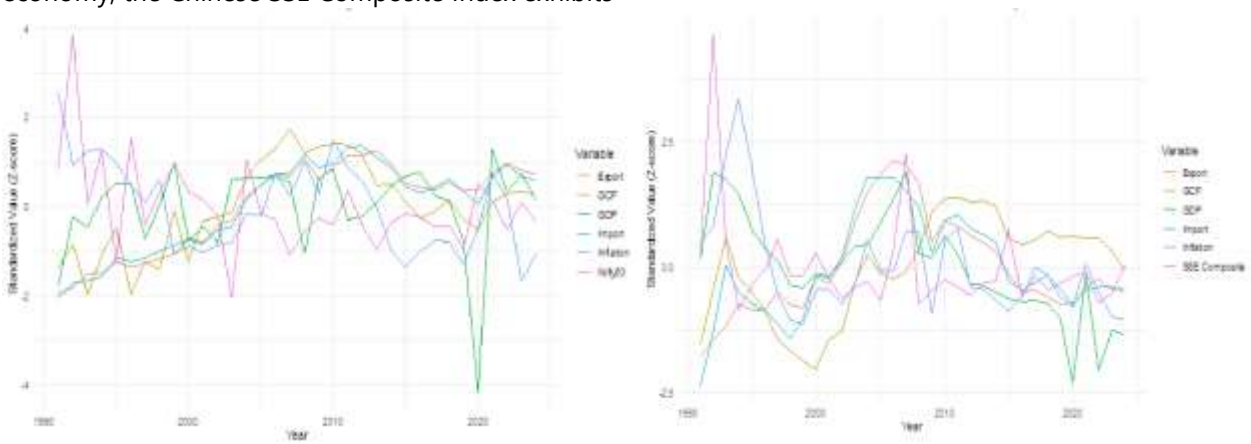

Fig: 1 Standardized Trends of Macroeconomic Variables Vs. Nifty 50 and SSE Composite

Note: Author Computation

The heat map representation for Wavelet Coherency transformation (WCT) analysis presented in Fig: 2, Panel: A demonstrate the difference between the Nifty 50 index and selected macroeconomic variables in India. The regions highlighted in warm colors yellow to red indicate stronger coherence, whereas cooler colors blue represent weaker relationships. The results reveal that GDP exhibits strong coherence with the Nifty 50 during the later years of the sample period, indicating that economic growth becomes increasingly influential in determining stock market performance over the long run. The inflation demonstrates periods of significant coherence with the stock market, particularly in medium- and long-term frequencies, suggesting that inflationary expectations influence investment decisions and equity valuations. GCF also shows strong long-run coherence with the Nifty 50, emphasizing the importance of capital formation in supporting stock market growth. Likewise, exports and imports display notable coherence in the latter part of the sample period, reflecting the growing role of international trade in shaping stock market dynamics. Overall, the findings indicate that macroeconomic variables exert varying influences on the Indian stock market across different time horizons.

The illustrated Fig: 2, Panel: B reports the Wavelet Coherence analysis transformation (WCT) between China's SSE Composite Index and macroeconomic variables. The results indicate significant time-varying relationships between stock market performance and economic fundamentals. GDP exhibits substantial coherence with the SSE Composite during the early and middle portions of the sample period, reflecting the importance of economic growth in driving equity market movements. The inflation demonstrates moderate coherence over selected periods, indicating that price stability remains an important determinant of stock market performance. GCF reveals strong and persistent coherence across longer frequencies, suggesting that investment and capital

accumulation contribute significantly to stock market development. Exports and imports also exhibit notable coherence with the SSE Composite, particularly during medium- and long-term horizons, highlighting the role of China's trade-oriented economy in influencing equity market behavior. The findings confirm that the relationships between macroeconomic variables and stock market performance are dynamic and frequency-dependent.

