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Relationship analysis of stocks prices and exchange rates of three leading Asian economies

ANISHA
Sant Mohan Singh Khalsa Labana Girls College, Barara, Ambala, India
anishagoyal1996@gmail.com
AASTHA KHERA
Kurukshetra University, Kurukshetra, India
aasthakhera12@gmail.com

Abstract. *This study attempts to investigate the dynamic relationship between the stock prices and exchange rate in the top three Asian economies, namely China, India and Japan extended from January 2010 to December 2019. We apply bivariate Vector Autoregression (VAR), Granger Causality Test, Impulse Response Functions and Variance Decomposition to study the short-term association of stock and exchange rate returns. It is interesting to note that stock markets are more influencing than currency markets in all three countries. The results of this study will be helpful for market participants and policy makers to take more efficient and informed decisions.*

Keywords: vector autoregression, stock index, exchange rate, causality, impulse response and variance decomposition.

JEL Classification: G15, C32.

Introduction

The stock market and exchange rate market are cardinal parts of financial environment of any country. It is hard to decide whether a country's foreign exchange rate steers stock market or stock market leads exchange rate. Turbulences in either or both the markets escalates tensions among policymakers. With the dynamic interrelatedness of the exchange rate market and the stock market, the study of these markets is always intriguing to policymakers, market participants and academicians. There are two major theories. One of them is "flow-oriented" approach according to which currency market leads stock market for example, if currency of a country depreciates then exporters of the country will get more competitive in international market as exports from home country will become cheaper for foreign importers and this will increase profits of the exporting firms and lead to rise in stock prices whereas if domestic currency appreciates then profits will decline as exporting will become less competitive (Dornbusch and Fischer, 1980). Whereas the "portfolio balance" approach suggests that stock market drive exchange rate. An outperforming stock market will make stock market more promising for foreign investors which will attract more foreign currency and it will increase the demand for domestic currency and lead to appreciation in domestic currency. When stock market is in declining trend then foreign investors lose confidence in the market and pull back their money which leads deprecation in the currency (Branson and Henderson, 1985). There is "monetary approach", according to which exchange rates and stock markets have no lead-lag relationship because both markets are affected by same and different other variables such as interest rates, inflation etc. (MacDonald and Taylor, 1992; Griffin and Stulz, 2001). Gavin (1989) discussed the importance of time between announcement and implementation of the expansionary fiscal policies suggesting that if fiscal expansion take too long to be implemented, it will generate big exchange rate appreciations and the impact on output and profitability will be small.

This study examines the relationship of the Exchange rate and stock market in the top three Asian countries namely India, China and Japan which together account for around one-fourth of the world's GDP and more than half of Asia's GDP. The reason for choosing these economies is rooted in the fact that all three countries have shown major changes in both markets in the last decade. Such as overvaluation of Yen in late 2011 decoupled stock market and exchange rate market, asset bubble burst in China in 2015 which made Chinese market more volatile. Political shift in India which incepted restyling of government policies like the formation of NITI Ayyog, demonetization, GST implementation and many more. Slow economic growth in a country makes it more vital to study interlinkages of stock market and exchange market to stimulate the economy and prevent a currency crisis. The steps like reduction in corporate tax in India in 2019 ways to pump up stock markets which were also reflected in the foreign exchange market too but for a short period.

Empirical studies have shown mixed evidences in different countries, in different periods. For example, a currency depreciation dampens the stock market in Germany whereas stock prices steer currency rates in Italy and Japan (Neih and Lee, 2001). Studies like Mishra (2004), Rahman and Uddin (2009) and Abidin et al. (2013) showed no interlinkages between stock returns and exchange rate changes. A bidirectional causality between both markets was argued by Bahmani-Oskooee and Sohrabian (1992). During the Asian crisis period, the Exchange rate market has strong implications in the stock market (Pan et al., 2006).

Most of the recent studies found no long-term association of stock and exchange rate returns but there are mixed findings regarding short-term linkages. This study is in agreement for long term relationship but there are varied results for short term relationship analysis between both variables. Further construct of this paper is given as second section is the review of some existing literature. The third section exhibits data and research methodology followed by the fourth section which reports the empirical results and the fifth section concludes the whole study.

Review of literature

Numerous empirical studies are in little concordance with theoretical studies such as Bahmani-Oskooee and Sohrabian (1992). It is one the earliest studies in this area and they detected a bi-facial causal relationship of S&P 500 Index and the real exchange rate of USD employed Granger causality test on monthly data from July 1973 to December 1988. And absence of any protracted association of both variables is suggested by the co-integration test.

