# Second Moment Spillover Across Stock and Indian Forex Market During Covid-19 Pandemic

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**ABSTRACT** This paper explored the second moment spillover across stock market (domestic & foreign) and Indian Foreign Exchange market (INR/USD, INR/GBP & INR/JPY) with three data frames labelled: Full Period (April 2, 2014, to March 31, 2021), Pre-Covid Period (April 2, 2014, to January 29, 2020) & Post-Covid Period (January 20, 2020, to March 31, 2021) by deploying Diebold & Yilmaz (2012) method. The empirical results insinuate that there is low connectedness across foreign (S&P 500; FTSE 100) and Indian Forex market except in case of Nikkei 225 which disappear in pre-covid period but inflate in post-covid period with moderate connectedness. Similarly, low connectedness across domestic stock market & Indian Forex market is experienced except in case of INR/JPY rate. Furthermore, in the context of own inducement, each series has shown high spillover which gradually decrease in post-covid period but in contrast, inducement from stock to forex market has increased except in case of CNX Nifty & INR/GBP. This empirical evidence expounds the presence of contagion effect across both the markets.

Keywords: contagion, Diebold & Yilmaz (2012), forex market, second moment, stock market, volatility spillover.

#### 1. Introduction

Volatility spillover idiosyncrasies with the swift transformation of stress across markets which potentially lead to systemic and non-systemic risk for stakeholders and economies. Such risk is accounted as diversion of profitability of transactions from its expected value which range to either side. Integration of Indian financial market is facilitated by major economic and financial sector reforms and shift towards market determined exchange rate system with timely RBI intervention. The underlying premise of dynamic of exchange rate with stock price purports dual approach [First moment (traditional) approach and Second movement (portfolio) approach].

The first moment approach (Dornbusch and Fisher, 1980) elucidate the effect of fluctuation (appreciation/depreciation) in real exchange rate (RER) on international competition of national goods and services and indebtedness of corporate which eventually affect the present and expected cash flow of corporate entities reflected in market valuation of stock prices. The second moment approach elucidate the relationship between the stock market price fluctuation and exchange rate movements where stock price driven by demand

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initially lead to a positive wealth effect and consequently affect demand for money and eventually interest rate. The upward movement in interest rate appealed foreign portfolio investments which result into appreciation in exchange rate. In contrast, downward movement in stock price drive negative wealth effect and outward movement of foreign portfolio investment which eventually lead to depreciation in exchange rate.

There is plethora of empirical evidence on the first moment relationship between exchange rate and stock prices while second moment study is comparatively unexplored and mostly focused on developed market. This study is crucial to capitalize the importance of linkage between developed & emerging market portfolio and risk management. Further, it has novel contribution in the context of considerations pertaining to cross-asset class i.e., exchange rate and stock market while accommodating Covid-19 pandemic. Further, contemporary time-domain technique i.e., Diebold & Yilmaz (2012) is employed to measure the connectedness across markets. This work would provide insight to calibrate hedging strategies, diversified portfolio, and capital mobility.

## 2. Literature Review

There is abundance of study in the context of spillover across stock market viz. Chou, Lin, and Wu (1999); Karolyi (1995); Harris & Pisedtasalasai (2006); Bhattacharya et.al (2001); Worthington & Higgs (2004); Li (2007); Joshi P. (2011); Dedi et al. (2016) and others. The pioneer research in the domain of volatility spillover was developed by Engle, Ito, and Lin (1990) through the proposition of dual hypotheses namely 'Heat Wave' (intra-market volatility) and 'Meteor Shower' (inter-market volatility) using GARCH and VAR modelling. Kanas (2000) explored six developed market, namely US, UK, Germany, France, Canada, and Japan by using bivariate E-GARCH modelling and document the unidirectional spillover from stock market to exchange rate in all market expect Germany. Antonakakis (2012) studied spillover across Euro, British Pound, JPY, and Swiss Franc in the context of INR/USD Dollar under time frame of pre and post introduction of euro and found significant spillover effect with bidirectional effect. However, magnitude of volatility declined in post euro time frame. Allen, et.al. (2017) concluded significant impact of US & Hong Kong market on Australian market by employing Diebold & Yilmaz (2012).

