Shock and Volatility Spillover Between Foreign Exchange Rate and Stock Market in Thailand and Taiwan during the 2008 Global Financial Crisis

Review of Integrative Business & Economics Research

Liberty S. Patiu
De La Salle University

Tomas S. Tiu*
De La Salle University

Alyssa Marie Gaile S. Ng Cha
De La Salle University

Andrei Jose M. Adriano
De La Salle University

Miguel Lorenzo L. Cagampan
De La Salle University

Jerome J. Koa Lee
De La Salle University

ABSTRACT

This study investigates the existence of volatility and shock transmission between the foreign exchange market to equity market in Thailand and Taiwan resulting from the 2008 Global Financial Crisis. It employed the BEKK-GARCH model to determine the direction of volatility and shock transmissions between these two markets using four sample periods from 2004 to 2018. The results revealed a bidirectional volatility transmission between the two financial markets for the periods 2004-2013, 2004-2008, and 2014-2018 and a unidirectional transmission from the foreign exchange market to the stock market in 2009-2013 in Thailand and Taiwan. A bidirectional shock transmission and a bidirectional volatility transmission during the period 2004-2008 and bidirectional volatility transmission during the period 2014-2018, and a unidirectional shock and volatility transmission from the foreign exchange market (USD/TWD) to the stock market for the entire period. For Thailand's equity and foreign exchange markets, only a unidirectional shock transmission for the three sample periods, except for the period 2014-2018, where a unidirectional volatility spillover from the foreign exchange market (USD/THB) to the equity market exists. The results prove the existence of a contagion spillover brought about by the Global financial crisis and the connectedness of financial market volatilities over the period. This study contributes to the existing literature on the behavior of the financial market.

Keywords: Volatility Transmission, Spillover transmission, foreign exchange, equity market.

Received 19 April 2024 | Revised 26 October 2024 | Accepted 17 January 2025.

1. INTRODUCTION

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Globalization over the past three decades has resulted in the growth of cross-border capital flows, diversity of investments, and the interconnectedness of financial markets worldwide. This resulted in increased trade transactions in the global market, especially those related to the importation and exportation of goods and services. These transactions can either result in a trade surplus or deficit. Trade surplus provides employment opportunities, market growth, and economic growth (Global Banking & Finance, 2018). It was further reported that some countries utilize competitive devaluation, which involves the strategic devaluation of a country's currency to increase its global exports and gain an advantage over other nations. Likewise, the cross-border transactions also resulted in increased foreign direct and portfolio investments from multinational companies, and institutional and individual investors. Especially for foreign direct investments, multinational companies bring to the host countries massive funds for their investments, and their operations could be influenced by exchange rate volatility, which affects their profitability and, ultimately, the value of their equities (Kisaka & Mwasaru, 2015). They noted that any potential impact, which might be export or import-dependent, must be considered from the firm's viewpoint.

In the era of global integration, increasing financial and economic interdependence has prompted researchers, investors, and even governments to monitor the activities of the financial markets which are very crucial for businesses and investors. To date, there has been research that were conducted to measure the extent of the volatility transmission not only across financial markets and other assets but also across countries and regions. Economic and financial disruptions have magnified the spillover effects of these financial assets from one market to another which can result in crisis or contagion.

Especially when the supervisory authorities or institutional bodies have not prepared for and anticipated these events to happen, the devastation is sometimes immeasurable, particularly in emerging market economies. Charanssangsomboom and Puapan (2014) reported that the Global Financial Crisis resulted in the divestment of foreign funds in Thailand that were worth around 250 billion THB and resulted in a roughly 50 percent decline in the Stock Exchange of Thailand (SET). This also led to the weakening of the local currencies in Asia.

Thailand and Taiwan were selected to test these theories since both these countries were significantly impacted by the effects of financial contagion and the role of volatility transmission and its potential for devastating consequences during the 1997 Asian Financial Crisis and the 2008 Global Financial Crisis (Fauzi & Wahyudi, 2016). The Thai baht's depreciation caused a sharp decline in stock prices, worsening the financial crisis. This event focused on how foreign exchange volatility could spill over to the stock market, escalated the crisis and spreading it to other Asian economies. The initial shock in Thailand's foreign exchange market caused a chain reaction of volatility in other markets, including Taiwan's stock market. During the global financial crisis, Taiwan's stock market manifested significant volatility due to spillover effects from the US and other global markets (Lien et al., 2020). This revealed how interconnectedness and volatility transmission can expedite the spread of financial crises across borders (Adriano *et al*., 2020).