Neih and Lee (2001) employed Engle-Granger and Johanson co-integration test on daily data of stock returns and exchange rates of G-7 countries from 1993-1996 in order to analyse interrelatedness of both variables. The Authors concluded that there is no significant long-term association between both variables in all G-7 countries but there is sign of short-run linkages in few countries such as currency depreciation leads to fall in stock market in Germany and rise in stock returns dampens currency in Italy and Japan the next day.

Mishra (2004) attempted to analyse the interrelatedness of stock market and currency market in using VAR and Granger Causality test on monthly data from collected from April 1992 to March 2002. The author also added two more variables like interest rate and demand for money in the VAR model. And detected absence of any lead-lag relationship between exchange rate returns and stock returns. Interestingly interest rates impact both stock prices and the exchange rate which reaffirms the monetary approach.

Pan et al. (2006) examined the interlinkages between the forex market and stock market for seven East Asian countries employing Granger causality tests, Variance Decomposition and Impulse response functions on daily data accumulated from January 1988 to October 1998. It showed time-varying causalities such as no causality runs from stock returns to exchange rate changes during the Asian Crisis while exchange rates cause stock prices in all countries except Malaysia. In the pre-crisis period, exchange rate oscillations sway stock prices in Hong Kong, Japan, Thailand and Malaysia, and Stock returns leads exchange rates changes in Hong Kong, Korea and Singapore.

Zhao (2010) analysed the Renminbi and Chinese stock market interaction from 1991 to 2009 using VAR and GARCH models and established that no substantial long-run relationship exists in both variables. Researcher also observed two-way volatility effects in both the variables which reflected currency market gets swayed by the past shocks in stock market and other way around.

Rahman and Uddin (2009) probed the dynamic relationship of stock returns and exchange rate returns in Bangladesh, India and Pakistan and observed that there is no long-term or short-term relationship between two variables. Abidin et al. (2013) concluded no causal relationship between exchange rates and stock markets of seven Australian countries

Lean et al. (2011) studied the interlinkages between stock market and exchange rates using co-integration and granger causality test in eight Asian countries over the period from 1991 to 2005 and found no long-run interaction between both variables even after employing structural breaks in the model. Though study reflected little short-run association that too in very few countries.

Alagidede et al. (2011) studied the causality between stock prices and exchange rates in Australia, Canada, Japan, Switzerland and the UK using three variations of Granger Causality tests from 1992 to 2005. The results showed that their causation from the exchange rate to stock prices in Canada, Switzerland, and the UK. The findings of the non-linear causality test showed linkage from stock price to exchange rate for Japan.

Kumar (2013) investigated the returns and volatility spillovers in India, Brazil, and South Africa. The results of the multivariate GARCH model suggested the interaction between stock and currency markets and stipulates the existence of bi-directional volatility spillovers.

Caporale (2014) investigated the interlinkages between stock returns and exchange rate returns during the 2008 financial crisis in six developed countries, namely the USA, Japan, the UK, the euro area, Canada and Switzerland. The bivariate UEDCC-GARCH models was applied country-wise to daily data from 2003 to 2011. Finding of the study realized one-way causation from stock market to forex market in the US and the UK, conversely from forex market to stock market in Canada, and two-way causation in the Euro area and Switzerland. The co-integration test suggested that the co-movement of exchange rates and stock prices in Japan and the Euro area had separated by the incipience of the financial crisis.

Sui and Sun (2016) added one more variable, interest differentials in the study to examine the interrelationship between local stock returns and foreign exchange rates in Brazil, Russia, India, China, and South Africa (BRICS) using VAR and VECM models. The results showed that the spillover effects generated from the foreign exchange rate shocks to the stock returns for all BRICS. On the other hand, stock-market shocks scantly impact the exchange-market in Brazil and Russia. The was no long-run relationship shown in any country between stock returns and exchange rate returns.

Data and research methodology

The daily adjusted closing price for benchmark stock market indices of China (SSE Composite Index), India (S&P CNX Nifty) and Japan (Nikkei225) was downloaded from the Yahoo finance website. The daily exchange rate data of Chinese Yuan (USD/YUAN), Indian Rupees (USD/INR) And Japanese Yen (USD/YEN) was expressed as local currency per US Dollar and it was obtained from International Monetary fund's database. The time

of all three stock indices series and exchange rate series was of 10 years from 4 January 2010 to 31 December 2019. All data series of stock indices and exchange rates were non-stationary. To make data series stationary, stock price and exchange rate series of all three Asian countries (China, India and Japan) were converted into continuously compounded returns or log returns.

$$RVariable = log(variable_t) - log(variable_{t-1})$$

The three stock returns and exchange rates are shown in Figure 1. These graphs show that volatility of returns of the exchange rate and stock indices in all three countries.