Xionget et.al. (2015) studied the spillover across RMB/US dollar exchange rate & PSH (Shanghai Composite Index) under two-time frame July 2005 – July 2008 (Constant appreciation period) & July 2008 -April 2010(decline appreciation period) and document the asymmetrical bi-directional spillover directed significantly from RMB to PSH. In contrast, during second period, spillover significantly directed from PSH to RMB. Moreover, some of study also suggest unidirectional movement from stock to exchange rate including Rubayat&Tereq (2017) in the context of Bangladesh, Fedorova& Saleem (2010). There are also studies in pre and post Asian financial crisis period where Choi

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et.al. (2009) presented both unidirectional and bidirectional spillover in New Zealand and Wu (2005) document only bidirectional movement for six East Asian countries.

In India, few studies were undertaken. Panda & Deo (2014) reported bidirectional asymmetrical spillover during pre & post crisis period and unidirectional during crisis period with prominent asymmetries during post crisis whereas Majumder & Nag (2015) documented the bidirectional asymmetrical spillover during crisis and post crisis period with prominent asymmetries for whole period. Jebran& Iqbal (2016) found unidirectional whereas Mitra (2017) found bidirectional spillover across stock and foreign exchange market. Sahoo, Behra& Trivedi (2017) using bivariate BEKK-GARCH model reported the bidirectional spillover during high volatility period & unidirectional during relative tranquil period. Mishra et.al. employed Diebold & Yilmaz (2012) and explained moderate level of connectedness among four exchange rates.

# 2.1 Objective

To explore the second moment spillover from stock market (domestic & foreign) to Indian foreign exchange market during Covid-19 pandemic.

## 3. Data & Methodology

The time-series data of exchange rate viz. INR/USD; INR/JPY & INR/GBP and indices namely CNX Nifty; S&P 500; Nikkei 225 & FTSE 100 are considered for the period April 2, 2014, to March 31, 2021. Further, the time frame is split into Pre-Covid Period (April 2, 2014, to January 29, 2020) & Post-Covid Period (January 20, 2020, to March 31, 2021) based on announcement of Covid-19 as pandemic by World Health Organization. The exchange rate series is retrieved from RBI warehouse & FBIL, and indices data accessed from NSE website and https://finance.yahoo.com. The series is modelled by employing GJR-GARCH (p, q) to extract volatility pattern. The standardized mean and variance equations of GJR-GARCH model are as follows:

$$R_t = \tilde{\theta} + \varepsilon_t \tag{1.1}$$

Where,

$$\begin{split} R_t &= \text{return series} \\ \widetilde{\boldsymbol{\theta}} &= \text{expected return} \\ \boldsymbol{\varepsilon}_t &= \text{white noise term (i.i.d)} \\ h_t &= \delta + \sum_{i=1}^q (\theta_i \, \varepsilon^2_{t-i} + \tau_i I_{t-i} \varepsilon^2_{t-i}) + \sum_{j=1}^p \alpha_j h_{t-j} \end{split}$$

Where,

 $\sum_{i=1}^{q} (\theta_i \, \varepsilon^2_{t-i} \text{ Indicates news about volatility from previous prd (ARCH term)} \\ \sum_{j=1}^{p} \alpha_j h_{t-j} \text{ Indicates last period forecast variance (GARCH term)}$ 

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## $\tau_i I_{t-i} \varepsilon_{t-i}^2$ Indicates asymmetric coefficient

All the data series are gauged at GJR-GARCH (1, 1) except INR/USD which is gauged at GJR-GARCH (1, 2) based on appropriate information criterion. Further, Diebold & Yilmaz (2012) model based on 'generalized forecast error variance decomposition' is employed to unfold volatility spillover.