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Some studies have measured the volatility spillovers from either the currency market or the stock market to another financial market, such as bonds, interest rates, commodities, and other markets. Others measured volatility from developed to developing market economies (Bensaida, 2023), and his findings reveal foreign exchange volatility spillover from developed countries to developing countries. Their findings reveal a unidirectional spillover before, during, and after the Global Financial Crisis. It was also found that return and volatility spillover are usually transmitted from developed economies. The latter are also receivers of the spillover, and the volatility spillovers occur during and after the crisis period. This study aims to determine the level and direction of the volatility and shock transmissions between the stock market returns and the exchange rate returns in Taiwan and Thailand during the Global Financial Crisis covering the pre-crisis, crisis until post-crisis periods.

2. LITERATURE REVIEW

Nyopa and Khumalo (2021) investigated the connectedness of the equities and exchange rate markets in Brazil, India, China, and South Africa (BRICS) from January 1997 to December 2018 using the spillover index approach. It was revealed that a significant interdependence exists in these markets except for China. It is more pronounced when the market is aggregated compared to country-level effects. Bilateral volatility spillover is evident in crises that occurred both locally and globally, especially those related to the US-China Trade and Lira crises. Spillover volatilities from the stock market dominated the foreign exchange market in Brazil, China, and South Africa, while stock market volatilities dominated in Russia and India.

Fu *et al*. (2011), and Muhammad *et al.* (2020) applied the BEKK-GARCH model in their respective studies on volatility transmission between foreign exchange and equity markets. Their results showed a unidirectional volatility transmission between the United States of America and Japan, India, China, Indonesia, Malaysia, the Philippines, and Thailand. Fu *et al.* (2011) found a unidirectional volatility transmission from the currency market to the equity market in their investigation of the asymmetric connection between these markets in Japan and the United States. They believe this was influenced by the unexpected news shock channels rather than the spillover effect. Their findings further reveal that stock market volatility is evident in declining markets and that the US market reacted aggressively when market conditions were not good. In contrast, the Japanese stock market reflected negative stock returns. This asymmetric effect is transmitted to the Japanese currency market. A bidirectional volatility transmission occurs between the Japanese and US stock markets.

Muhammad *et al.* (2020) applied multivariate GARCH models (Engle's DCC-GARCH and bivariate BEKK GARCH) to determine shock and volatility transmissions between foreign and stock markets in the Pakistan Stock Exchange for 2001-2019. A statistically negative and significant shock spillover from the foreign exchange to the stock market was evident. In contrast, the transmission from the stock market to the foreign exchange market is statistically not significant. It proves a significant unidirectional shock spillover between the foreign exchange and stock markets. The volatility transmission from the foreign exchange market to the stock market is positive and statistically significant, while the volatility transmission from the stock market is statistically not significant.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

3. FRAMEWORK OF THE STUDY

3.1 Efficient Market Hypothesis

The Efficient Market Hypothesis was developed by Fama (1965, 1970) and is based on the premise that prices are reflected in the available information and that the movement of securities follows a random walk (Muthama & Mutothya, 2013). Prices of shares fully reflect the information available in the market without bias, creating an impartial estimate of a share's intrinsic value. Moreover, according to the theory, stocks trade at their fair value. Kakran *et al.* (2024) noted that efficiency is a result of any rational information that is available and used in a financial market. It has three levels of information sets, namely, weak form, semi-strong form, and strong form efficiency. It is believed that all information is reflected in the price of security under a robust and efficient market. Kakran *et al.* (2024) added that this theory indicated that imperfect pricing of assets and the existence of this imperfection is inherent in any financial market.

3.2 Purchasing Power Parity

This theory details the relationship between the movements in exchange rates and price levels and where exchange rates should move towards the price that would be equal to an identical set of goods and services (The Big Mac Index, 2019). Any differences in prices will eventually adjust over an indefinite number of times to indicate changes in their respective price level, hence the law of one price (Paul et al., 2017). Therefore, if a country's price levels in a specific basket of goods or in general are increasing, it is implied that the said country's exports will be less aggressive. The PPP theory helps determine the living costs of other countries using, for example, the Big Mac Index. According to the World Bank (2017), this theory is a valuable tool for comparing a nation's GDP, which helps determine large or small economies. The calculation part of the theory is rather complicated since it involves numerous factors, such as differences in taxes, tariffs, transportation costs, and import costs.