Figure 1. *Daily returns and exchange rates of China, India and Japan*

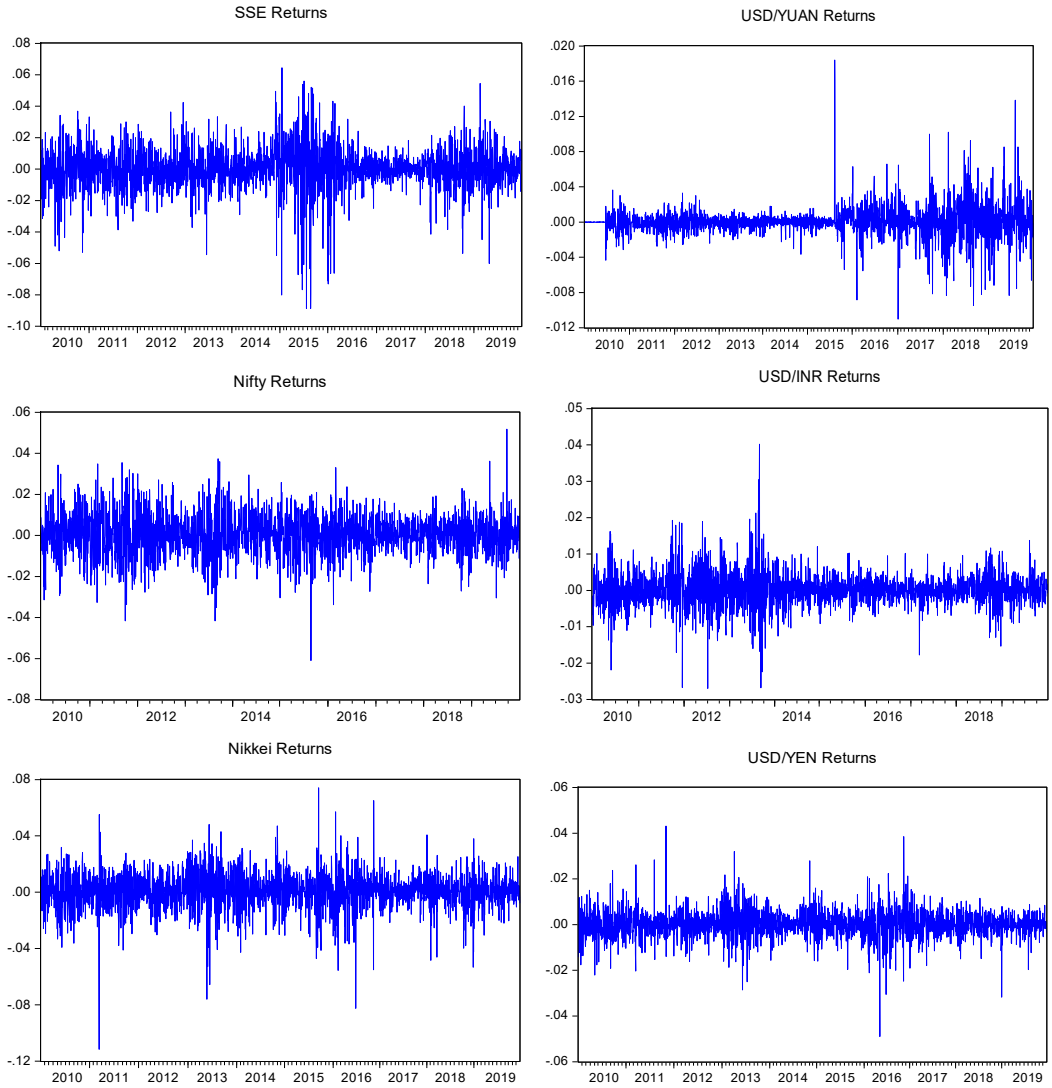


Table 1 shows descriptive statistics of all the data series. It describes mean as a measure of central tendency, standard deviation as a measure of statistical, Skewness and Kurtosis as a measure of the shape of the distribution, Jarque-Bera as a goodness-of-fit measure of normality and number of observations.

The results of standard deviations of the top three Asian economies show that stock index of India is less volatile than its counterparts and Japanese Yen is least volatile in all three currencies. The values of skewness and kurtosis show that the stock index of china is more skewed that Nifty and Nikkei225. All three indices are negatively skewed and exchange rate returns are skewed to the right except Japanese Yen. Chinese Yuan is more peaked than Indian rupees and the Japanese yen. Nifty is least peaked than its counterparts. Jarque-Bera results show all values are far from zero therefore the null hypothesis of normal distribution is rejected.

