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Return Spillover Effects among Emerging Asian Currencies: Evidence from Countries along the Belt and Road Initiative

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Abstract
This paper investigates the connectedness and return spillovers among 10 emerging Asian Foreign Exchange (FX) pairs against the US Dollar: USD_TRY, USD_INR, USD_LKR, USD_MYR, USD_IDR, USD_PKR, USD_PHP, USD_CNY and USD_VND. We applied Diebold and Yilmaz (2012) Spillover Index approach based on Variance Decomposition on daily exchange rates of selected currencies. Result shows a moderate and non-trivial level of return spillovers with pronounced peaks during major crises periods. Thai Baht, Indian Rupee and Turkish Lira appeared as major net spillover transmitters, while Vietnamese Dong, Sri Lankan and Pakistani Rupee are found as major net receivers of return spillovers. These findings have significant implications for investors, fund managers and regional policy coordination.

Keywords: Belt and Road Initiative, Currency Markets, Return Spillovers, Global Financial Crises, Covid-19 Pandemic

Introduction

A Foreign Exchange (FX) market is the primary channel of communication through which financial crises and economic disturbances are transmitted across countries. Exchange rate returns have a direct impact on capital investment flows, external balances and trade competitiveness for developed countries in general and emerging countries in particular. Therefore, abrupt movement can substantially affect financial stability, inflation and debt sustainability. As a result, quantifying the percentage with which return shocks in one foreign exchange market are transmitted to other markets is important for risk managers, international investors and regulators in order to understand the channel of contagion transmission. This helps in formulating effective portfolio diversification and macro-prudential strategies.

Investors across the world are attracted towards currency markets due to lower entry barriers and decentralization mechanism. The Changing political and financial environment has significant impact on non-stop operations and huge volume of trading activities. Resultantly, return spillovers in Forex markets are affected by government interventions and macroeconomic news releases (Wen & Wang, 2020).

This study investigates the return spillover effect among 10 emerging Asian currencies with their exchange rates determined against US dollar using the spillover/connectedness framework on an extended period from 2005 to 2023. We used the Diebold and Yilmaz (2012) variance decomposition approach because it provides separate measures of total and directional spillovers and a transparent categorization of spillover shocks into own market and cross market variances. The DY indices are widely accepted as standardized measures for return connectedness across markets and assets. They help in identifying transmitters/receivers roles and dynamic patterns of contagion effects.

Our study has added important insights to the existing literature in three different ways. First, it provides evidence on return spillover effects of a focused set of emerging currency markets using daily observations for an extended period of 18 years (2005-2023), providing insights on both crises and tranquil periods. Second, the directional spillover analysis clarified which currencies are regional spillover shocks transmitters and which are net absorbers. Thirds, the study also provide striking evidence on sharp rise in return spillovers during crises episodes. The remaining paper proceeds as follows. Section 2 provides review of relevant literature. Section 3 gives explanation of data and the method used for analysis. Section 4 interprets the results provided in dynamic averaged return connectedness table, rolling window plots and network plots. Section 5 concludes the discussion with provision of policy implications to investors and regulators.

Literature Review

Previous studies on co-movements and foreign exchange markets spillovers fall under various dimensions. Some studies investigated spillover effect among different foreign exchange markets. Like Bubak *et al.* (2011) investigated dynamics spillovers among central European currencies by using spillover index framework and found significant spillover effect. Similarly, Antonakakis (2012) studied co-movements between world leading exchange rates returns before and after the introduction of Euro. Results from dynamic correlation and VAR-based spillover index provide evidence of significant returns interdependence. Moreover, the study argued that return spillovers are strongly positively associated with extreme events.

Greenwood *et al.* (2016) studied return spillovers among G10 currencies using an empirical network model and found substantial time variations among currencies. They also found that cross-currency spillovers get strengthen during stress episodes. Wen and Wang (2020) investigated the directional and total connectedness among global foreign exchange markets through LASSO VAR approaches and Spillover index framework. They found that among large currencies US Dollar and Euro acted as net transmitters and Japanese Yen and British Pound appeared as net receivers of spillover shocks. Other studies which fall under this category are Barunik *et al.* (2017), Kilic (2017) and Salisu *et al.* (2018).