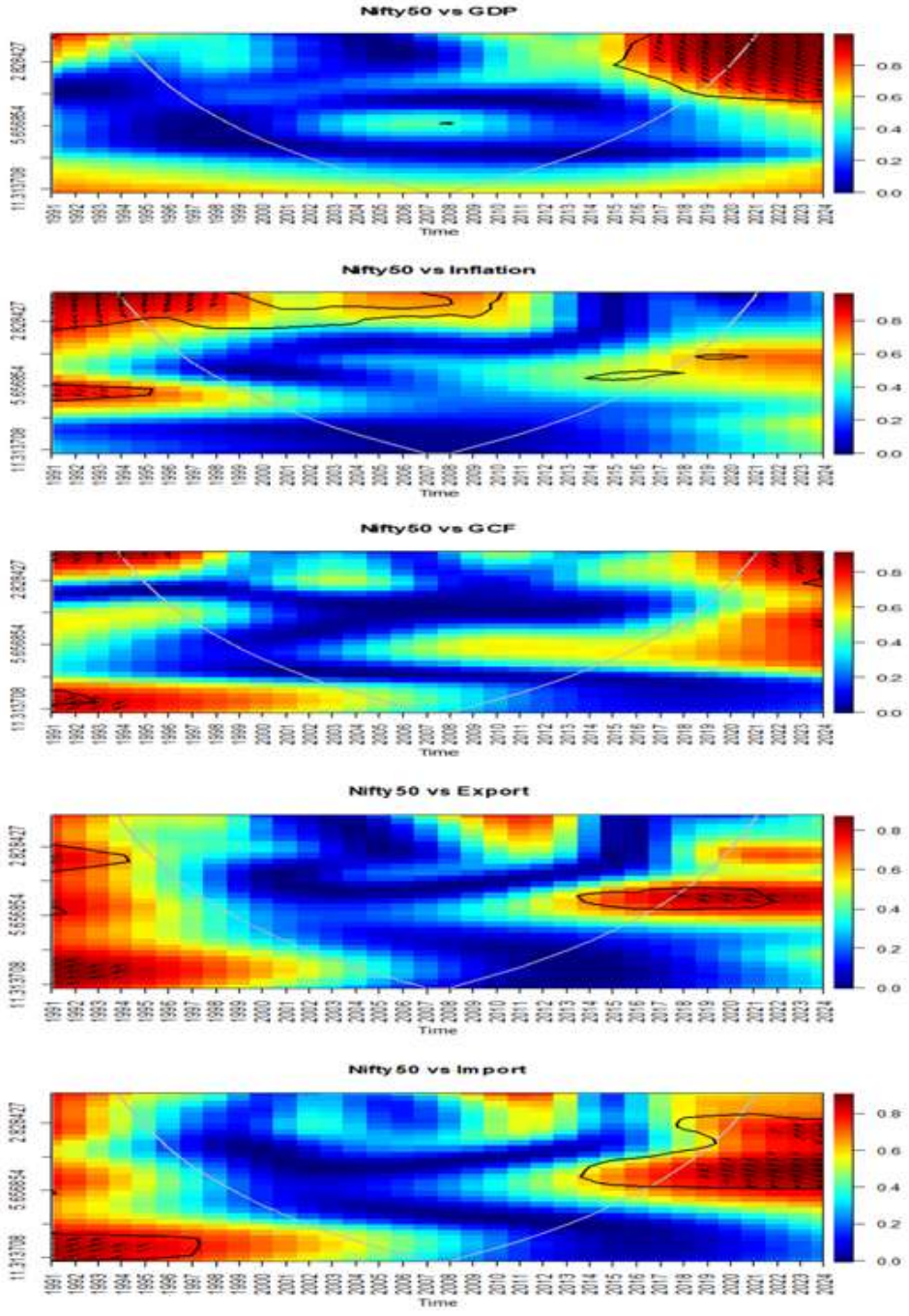

Fig: 2, Panel A WCT for Macroeconomic Variable and Nifty50, India
Note: Author Computation