Table 1. *Descriptive statistics of returns of stock indices and exchange rates*

	China		India		Japan	
	SSE	USD/YUAN	Nifty	USD/INR	Nikkei	USD/YEN
Mean	-0.0000266	0.00000994	0.000376	0.000188	0.000344	0.0000686
Std. Dev.	0.01396	0.001766	0.010029	0.004835	0.013289	0.006096
Skewness	-0.826378	0.951321	-0.092224	0.279907	-0.603856	-0.027443
Kurtosis	8.862656	18.3395	4.741916	8.700754	8.184342	8.64768
Jarque-Bera	3578.829	23045.86	291.36	3115.772	2741.506	3086.257
Observations	2315	2315	2279	2279	2322	2322

Unit root test and co-integration test

To make data series stationary, continuous log-returns of stock indices and exchange rates are taken and stationarity of the data series is tested using ADF and KPSS. We investigated the long-term co-movement of stock indices and exchange rates of China, India and Japan using two steps Engle and Granger (1987) co-integration test is applied. because as we are interested in analysing trend between the means and variances of stock index values and exchange rates, we employed co-integration test on stock index values and exchange rates series instead of returns. Table 2 and Table 3 exhibits the results of the unit root test and co-integration test of stock indices and exchange rates of China, India and Japan.

Table 2. *Unit root test of returns*

	ADF Test t-statistics	KPSS Test t-statistics
India:		
USD/INR	-22.08957	0.075378
Nifty	-45.02153	0.052151
China:		
USD/YUAN	-42.57641	0.479037
SSE	-47.31246	0.104857
Japan:		
USD/YEN	-50.79252	0.158990
Nikkei	-50.26382	0.078216

Note: The critical values for ADF and KPSS test at 1 percent significance level are -3.4327 and 0.739, respectively.

Table 3. *Co-integration test of stock indices and exchange rates*

Dependent	Tau- statistic	Probability	z-statistic	Probability
India:				
USD/INR	-2.436337	0.3080	-11.06632	0.3045
Nifty	-2.083912	0.4842	-9.610483	0.3875
China:				
USD/YUAN	-0.988116	0.9037	-2.601419	0.9011
SSE	-2.101477	0.4750	-8.656718	0.4500
Japan:				
USD/YEN	-1.373701	0.8083	-4.009782	0.8090
Nikkei	-1.114296	0.8788	-5.001432	0.7324

Granger causality test

To establish the causality between stock returns and exchange rate returns of China, India and Japan we conducted the Granger causality (1969) test. As Granger causality establishes the correlation of one variable with the past values of other variable therefore lag length is an important issue which applying Granger causality test (Brooks 2008). Lag length was selected on SIC basis. Table 4 exhibits the results of Granger Causality.

Table 4. *Granger causality test*

Null Hypothesis	Obs.	F-Statistic	Probability	Results
RUSD_YUAN does not Granger Cause RSSE	2313	0.80788	0.4459	Accept
RSSE does not Granger Cause RUSD_YUAN		17.5406	3E-08	Reject
RUSD_INR does not Granger Cause RNIFTY	2275	0.21296	0.8082	Accept
RNIFTY does not Granger Cause RUSD_INR		50.0689	5.00E-22	Reject
RUSD_YEN does not Granger Cause RNIKKEI	2320	3.69191	0.0251	Reject
RNIKKEI does not Granger Cause RUSD_YEN		34.7643	1.00E-15	Reject

Note: at 5% significance level.

Vector Autoregression (VAR)

We have used vector autoregression (VAR) framework as there is no need to establish endo-exogeneity of the variables. All variables are endogenous and multiple equations are estimated. Having three variable means having three equations. The simplest form of VAR is bivariate model in which we have only two variables R_1 and R_2 of whose present values depend on different composition of the preceding k values of both the variables, and error values.

$$R_{1t} = A_{10} + A_{11} R_{1t-1} + \cdots + A_{1k} R_{1t-k} + B_{11} R_{2t-1} + \cdots + B_{1k} R_{2t-k} + u_{1t} \quad (1)$$

$$R_{2t} = A_{20} + A_{21} R_{2t-1} + \cdots + A_{2k} R_{2t-k} + B_{21} R_{1t-1} + \cdots + B_{2k} R_{1t-k} + u_{2t} \quad (2)$$

In matrix form,

$$R_t = A_o + A_1 R_{t-1} + A_2 R_{t-2} + \cdots\cdots + A_k R_{t-k} + u_t$$

$$w \times 1 \quad w \times 1 \quad w \times ww \times 1 \quad w \times ww \times 1 \quad \cdots\cdots \quad w \times ww \times 1 \quad w \times 1$$

There is w = 2 variables in the system.