Another group of studies investigated the spillover transmission from strong currencies towards weak currencies. Shu *et al.* (2015) and Sehgal *et al.* (2017) investigated the spillover effect in Asian region. Orlowski (2016) and Kocenda and Moravcova (2019) studied the spillovers effect in European currencies. Mai *et al.* (2018) and Li *et al.* (2018) studied currency market spillovers in the context of Belt and Road Initiative. Some other studies like Kumar *et al.* (2019), Coronado *et al.* (2020) and Reboredo *et al.* (2021) studied the dependence structure and time varying spillovers between currency markets and stock markets. Various studies investigated the spillovers among currency markets crude oil (Zhang *et al.*, 2008; Hameed *et al.,* 2021; Wang & Xu, 2022; Lu *et al.,* 2023). Moreover, another group of studies focused on spillovers among foreign exchange

markets and commodity markets (Yip *et al.*, 2017; Belasan and Demirer, 2019; Yildirim *et al.*, 2022 & Palakkod, 2022). Some other researchers studied spillovers among foreign exchange markets and crypto-currencies like Elsayed *et al.* (2022), Hsu (2022), Nikhili *et al.* (2023) and Zhang *et al.* (2025).

Majority of the previous studies focused on examining the effect of economic and policy factors on spillover transmission across foreign exchange markets. Major currencies like US Dollar, Canadian Dollar, British Pound Sterling and Japanese Yen etc were examined. However, weak currencies particularly those of emerging and developing economies were mainly ignored in the Forex markets network. Correlation based networks were used to study the topology structure of currency markets spillovers. These networks are based on linear correlation among foreign exchange markets data, thus fail to capture the spillover and the lead-lag relationship across regional Forex markets. To fill this gap in previous literature, our study employs the refined approach developed by Diebold and Yilmaz (2012) to measure the strength and direction of return spillovers among 10 emerging Asian currencies along the Belt and Road Initiative region.

Data and Methodology

The dataset is composed of daily exchange rate returns computed through log changes of 10 US Dollar pairs; USD_TRY, USD_INR, USD_LKR, USD_MYR, USD_IDR, USD_PKR, USD_PHP, USD_CNY and USD_VND for 2005-2023. Sample currencies used are Turkish Lira, Indian Rupee, Sri Lankan Rupee, Malaysian Ringgit, Indonesian Rupiah, Pakistani Rupee, Philippine Peso, Thai Baht, Chinese Yuan and Vietnamese Dong. Returns are calculated as daily log differences of the exchange rate quoted on websites of Investing.com, Yahoo-finance and Wall Street Journal. The sample period covers Global Financial Crises, the Belt and Road Initiative and Covid-19 Pandemic. This period allows the dynamic return spillover profile to reflect multiple global and regional shock episodes. The study has applied Diebold and Yilmaz (2012) Spillover Index method based on Generalized Forecast Error Variance Decomposition (GFEVD) to an estimated VAR of the return system in order to quantify different measures of return spillovers. Spillover Index framework characterizes three main steps; data preparation, estimating the model, and computation of spillover indices. All the estimations are carried out in R which is the recommenced software for running the said method. Daily closing prices of exchange rates against US dollar are converted into continuously compounding returns using natural log formula.

$$Rt = ln (Pi / Pi-1)$$

Where ***Rt*** represents returns***, ln*** denotes natural log, ***Pi*** represent current price and ***Pi-1*** shows lag price or yesterday's price.