### 3.1 Diebold & Yilmaz (2012) Index

This contemporary method explains the connectedness as the fraction of variances in the forecast contributed by other than own error element which depicts by off-diagonal elements to the total of the entire matrix. In contrast, the diagonal matrix depicts the forecast contributed by own error element. Generalized VAR framework is the fundamental of DY index (2012) which eliminates the potential dependability on ordering and focused on measurement of directional connectedness. The modelling equation of stationery covariance of variable in VAR (q) is

$$v_t = \sum_{i=1}^{q} \beta_i s_{t-i} + \mu_t \tag{2.1}$$

There are variance decompositions, to access GFEVD of each variable in parts under system which contributes to shocks in the same.

$$\left(\omega_{L_{I,J}}\right) = \frac{\sigma_{JJ}^{-1} \sum_{l}^{L^{-1}} ((\pi_{l} \varepsilon)_{I,J})^{2}}{\sum_{l}^{L^{-1}} ((\pi_{l} \varepsilon \pi)_{I,I})^{2}}$$
(2.2)

 $\pi_l$  are n x n matrices of coefficient parallel to lag L and  $\sigma_{JJ} = \varepsilon_{JJ}$ . The forecast coefficient  $\omega_{L_{I,J}}$  depicts the value of J<sup>th</sup> variable in the system of GFEVDon I<sup>th</sup> variable series. The connectedness equation is as follows:

$$S_L = 100 \frac{(\sum_{I \neq J} (\widetilde{\omega}_L)_{I,J})}{\sum (\widetilde{\omega}_L)_{I,J}} = 100 \left( 1 - \frac{T\{\widetilde{\omega}_L\}}{\sum \widetilde{\omega}_{L_{I,J}}} \right)$$
(2.3)

 $S_L$  = Connectedness of entire system.

T = Trace operator (relative contribution of other variables to the forecast error variance)

#### 3.2 Empirical Results

Table 1 documented the descriptive statistics of exchange rate and stock indices series which elucidates that exchange rate (INR/USD) exhibit highest mean return followed by Japanese Yen (INR/JPY) and Great Britain pound (INR/GBP) whereas in the context of return volatility, Japanese Yen show more volatile position followed by GBP & USD.

Furthermore, stock indices Nikkei 225 exhibit highest mean return followed by S&P 500, CNX Nifty and negative FTSE 100. A similar trend is shown by standard deviation coefficients with lowest positive FTSE 100 index. The skewness coefficient is negative for

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Japanese Yen whereas all other series depicts positive coefficient. While explaining distribution pattern, Kurtosis shows the leptokurtosis attribute. In addition, Jarque-Bera test rejects the null hypothesis of normal distribution which in nutshell, proclaim the exhibition of non-normality distribution pattern in all the considered time series.

Test	]	Exchange Rat	e	Stock Market Indices			
Statistics				Domestic		Foreign	
	INR/USD	INR/GBP	JPY/INR	CNX Nifty	S&P 500	FTSE 100	Nikkei 225
Mean	0.000124	1.03E-05	8.52E-05	0.000405	0.000413	-9.45E-06	0.000427
Median	0.000000	0.000105	-0.00015	0.000692	0.000594	0.000480	0.000739
Maximum	0.013738	0.028133	0.035309	0.084003	0.089683	0.086664	0.077314
Minimum	-0.01529	-0.06769	-0.0317	-0.13904	-0.12765	-0.11512	-0.08253
Std. Dev.	0.003304	0.006042	0.006194	0.011177	0.011514	0.010802	0.012836
Skewness	-0.0484	-0.89617	0.417456	-1.54464	-1.02807	-0.90276	-0.15181
Kurtosis	4.784748	13.71656	5.828221	25.47223	23.80778	16.38065	8.614809
Jarque- Bera	224.5604	8298.439	611.2502	36168.23	30730.91	12814.30	2222.501
Probability	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
Observations	1687	1687	1687	1687	1687	1687	1687

Table 1: Descriptive Statistics

Source: Computed

Table 2.1 documents the connectedness across stock market of India & USA and the forex market of India for the full period under study. The empirical exploration is initiated with the pre-testing of properties of data series which explain the non-stationery attributes. Consequently, log data is converted into stationery series at first difference. Further, GJR-GARCH variance series is modelled for each variable to extracted volatility pattern. At last, Diebold & Yilmaz (2012) methodology is deployed to explore the connectedness of index across stock and foreign exchange market. In each table of DY index, the diagonal elements depict the spillover due to own inducement whereas other elucidate the spillover due to other series inducement.