For calculating VAR model, Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) is used to select appropriate lag length. Selected lag length are

2, 1 and 2 for China, India and Japan, respectively. Table 5 shows obtained bivariate VAR models exhibiting relationship between stock and exchange rate returns.

Table 5. *VAR Models*

China: $RSSE = -0.00002 + 0.01601*RSSE_{-1} + 0.01557*RSSE_{-2} + 0.04149*RUSD\_YUAN_{-1} + 0.20004*RUSD\_YUAN_{-2}$ $RUSD\_YUAN = 0.00000817 + 0.12284*RUSD\_YUAN_{-1} + 0.00909*RUSD\_YUAN_{-2} + 0.01499*RSSE_{-1} + 0.00361*RSSE_{-2}$
India: $RNIFTY = 0.00035 + 0.05444*RNIFTY_{-1} - 0.02113*RUSD\_INR_{-1}$ $RUSD\_INR = 0.00023 - 0.07858*RUSD\_INR_{-1} - 0.10285*RNIFTY_{-1}$
Japan: $RNIKKEI = 0.00035 - 0.04442*RNIKKEI_{-1} + 0.04599*RNIKKEI_{-2} + 0.01311*RUSD\_YEN_{-1} - 0.13833*RUSD\_YEN_{-2}$ $RUSD\_YEN = 0.00004 + 0.1467*RUSD\_YEN_{-1} - 0.06138*RUSD\_YEN_{-2} + 0.07479*RNIKKEI_{-1} + 0.05984*RNIKKEI_{-2}$

After forming VAR models, we check the stability of the VAR models using Inverse Roots of AR Characteristic Polynomial following Lütkepohl (2001) and Mishra (2004). The results proclaim that the inverse roots of AR characteristics polynomials for each system have modulus less than one. All three Systems of China, India and Japan satisfy the stability condition as no roots lie out the unit circle.

Impulse response functions

Impulse response functions record the responsiveness of variable in VAR to innovations in the error term. We have applied Cholesky one Standard deviation innovations to each equation to examine the degree and impact of the shock to a given variable. Responses are measured for 10 periods. Table 6 reports the response of stock (exchange rate) returns to one S.D. innovation in exchange rate (stock) returns in all three countries namely, China, India and Japan.