Figure 1 shows the graphical representation of daily exchange rate returns of 10 emerging Asian currencies against US dollar pertaining to countries along Chinese Belt and Road Initiative. The time series of closing prices of foreign exchange rates are not stationary at level. However, the first difference i.e log returns are normally stationary. The Plot shows that all the return series have constant mean and variance overtime. Volatility clustering inherent in some of the series are due to different crises episodes. Table 1 shows the Descriptive Statistics of log returns of 10 emerging foreign exchange markets along Belt and Road Initiative. In the Table, it can be seen that Turkish currency followed by Pakistani currency shows both highest average returns and volatility. Turkish Lira and Malaysian Ringgit are negatively skewed; while returns of all other exchange rates are positively skewed. Sri Lankan Rupee and Vietnamese Dong bears the highest Kurtosis measure.

VAR model and Forecast Error Variance Decomposition

The measurement of foreign exchange returns spillovers is based on a stationary N-Variable Vector Autoregressive (VAR) Model originally introduced by Engle *et al.* (1988).

$$\boldsymbol{Xt} = \boldsymbol{\beta 1}\, \boldsymbol{Xt-1} + \boldsymbol{\beta 2}\, \boldsymbol{Xt-2} + \cdots + \boldsymbol{\beta p}\, \boldsymbol{Xt-p} + \in \boldsymbol{t}$$

$$\boldsymbol{X_t} = \sum_{i=1}^{p} \boldsymbol{\beta_i}\ \boldsymbol{X_{t-i}} + \boldsymbol{\epsilon_t}$$

In above mentioned equation, $\boldsymbol{Xt}$ is a vector which is composed of return spillovers of considered exchange rates, $\boldsymbol{\beta i}$ are parameters or moving average coefficient matrices, $\boldsymbol{Xt\text{-}i}$ is one order lag value of Returns Vector $\boldsymbol{Xt}$ and $\boldsymbol{\mathcal{E}}t \sim (0, \sum)$ is a vector of disturbances that are identically and autonomously distributed.

The VAR model can be expressed in moving average form like,

$$\boldsymbol{Xt} = \sum_{\boldsymbol{i=1}}^{\infty} \boldsymbol{A_i}\ \boldsymbol{\varepsilon_{t-i}}$$

This step allows us to simulate the interconnectedness among foreign exchange markets and proceed to spillover analysis.

Generalized Forecast Error Variance Decomposition (GFEVD)

If we denote the KPPS H-step-ahead forecast error variance decompositions with θ_{ij}^{g} (H), for H = 1, 2, …, we have

$$\theta_{ij}^{g}(H) = \frac{\sigma_{jj}^{-1} \sum_{h=0}^{H-1} (e_i' A_h \Sigma e_j)^2}{\sum_{h=0}^{H-1} (e_i' A_h \Sigma A_h' e_i)}$$

where Σ is the variance matrix for error vector ε, σjj is the standard deviation of the error term for the jth equation and ei is the selection vector with 1 as the ith element and zeros otherwise.

Every entry of the row sum can be be normalized like,

$$\tilde{\theta}_{ij}^{g}(H) = \frac{\theta_{ij}^{g}(H)}{\sum_{j=1}^{N} \theta_{ij}^{g}(H)}.$$

Note that, by construction, $\sum_{j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = 1$ and $\sum_{i.j=1}^{N} \tilde{\theta}_{ij}^{g}(H) = \mathrm{N}$.

Figure 1: Graphs of Return Series of Emerging Asian Foreign Exchange Markets along BRI from 2005-2023.

Table 1: Descriptive Statistics of Log Returns of 10 Emerging BRI Foreign Exchange Markets from 2005-23.