	INR/USD	CNX NIFTY	S&P 500	FROM
INR/USD	89.72	5.51	4.77	3.43
CNX NIFTY	7.05	75.21	17.74	8.26
S&P 500	7.93	45.48	46.59	17.80
ТО	4.99	17.00	7.50	29.50

Table 2.1: Output of DY Index of INR/USD (Full Period)

Source: Computed

For Full Period, it is depicted that in the context of own inducement, INR/USD, CNX Nifty & S&P 500 show89.72%, 75.21% & 46.59% respectively. On the contrary, in the context of other series inducement, spillover from stock market CNX Nifty and S&P

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500to foreign exchange market (INR/USD) is 5.51% & 4.77% which shows low connectedness. The overall system contains only 29.50% DY index.

Table 2.2 documents the connectedness across stock market of India & USA and the forex market of India for the pre-covid period under study. For Pre-Covid Period, it is documented that in context of own inducement, INR/USD, CNX Nifty & S&P 500 show99.31%, 99.31% & 94.30% connectedness respectively which is relatively high in comparison of full period. On the other side, in context of other series inducement, spillover from stock market CNX Nifty and S&P 500to foreign exchange market (INR/USD) is 0.32% & 0.37% which shows relatively very low connectedness. The overall system contains only 2.81% DY index which is relatively very low compared to full period. i.e., 29.50%.

	INR/INR/USD	CNX NIFTY	S&P 500	FROM
INR/USD	99.31	0.32	0.37	0.23
CNX NIFTY	1.85	99.31	0.19	0.68
S&P 500	3.24	2.45	94.30	1.90
ТО	1.70	0.92	0.19	2.81

Table 2.2: Output of DY Index of INR/USD (Pre- Covid)

Source: Computed

Table 2.3 documents the connectedness across stock market of India & USA and the forex market of India for the post-covid period under study. For Post-Covid Period, it is documented that in context of own inducement, INR/USD; CNX NIFTY & S&P 500 show99.31%; 99.31% & 94.30% connectedness respectively which is relatively high in comparison to full period. On the other side, in context of other series inducement, spillover from stock market CNX NIFTY and S&P 500to foreign exchange market (INR/USD) is 20.27% & 15.87% which shows somehow moderate connectedness. The overall system contains 44.21% DY index which is relatively high compared to full period (29.50%) & pre-covid period 2.81%.

	INR/USD	CNX NIFTY	S&P 500	FROM
INR/USD	63.86	20.27	15.87	12.05
CNX NIFTY	20.58	55.89	23.53	14.70
S&P 500	19.41	32.99	47.60	17.47
ТО	13.33	17.75	13.13	44.21

Table 2.3: Output of DY Index of INR/USD (Post- Covid)

Source: Computed

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	INR/GBP	CNX NIFTY	FTSE	FROM
INR/GBP	98.56	0.98	0.46	0.48
CNX NIFTY	16.86	80.39	2.75	6.54
FTSE	11.49	53.16	35.35	21.55
ТО	9.45	18.05	1.07	28.57

Table 3.1: Output of DY Index of INR/GBP Full Period

Table 3.2: Output of DY Index of INR/GBP (Pre-Covid)

	INR/GBP	CNX NIFTY	FTSE	FROM
INR/GBP	99.28	0.70	0.01	0.24
CNX NIFTY	0.00	99.63	0.36	0.12
FTSE	0.41	2.36	97.23	0.92
ТО	0.14	1.02	0.13	1.28

Table 3.1 documents the connectedness across stock market of India & Great Britain and the forex market of India for the full period under study. In the context of spillover from stock market CNX NIFTY and FTSE 100 to foreign exchange market INR/GBP the results show 0.98% & 0.46% connectedness respectively which is very low. The overall system contains 28.57% DY index. Table 3.2 documents the connectedness across stock market of India & Great Britain and the forex market of India for the pre period under study. In context of spillover from stock market CNX Nifty and FTSE 100 to foreign exchange market (INR/GBP), the results show 0.70% & 0.01% respectively which depicts very low connectedness. The overall system contains only 1.28% DY index which is relatively very low compared to full period. i.e., 28.57%.