Table 6. *Impulse response functions*

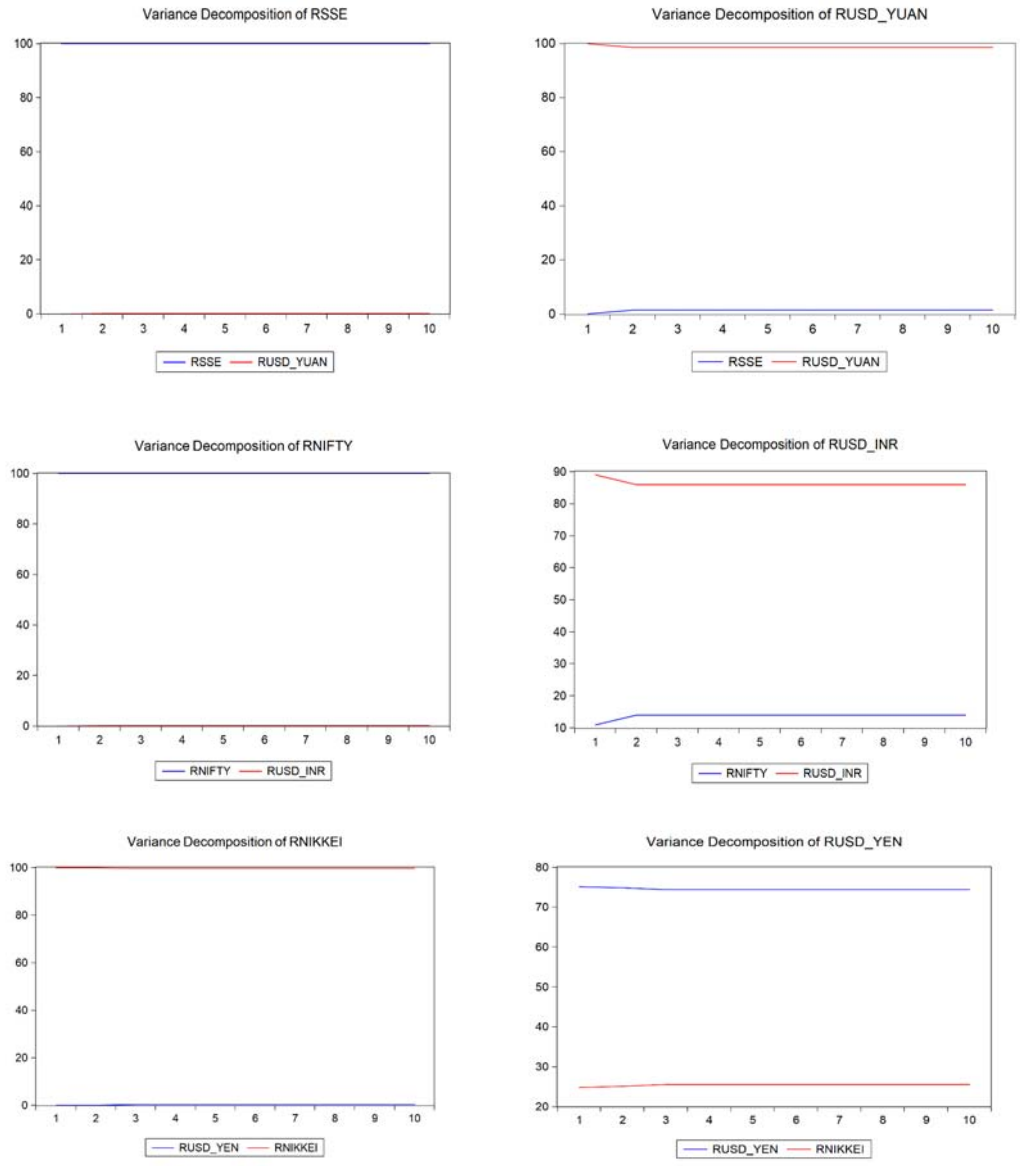
	Response of stock returns to one S.D. Innovation in exchange rate returns			Response of exchange rate returns to one S.D. Innovation in stock returns		
Periods	China	India	Japan	China	India	Japan
1	0.00E+00	0	0	1.43E-06	-0.00156	0.002992
2	-7.23E-05	-9.42E-05	6.82E-05	-0.00021	-0.00091	0.000553
3	-0.000358	2.27E-06	-0.00073	2.13E-05	1.18E-05	0.000488
4	-5.15E-05	-6.62E-07	1.39E-04	-1.92E-06	-6.14E-06	-0.00012
5	-1.56E-05	3.07E-08	-1.15E-05	6.44E-08	2.25E-07	-6.38E-06
6	-3.58E-06	-5.01E-09	2.99E-06	1.62E-07	-4.51E-08	-1.96E-06
7	-5.92E-07	3.19E-10	2.90E-06	4.03E-09	2.54E-09	-1.48E-06
8	-1.34E-07	-4.00E-11	-1.31E-06	6.04E-09	-3.52E-10	1.02E-06
9	-2.18E-08	3.02E-12	2.36E-07	1.01E-09	2.49E-11	-1.19E-07
10	-3.51E-09	-3.31E-13	-5.01E-08	1.44E-10	-2.87E-12	2.02E-08
Cholesky ordering: Stock returns, Exchange rate returns.						

Returns Spillovers measurement

In this study we measure returns spillovers based on VAR models. This spillover index methodology proposed by Diebold and Yilmaz (2009). Variance decomposition tells how much own shock contributed and how much other variable's shock contributed in fluctuations in an individual variable. We can proportion the effect of each variable on its own and other variables taking different time horizons. These results will be used to report interrelatedness and spillover effects in markets which will give spillover index. (Diebold

and Yilmaz, 2009; Kumar, 2013). The graphical representation of Variance decomposition is presented in Figure 2.

Figure 2. *Variance decomposition of returns of indices and exchange rates*



Results and findings

Stationarity test or unit root test

Firstly, we analysed the stationarity of the data using ADF and KPSS. In Augmented Dicky Fuller test, the null hypotheses are Series have unit root. The calculated values of t-statistics of are shown in Table 2 which shows value of t-statistics in all series is less than the critical value at 1 percent significance level. So, we reject the null hypotheses in all series. According to ADF test series of exchange rate returns and stock market returns of all three countries India, China and Japan are stationary. The results of KPSS statistics support the results of ADF test. As the estimated test statistic values are less than the critical values at 1% significant level. So, we failed to reject the null of hypothesis of stationarity in KPSS test.