	USD_ TRY	USD_ INR	USD_ LKR	USD_ MYR	USD_ IDR	USD_ PKR	USD_ PHP	USD_ THB	USD_ CNY	USD_ VND
Mean	0.0006	0.0001	0.0002	0.00004	0.0001	0.0003	0.00005	-0.00003	-0.00003	0.00009
Standard Deviation	0.01047	0.00439	0.00459	0.00387	0.00449	0.00475	0.00367	0.00469	0.00200	0.00222
Kurtosis	45.8794	6.76934	207.835	5.9095	36.7486	61.5602	2.3910	139.138	17.789	231.506
Skewness	-0.06055	0.18411	7.28726	-0.49640	0.72339	2.73868	0.00494	0.16093	0.30774	6.15439
Minimum	-0.19504	-0.0355	-0.0606	-0.03596	-0.06471	-0.05410	-0.02247	-0.11034	-0.02019	-0.04671
Maximum	0.14756	0.03694	0.11953	0.02026	0.07617	0.07960	0.01765	0.10951	0.02559	0.06075
Count	4741	4741	4741	4741	4741	4741	4741	4741	4741	4741

Source: Compiled by Author

Calculation of Spillovers

Total Spillover Index

We can construct the Total Return Spillover Index by using returns contributions from the KPPS variance decomposition as,

$$S^g(H) = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \cdot 100 = \frac{\sum_{\substack{i,j=1 \\ i \neq j}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \cdot 100.$$

Directional Spillovers

Directional spillovers 'FROM' received by Market i can be written as

$$S_{i\cdot}^g(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ij}^g(H)} \cdot 100 = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ij}^g(H)}{N} \cdot 100.$$

While the Directional Spillover 'TO' can be written as

$$S_{\cdot i}^g(H) = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^g(H)}{\sum_{i,j=1}^{N} \tilde{\theta}_{ji}^g(H)} \cdot 100 = \frac{\sum_{\substack{j=1 \\ j \neq i}}^{N} \tilde{\theta}_{ji}^g(H)}{N} \cdot 100.$$

Net Spillovers

The measure of net returns spillovers from markets i to all other markets j can be expressed as:

$$S_i^g(H) = S_{\cdot i}^g(H) - S_{i\cdot}^g(H).$$

3.2.2 Net Pairwise Transmission (NPT)

From net returns spillover, the measure of net pairwise spillovers is written as:

$$S_{ij}^g(H) = \left(\frac{\tilde{\theta}_{ji}^g(H)}{\sum_{i,k=1}^{N} \tilde{\theta}_{ik}^g(H)} - \frac{\tilde{\theta}_{ij}^g(H)}{\sum_{j,k=1}^{N} \tilde{\theta}_{jk}^g(H)} \right) \cdot 100$$

$$= \left(\frac{\tilde{\theta}_{ji}^g(H) - \tilde{\theta}_{ij}^g(H)}{N} \right) \cdot 100.$$

Results and Discussion

Total Return Spillovers

Results of Static Spillover Analysis of considered emerging foreign exchange markets along Belt and Road Initiative are displayed in Table 2. The Total Spillover/Connectedness Index is equal to 37.13%. It implies that on average approximately one-third of the forecast error variance in each currency's return is due to cross market spillovers. This figure indicates a moderate to high level of interdependence among 10 Asian emerging foreign exchange markets. As compare to developed markets, it suggests that the level of integration has strengthened over time, however; considerable segmentation still exists. Our results are in line with findings of Antonakakis (2012) and Sugimoto *et al.* (2014). The findings are also aligned with the steady pace of economic liberalization and exchange rate regime diversity in emerging BRI countries.

Directional Spillovers 'TO'

The Directional Spillover results exhibited diverse transmission patterns. Malaysian, Indian and Thailand currencies emerged as major transmitters of return spillover shocks. The respectively transmitted 55.15%, 51.76% and 51.05% shocks to the BRI emerging foreign exchange markets spillovers. This dominance transmission pattern reflects stronger trade ties, open financial markets and comparatively stable macroeconomic situations. Philippine, Indonesia and Turkish Currencies also followed the same pattern. Sri Lanka, Pakistan and Vietnamese currencies transmitted least portion of return spillovers. On the receiving front, Malaysia, Indonesia and Philippine currencies appeared as major recipient of return spillover shocks. These currencies absorbed 54.12%, 48.39% and 46.74% return shocks from BRI emerging foreign exchange rate system.