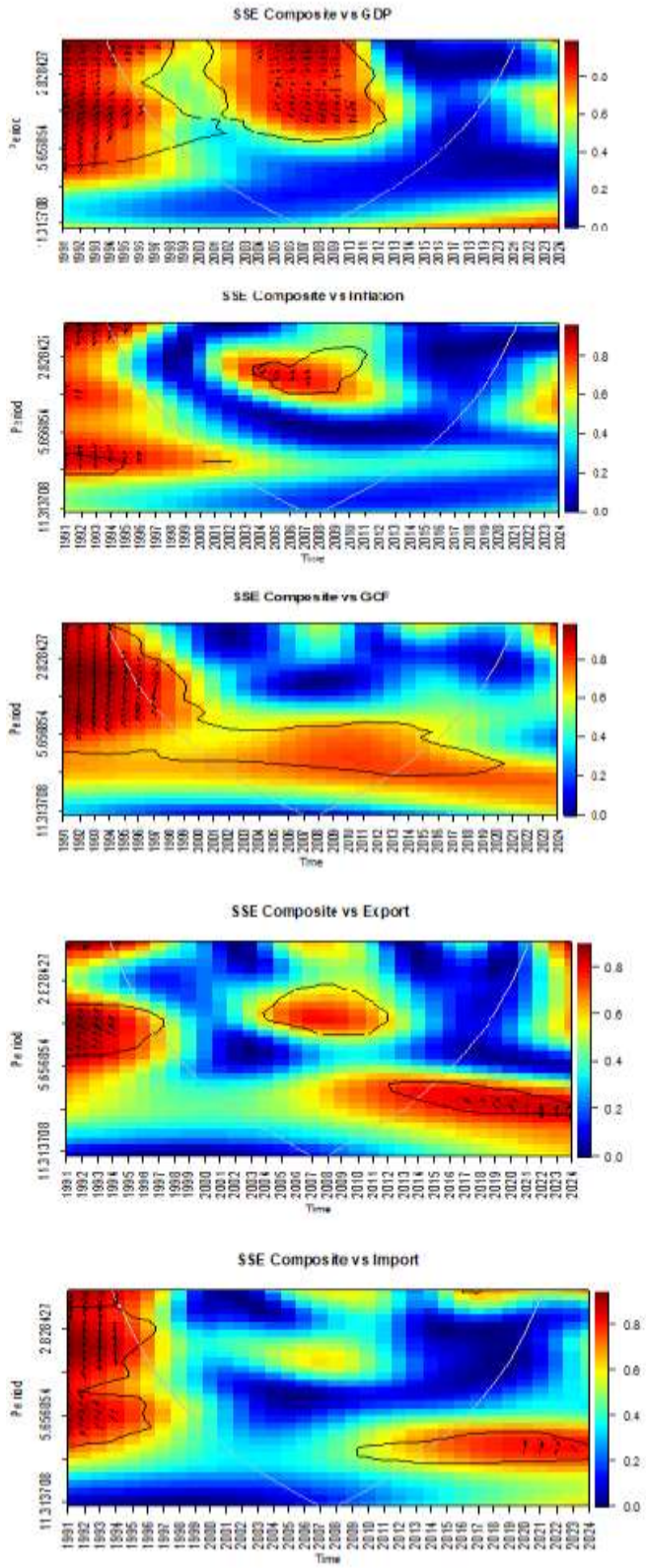

Fig: 2, Panel B WCT for Macroeconomic Variable and SSE Cmposite, China
Note: Author Computation

IV. CONCLUSION

This study examined the time-varying interactions between macroeconomic factors and stock market volatility in India and China using Wavelet Coherency Analysis. The findings reveal that the relationship between macroeconomic variables and stock market performance is dynamic, heterogeneous, and frequency-dependent rather than constant over time. The correlation analysis indicates strong associations between exports and imports in both economies, highlighting the importance of trade integration in shaping economic performance. The wavelet coherence results further demonstrate that GDP, inflation, exports, imports, and gross capital formation exhibit varying degrees of co-movement with stock market volatility across different time horizons. In India, GDP and gross capital formation display stronger long-run coherence with the NIFTY 50 index, while inflation and trade-related variables show significant influence during selected medium- and long-term periods. Similarly, in China, GDP, exports, imports, and capital formation exhibit substantial coherence with the SSE Composite Index, confirming that macroeconomic fundamentals remain critical determinants of stock market behavior. The findings also suggest that periods of economic uncertainty and structural changes strengthen the interaction between macroeconomic conditions and stock market volatility, emphasizing the importance of considering both time and frequency dimensions when evaluating financial market dynamics.

From a policy perspective, the results imply that policymakers should maintain stable macroeconomic environments through effective monetary, fiscal, and trade policies to reduce excessive market volatility and strengthen investor confidence. The main attention should be given to sustaining economic growth, promoting productive capital formation, and managing inflationary pressures, as these factors exert significant long-term influence on stock market performance. For investors and portfolio managers, the study highlights the importance of incorporating macroeconomic indicators into investment strategies, especially when making long-term allocation decisions. Future research may extend this analysis by incorporating additional macroeconomic variables such as interest rates, exchange rates, and monetary aggregates, while also employing advanced Wavelet techniques Furthermore, expanding the sample to include developing and developed economies would provide broader insights into the comparative dynamics of macroeconomic fundamentals and stock market.

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