Co-integration Test

Findings of co-integration test are given in Table 3. The null hypotheses states that series are not cointegrated. The results of tau-statistic and z-statistic, both do not reject the null hypotheses at 1 percent significant level which proclaims there is unit root in residuals therefore no co-integration between stock indices and exchange rates in china, India and Japan. So, no long-term linkages between SSE and USD/YUAN, Nifty and USD/INR, and Nikkei and USD/YEN. The results of the study are in congruence with the earlier studies in various countries.

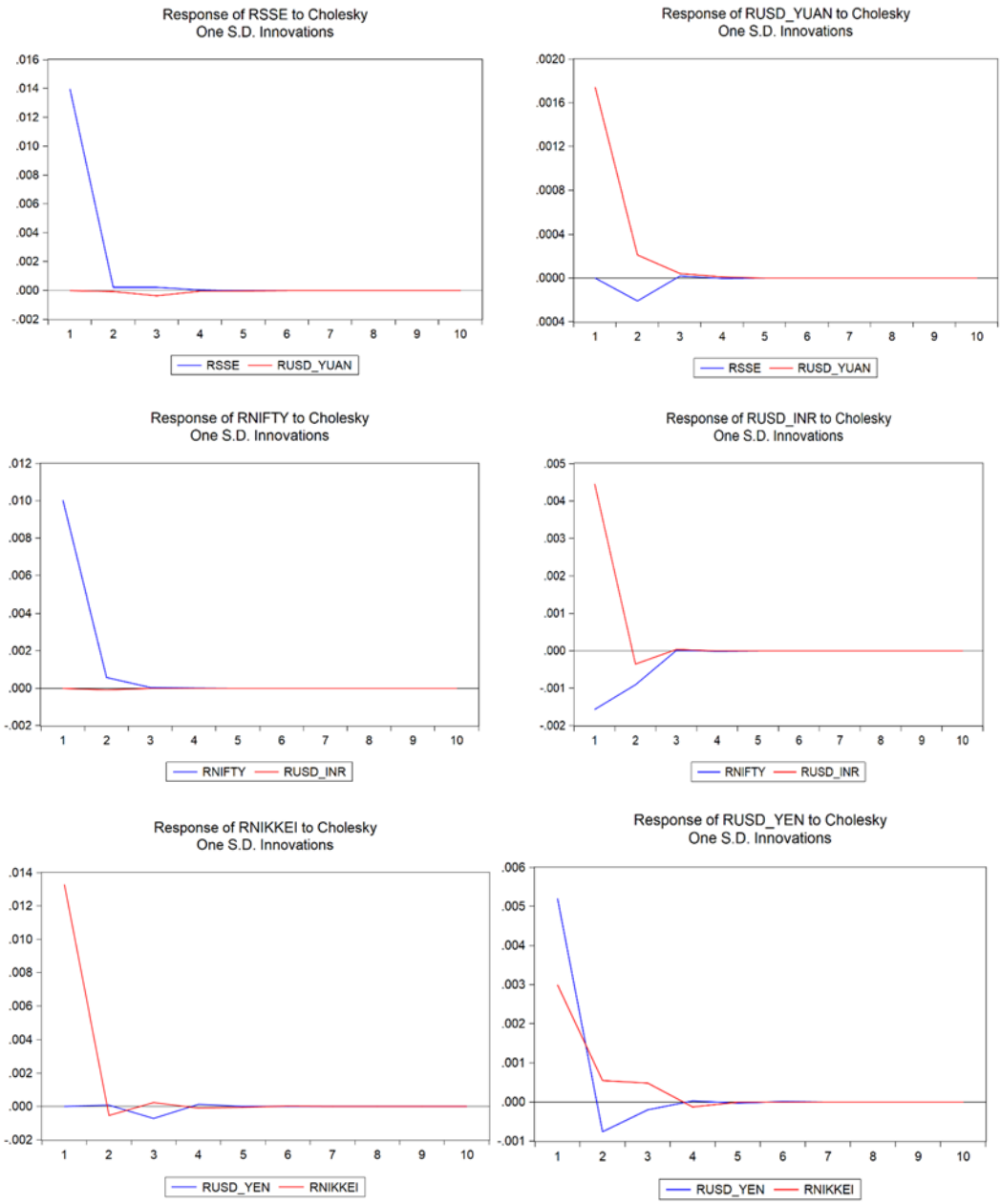
Granger Causality

Table 4 exhibits the results of Granger Causality test. The results of the test suggest that there is unidirectional causality from Stock returns to Exchange rate returns in China and India whereas in Japan there both variables are leading each other.