Net Return Spillovers

Thailand Currency transmits more spillover shocks than it received from other markets in the system with a net spillover value of +8.90 making it the top net transmitter. Turkish and Indian currencies appeared as second and third largest net transmitters. On the contrary side, Vietnamese Dong received more spillovers than it transmitted to other markets with a net value of -7.51, making it the largest net receiver of return spillovers. Sri Lankan and Pakistani Currencies also appeared as major net receivers.

Net Pairwise Transmission

The NPT value for Thai Baht and Indian Rupee is the highest among all others i.e 9.00 and 8.00 respectively. This implies that both of these currencies send return shocks to more markets than it received from, making them the major foreign exchange rate pairwise spillover exporters. Sri Lankan market is fully isolated from regional return spillover system with a NPT value of 0.00. Pakistan Currency is least integrated as its NPT value is 1.00.

Figure 2 shows the Dynamic Total Return Spillovers among considered currency markets. Rolling Window helps to capture major shifts in spillover transmission over time due to crises episodes. For this purpose a rolling window of 200 days is used. The total spillover index fluctuates between 25-50% highlighting notable variations over time. Initially, the index ranges between 30-45% showing moderate to high interdependence. Just before Global Financial Crises, in 2007 a clear dip can be seen. However, with the onset of GFC, the index reaches 50% showing that spillovers intensified during crises period. The period 2010-2014 demonstrate higher and stable spillover of 40-45%. In the periods 2015-2018, return spillovers remained elevated than previous period. A Sharpe spike can be seen during the global pandemic of Covid-19, taking the index to more than 50% which is the highest peak after 2008 financial crises, implying a shot term contagion. The index fall back and stabilized at 40-45% showing moderate but persistent return spillover transmission. Figure 3 Shows the Return Spillover Network Plot confirms the results displayed in Table 2.

	USD_TRY	USD_INR	USD_LKR	USD_MYR	USD_IDR	USD_PKR	USD_PHP	USD_THB	USD_CNY	USD_VND	FROM
USD_TRY	65.27	7.16	1.56	4.75	3.43	1.50	5.26	6.62	2.34	2.11	34.73
USD_INR	6.87	54.43	2.05	7.20	6.45	1.66	8.17	7.32	4.21	1.65	45.57
USD_LKR	2.28	3.07	78.69	2.51	2.58	2.11	2.16	2.23	2.34	2.03	21.31
USD_MYR	6.98	7.51	1.45	45.88	11.09	1.38	9.10	8.76	6.27	1.59	54.12
USD_IDR	5.67	8.07	1.42	12.04	51.61	1.31	7.32	6.50	4.23	1.84	48.39
USD_PKR	2.03	2.52	1.72	2.29	2.57	80.87	1.80	2.30	1.70	2.20	19.13
USD_PHP	6.20	8.74	1.20	9.25	6.44	1.26	53.26	8.00	4.09	1.57	46.74
USD_THB	5.96	7.20	1.36	6.83	4.74	1.71	7.35	57.85	5.40	1.60	42.15
USD_CNY	3.04	5.00	1.77	6.83	4.57	1.50	4.18	6.64	64.70	1.76	35.30
USD_VND	2.34	2.49	2.00	3.43	2.94	1.89	2.87	2.68	3.21	76.14	23.86
TO	41.35	51.76	14.52	55.15	44.80	14.32	48.22	51.05	33.77	16.35	371.29
Inc.Own	106.62	106.19	93.21	101.03	96.41	95.19	101.48	108.90	98.47	92.49	cTCI/TCI
NET	6.62	6.19	-6.79	1.03	-3.59	-4.81	1.48	8.90	-1.53	-7.51	41.25/37.13
NPT	7.00	8.00	0.00	6.00	4.00	1.00	5.00	9.00	3.00	2.00	

Table 2 Return Spillovers among Emerging Asian Foreign Exchange Markets along Belt and Road Initiative