3.3. Statement of Hypothesis

Ho_1: The 2008 Global Financial Crisis did not significant cause volatility and shock spillover between foreign exchange rate returns and stock market index returns in Taiwan during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{1a}: The 2008 Global Financial Crisis did not cause volatility spillover from the foreign exchange rate returns to the stock market index returns in Taiwan during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{1b}: The 2008 Global Financial Crisis did not cause volatility spillover from the stock market returns to foreign exchange market returns in Taiwan during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{1c}: The 2008 Global Financial Crisis did not cause shock spillover from the foreign exchange rate returns to the stock market index returns in Taiwan during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{1d}: The 2008 Global Financial Crisis did not cause shock spillover from the stock market returns to foreign exchange market returns in Taiwan during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Ho_2: The 2008 Global Financial Crisis did not cause volatility and shock spillover between foreign exchange rate returns and stock market index returns in Thailand during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{2a}: The 2008 Global Financial Crisis did not cause volatility spillover from the foreign exchange rate returns to the stock market index returns in Thailand during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{2b}: The 2008 Global Financial Crisis did not cause volatility spillover from the stock market returns to foreign exchange market returns in Thailand during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{2c}: The 2008 Global Financial Crisis did not cause shock spillover from the foreign exchange rate returns to the stock market index returns in Thailand during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.
Ho_{2d}: The 2008 Global Financial Crisis did not cause shock spillover from the stock market returns to foreign exchange market returns in Thailand during the periods 2004-2013, 2004-2008, 2009-2013, and 2014-2018.

4. METHODOLOGY

4.1 Research Design

The study utilized an explanatory research design to examine the volatility and shock transmission between the equity market and the currency market in Thailand and Taiwan. It also employed the descriptive comparative research design to determine the differences in the spillover effects during the sample period (2004-2018) using four sub-periods, namely, 2004-2013, 2004-2008 (pre-crisis), 2009-2013 (post-crisis), and tranquil period (2014-2018).

4.2 Method of Data Collection

The data consists of the daily closing spot exchange rates vis-a-vis USD (USD/TWD and USD/THB) and stock indices in the Taiwan Stock Exchange and Thailand's SET 100 for the period 2004 to 2018 to cover the pre-crisis to the post-2008 Global Financial Crisis and the tranquil period which were taken from the Bloomberg database and the BEKK-GARCH model will be utilized to determine whether the volatility transmission will be unidirectional, bidirectional, or has no direction at all.

Purposive sampling was used in selecting the countries used in this study. Thailand and Taiwan were among the countries that were included in the MSCI list of emerging market economies of the Asia Pacific Region that adopted a floating exchange rate regime before the global financial crisis. 2004 to 2018. The same authors also used the Republic of Korea and the Philippines in their study to measure volatility transmission between the two financial markets (Adriano *et al.*, 2020). In this study, we covered the period from 2004 to 2013 with two sub-periods from 2004 to 2008 and 2009 to 2013 to account for the 2008 Global Financial Crisis, the period 2014-2018 for the tranquil period to compare possible volatility transmission between foreign exchange rate and the stock market of the selected emerging markets.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

To measure the presence of volatility and shock spillover between foreign exchange and equity markets, we use daily data from the stock exchange's equity index (Taiwan Equity Index and Thailand) and spot foreign exchange rates for the USD/THB and USD/TWD. The researchers employed two diagnostic tests (Ljung Box Q-Statistics and Unit Root Test) before utilizing the BEKK-Garch model (to examine unidirectional, bidirectional, and no relationship between these two markets).

4.3 Method of Data Analysis

Listed below is the summarized step-by-step method for analyzing the data collected:

Step 1 Gather daily closing prices of the foreign exchange rate and stock market indices with a sampling period from the years 2004 to 2018.

Step 2 Convert foreign exchange rate and stock market indices into exchange rate changes and stock market returns respectively.

Step 3 Use descriptive statistics to determine the standard error and skewness of the data.

Step 4 Use the Unit Root Test to determine the stationarity of data.

Step 5 Run the BEKK-GARCH model to determine the direction of volatility between the Stock Market and the Foreign Exchange Rate.