Impulse Response Functions (IFRs)

The results of Impulse Response functions of stock returns and exchange rate returns are exhibited in Table 6 and IRFs are graphically presented in Figure 3. The first graph in Figure 3 shows the responses of RSSE to one-unit impulse in RSSE and RUSD_YUAN. The response of a shock to RSSE is a big positive change in SSE in first period and then falls near to zero till second period. There is no significant change in RSSE to a shock in RUSD_YUAN which concords findings of Granger Causality test. The second graph in Figure 3 represents the responses of RUSD_YUAN to an impulse in RUSD_YUAN and RSSE. The response of RUSD_YUAN to one innovation to RSSE is zero in first period and negative in second and then dies out over time. A shock in RUSD_YUAN brings positive change in first period and then lead to zero over time.

Figure 3. *Impulse response functions*



The third graph in Figure 3 shows the responses of RNIFTY to shocks in RNIFTY and RUSD_INR. The one-unit shock in RUSD_INR brings no significant change in RNIFTY whereas the fourth graph shows that one-unit shock in RNIFTY brings negative change in RUSD_INR which stays up to 3 periods. This means if stock market in India outperforms then Indian rupees appreciates.

The fifth graph exhibits the response of RNIKKEI to one-unit shock in RNIKKEI and RUSD_YEN. The response of RNIKKEI to an innovation in RUSD_YEN is zero in first two periods and then negative in third period and response to own shock is positive in first period and falls below zero in second period. The responses of RUSD_YEN to RNIKKEI and RUSD_YEN are presented in the sixth graph. It is interesting to observe that the response of RUSD_YEN to an impulse in RNIKKEI is positive up to three periods. This means if stock market outperforms in Japan then Japanese Yen depreciates.

Decomposition of forecast error variance and Returns spillover

This study analyses the ten period ahead Variance decomposition of variables following Kumar (2013). The detailed results of returns spillover and spillover index are shown in Table 7.

Table 7. *Returns spillovers*

China			
	SSE	USD/YUAN	contribution from others
SSE	99.931	0.069	0.069
USD/YUAN	1.417	98.583	1.417
contribution to others	1.417	0.069	1.486
contribution including own	101.348	98.652	0.743 percent spillover index
India			
	Nifty	USD/INR	contribution from others
Nifty	99.991	0.009	0.009
USD/INR	14.026	85.974	14.026
contribution to others	14.026	0.009	14.035
contribution including own	114.017	85.983	7.0175 percent spillover index
Japan			
	Nikkei	USD/YEN	contribution from others
Nikkei	99.684	0.316	0.316
USD/YEN	25.587	74.413	25.587
contribution to others	25.587	0.316	25.903
contribution including own	125.271	74.729	12.965 percent spillover index

The cell (c, d) in Table 7 indicates that the proportion of contribution in variation in c series, originating from shocks in d series taken at ten period horizon. The numerator of the spillover index is calculated by adding the values of the contribution to other or the contribution from other. Similarly, the denominator of the spillover index is calculated by adding values of the contribution including own.

The results of Variance decomposition elucidate that shocks to stock returns describe 1.417, 14.026 and 25.587 per cent of fluctuations in forex returns in China, India and Japan respectively and shocks to forex returns explain 0.069, 0.009 and 0.316 per cent fluctuations in stock returns in China, India and Japan. The single value of spillover index shows that Japan (12.9 percent) has maximum return spillover and China (0.73 percent) has least return spillover. India has 7.01 per cent return spillover.

Conclusion

This study investigated the dynamic relationship between the stock market and exchange rate in the top three Asian economies, namely China, India and Japan from January 2010

to December 2019. The results of the Granger Causality test showed that Stock returns lead Exchange rate returns in China and India whereas there is two-way causation in Japan. The Impulse response functions showed that one-unit shock in stock returns brings appreciation in domestic currency value in china and India whereas in Japan one-unit shock in stock returns causes deprecation Japanese Yen. The results of variance decomposition showed that the Japanese stock market explains the maximum variation of the exchange rate, followed by India and China. Forex returns explains the maximum variance in stock market in Japan, followed by China and India though the magnitude is insignificant. It is interesting to note that stock markets are more influencing than currency markets in all three countries. And the values of returns spillover index indicates that stock market and currency market are more correlated in Japan than India and China. In all three countries, relationship in stock market and exchange rate market is different with magnitude and direction. The reason can be distinctive political, economic and legal environment in various countries. The results of the study will useful for market participants and policymakers as it contributes to a better understanding of the relationship between the stock market and exchange rate in China, India and Japan.

While this is a Bi-variate approach to study the relationship of stock market and exchange rate market, this can be extended by adding more macroeconomic variables such as interest rates, inflation etc. The inclusion of more countries in the purview of the study may provide new insights.

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