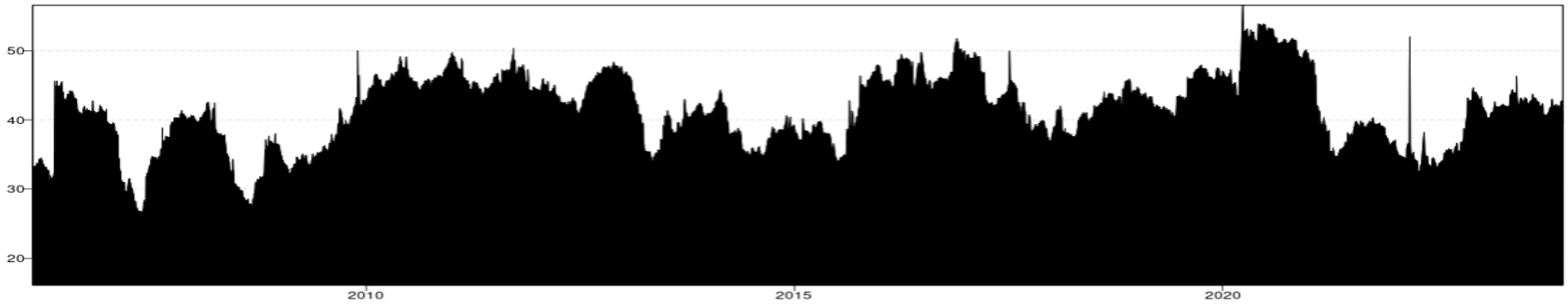

Figure 2 Dynamic Return Spillovers among Emerging Asian Foreign Exchange Markets along Belt and Road Initiative

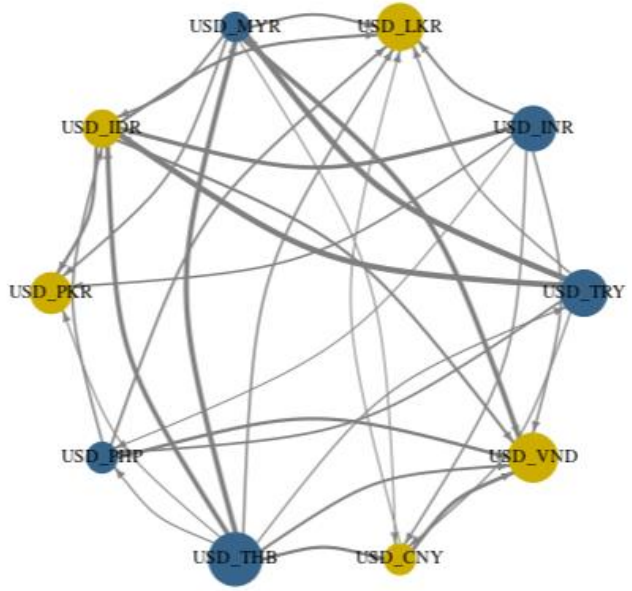

Figure 3 Dynamic Return Spillovers among Emerging Asian Foreign Exchange Markets along Belt and Road Initiative

Conclusion and Policy Implications

The Paper investigated the dynamics of return spillovers among 10 emerging foreign exchange markets of Belt and Road aligned Asian countries over a period of 2005-23. The analysis revealed moderate to high degree of interdependence with substantial heterogeneity across markets. Malaysian, Indian and Thailand currencies appeared as major transmitters while Indonesia, Philippine and Indian currencies appeared as major receivers of return spillover shocks. Thailand Currency appeared as net transmitter while Vietnamese currency is found the net receiver of spillover transmission.

These findings have several policy implications. Investors may consider the moderate interdependence among considered foreign exchange markets while diversifying FX portfolios, as regional contagion effect reduce the attraction of diversification. Policy makers particularly central banks in emerging BRI region shall closely monitor the bilateral exchange rate dynamics as well as the network channels identified here. Future researchers may target sub samples like pre and post crises period and apply Frequency-Domain or Quantile Connectedness Approach to distinguish short run and long run spillovers.

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