4.3.1. Statistical Tools

Following Akay (2017), the researchers will convert stock market indices and foreign exchange rates into stock market returns and exchange rate changes respectively.

$$SR_t = Ln\ (P_t / P_{t-1})\ X\ 100 \quad (1)$$

$$FC_t = Ln\ (R_t / R_{t-1})\ X\ 100 \quad (2)$$

Where:

SR_t is the daily return; P_t is the closing stock price of stock indices for the day t; P_{t-1} is the previous closing stock price; FC_t is the daily changes; R_t is the closing foreign exchange rate for the day t; R_{t-1} is the previous closing foreign exchange rate Ln is the natural logarithm.

4.3.1.1. Unit Root Test

Using the Augmented dickey-fuller unit root test is essential before utilizing the BEKK-GARCH model. The result could either be stationary or nonstationary. A time series must be stationary as this helps ensure that the series is stationary because estimates obtained from non-stationary series are not reliable (Liu and Chou, 2016). A stationarity result should be established in the data in conducting time series regression analysis due to seasonality and the trends within the data will make predictable regression, which will forfeit its results. The null hypothesis for this is that there is a unit root while the alternative hypothesis is that there is no unit root. If the results show that there is a unit root, differencing in the data will be conducted (Emenike, 2014).

4.3.1.2. BEKK/GARCH Model

After determining that the variables under analysis were stationary, we estimated own and

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

cross-market volatility and its tenacity, the MGARCH BEKK model is essential to use in such cases. According to Engle and Kroner (1995), the BEKK model is defined as follows:

$$H_t = C_0^{*'} C_0^{*} + \sum_{k=1}^{K} A_{1k}^{*'} \varepsilon_{t-1} \varepsilon_{t-1}^{'} A_{1k}^{*} + \sum_{k=1}^{K} G_{1k}^{*'} H_{t-1} G_{1k}^{*} \quad (3)$$

$C_0^{*}C_0^{*}$, $A_{1k}^{*}A_{1k}^{*}$ and $G_{1k}^{*}G_{1k}^{*}$, are nxn parameter matrices, where $C_0^{*}C_0^{*}$ is a triangular matrix, K, determines the generality of the process. The second term aforementioned above in the form of a formula is defined as an ARCH term, and the third term is defined as a GARCH term (Akay, 2017).

The BEKK model for the GARCH process is expressed as the following:

$$H_t = C_0^{*'} C_0^{*} + A_{11}^{*'} \varepsilon_{t-1} \varepsilon_{t-1}^{'} A_{11}^{*} + G_{11}^{*'} H_{t-1} G_{11}^{*} \quad (4)$$

In the bivariate case, the BEKK model becomes:

$$H_t = C_0^{*'} C_0^{*} + \begin{bmatrix} a_{11}^{*} & a_{12}^{*} \\ a_{21}^{*} & a_{22}^{*} \end{bmatrix}' \begin{bmatrix} \varepsilon_{1,t-1}^{2} & \varepsilon_{1,t-1}\varepsilon_{2,t-1} \\ \varepsilon_{2,t-1}\varepsilon_{1,t-1} & \varepsilon_{2,t-1}^{2} \end{bmatrix} \begin{bmatrix} a_{11}^{*} & a_{12}^{*} \\ a_{21}^{*} & a_{22}^{*} \end{bmatrix} + \begin{bmatrix} g_{11}^{*} & g_{12}^{*} \\ g_{21}^{*} & g_{22}^{*} \end{bmatrix}' H_{t-1} \begin{bmatrix} g_{11}^{*} & g_{12}^{*} \\ g_{21}^{*} & g_{22}^{*} \end{bmatrix} \quad (5)$$

The model if subscripts and GARCH terms are ignored will be as follows.