Table 3.3 documents the connectedness across stock market of India & Great Britain and the forex market of India for the post period under study. In context of spillover from stock market CNX Nifty and FTSE 100 to foreign exchange market (INR/GBP), the results show 0.26% (decrease from pre-covid) & 1.77% (increase from pre-covid) respectively which depicts very low connectedness.

	INR/GBP	CNX NIFTY	FTSE	FROM
INR/GBP	97.97	0.26	1.77	0.68
CNX	62.97	34.97	2.06	21.68
FTSE	43.16	21.55	35.30	21.57
ТО	35.38	7.27	1.28	43.92

Table 3.3: Output of DY Index of INR/GBP (Post- Covid)

Source: Computed

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Table 4.1 documents the connectedness across stock market of India & Japan and the forex market of India for the full period under study. In context of spillover from stock market CNX Nifty and Nikkei 225 to foreign exchange market (INR/JPY), the results show 21.13% & 1.13% respectively which depicts moderate connectedness between CNX Nifty &INR/JPY whereas very low connectedness between Nikkei 225 &INR/JPY. The overall system contains 22.81% DY index.

	INR/YEN	CNX NIFTY	Nikkei	From
			225	
INR/YEN	77.74	21.13	1.13	7.42
CNX NIFTY	2.46	90.07	7.47	3.31
Nikkei 225	11.63	24.60	63.78	12.07
ТО	4.70	15.24	2.87	22.81

Table 4.1: Output of DY Index of INR/YEN (Full Period)

Source: Computed

Table 4.2 documents the connectedness across stock market of India & Japan and the forex market of India for the pre period under study. In context of spillover from stock market CNX Nifty and Nikkei 225 to foreign exchange market INR/JPY, the results show 0.01% & 1.59% respectively which depicts very low connectedness between CNX Nifty &INR/JPY and very low connectedness between Nikkei 225 &INR/JPY.The overall system contains only 6.93 % DY index which is relatively very low compared to full period i.e., 22.81%.

Table 4.2: Output of DY Index of INR/YEN Pre- Covid

	INR/YEN	CNX NIFTY	Nikkei 225	From
INR/YEN	98.40	0.01	1.59	0.53
CNX NIFTY	0.24	97.40	2.36	0.87
Nikkei 225	16.60	0.01	83.39	5.54
То	5.61	0.00	1.32	6.93

Source: Computed

Table 4.3 documents the connectedness across stock market of India & Japan and the forex market of India for the post period under study. In context of spillover from stock market CNX Nifty and Nikkei 225 to foreign exchange market (INR/JPY), the results show 53.11% (increase from full & pre-covid) & 27.65% (increase from full & pre-covid) respectively which depicts low connectedness between CNX Nifty &INR/JPY and between Nikkei 225 &INR/JPY. The overall system contains only **6.93** % DY index which is relatively very low compared to full period i.e., 22.81%.

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	INR/YEN	CNX NIFTY	Nikkei 225	From
INR/YEN	19.24	53.11	27.65	26.92
CNX NIFTY	9.36	63.12	27.52	12.29
Nikkei 225	8.23	51.12	40.65	19.78
То	5.86	34.74	18.39	58.99

Table 4.3: Output of DY Index of INR/YEN Post- Covid

Source: Computed

## 6. Conclusion

The study documented low connectedness from domestic (CNX Nifty) & foreign stock market (S&P 500, FTSE 100 & Nikkei 225) to Indian forex market except somehow moderate connectedness from domestic (CNX Nifty) to INR/JPY exchange rate which insinuate that at financial front, there is diversified foreign portfolio opportunity for international investors and risk managers. In addition, at economic stability front, it implies calculated approach for RBI intervention and government policy makers. The precovid period shows very low level of spillover as measured through Diebold & Yilmaz index which suggests that international investors have diversified foreign portfolio opportunity and at trade front, the outcome of the study infers secured value of bills receivables & payables. But, after the outbreak of Covid-19 pandemic, connectedness across stock and forex market has significantly inflated which affirm the contagion effect. Hence, it is crucial for economies & financial market players to revisit their portfolio strategies; risk management approaches; international trade practices; timing if artificial interventions in forex market & policy implementation in considering instability in domestic & world market due the infusion of news volatility rather than fundamentals disturbance.

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