$$h_{11} = c_{11} + a_{11}^{*2}\varepsilon_{1,t-1}^{2} + 2a_{11}^{*}a_{21}^{*}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}^{*2}\varepsilon_{2,t-1}^{2} + g_{11}^{*2}h_{11,t-1} + 2g_{ss}^{*}g_{21}^{*}h_{12,t-1} + g_{12}^{*2}h_{22,t-1} \quad (6)$$

$$h_{12} = c_{12} + a_{11}^{*}a_{12}^{*}\varepsilon_{1,t-1}^{2} + \left(a_{21}^{*}a_{12}^{*} + a_{11}^{*}a_{22}^{*}\right)\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{21}^{*}a_{22}^{*}\varepsilon_{2,t-1}^{2} + g_{11}^{*}g_{12}^{*}h_{11,t-1} + (g_{12}^{*}g_{21}^{*} + g_{11}^{*}g_{22}^{*})h_{12,t-1} + g_{21}^{*}g_{22}^{*}h_{22,t-1} \quad (7)$$

$$h_{22} = c_{22} + a_{12}^{*2}\varepsilon_{,t-11}^{2} + 2a_{12}^{*}a_{22}^{*}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + a_{22}^{*2}\varepsilon_{2}^{2} + g_{12}^{*2}h_{11,t-1} + 2g_{12}^{*}g_{22}^{*}h_{12,t-1} + g_{22}^{*2}h_{22,t-1} \quad (8)$$

In the model, both the conditional variances ($h_{ii,t}h_{ii,t}$) and the conditional covariances ($h_{ij,t}h_{ij,t}$) of the asset returns are influencing each other. $c_{ii}c_{ii}$ represents the constant term for the asset i i, and represents the constant term of volatility spillover between asset i i, and j j. $a_{ii}a_{ii}$ Outlines the effect of a shock in the past on conditional variance, a_{ij} a_{ij} outlines the effect of a shock in the past on conditional covariance (volatility spillover). The term $b_{ii}b_{ii}$ describes the persistence of past shocks' effects on conditional variance and $b_{ij}b_{ij}$ describes the persistence of past shock's effects on conditional covariance.

5. RESULTS AND DISCUSSIONS

As shown in Table 1, the highest average daily exchange rate changes were evident in 2014-2013 (μ = 0.003%, SD = 0.240) and 2009-2013 (μ = -0.010%, SD = 0.373) in Thailand. Despite the highest mean values, the highest standard deviation was recorded in 2009 at 0.278. Both Taiwan and Thailand recorded the highest currency returns during the post-crisis period, while Thailand posted the highest TWSE Index returns in 20at 0.087

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

(SD = 1.280). For the average daily stock market returns during the post-crisis period with $\mu = 0.045$ and $\mu = 0.087$. However, the highest standard deviations were seen during the pre-crisis period (2004-2008) at 2.977 and 1.532, respectively.

Table 1. Descriptive Statistics

Taiwan's Financial Market								
	TAIEX Index Returns				USD/TWD Returns			
Period	2004-2013	2004-2008	2009-2013	2014-2018	2004-2013	2004-2008	2009-2013	2014-2018
Size	2537	1279	1258	1220	2537	1279	1258	1220
Mean	0.011	-0.023	0.045	0.009	-0.005	-0.003	-0.007	0.003
Std. Deviation	2.295	2.977	1.267	0.831	0.273	0.268	0.278	0.240
Skewness	-8.275	-7.460	-0.316	-0.823	-0.199	-0.369	-0.043	-0.120
Excess Kurtosis	191.697	132.654	3.818	6.442	5.004	3.763	6.061	2.084
Minimum	-54.517	-54.517	-7.244	-6.521	-1.724	-1.724	-1.717	-0.929
Maximum	21.355	21.355	6.525	3.694	1.531	1.335	1.531	1.111
Jarque Bera (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Financial Market	SET Index Returns				USD/THB Returns			
Period	2004-2013	2004-2008	2009-2013	2014-2018	2004-2013	2004-2008	2009-2013	2014-2018
Size	2443	1224	1219	1220	2443	1224	1219	1220
Mean	0.0203	-0.046	0.087	0.015	-0.005	-0.010	-0.001	-0.001
Std. Deviation	1.4131	1.532	1.280	0.773	0.336	0.373	0.294	0.275
Skewness	-0.8853	-1.226	-0.208	-0.505	0.173	0.366	-0.205	-0.045
Excess Kurtosis	12.446	16.461	2.431	4.838	14.426	17.136	4.174	1.531
Minimum	-16.063	-16.06	-5.812	-5.373	-3.174	-3.174	-2.273	-1.183
Maximum	10.577	10.577	6.189	4.484	3.813	3.813	1.482	1.196
Jarque Bera (p-value)	0.0000	2E-16	2E-16	2E-16	2E-16	2.20E-16	2.20E-16	#####

Both the stock returns and changes in exchange rates in the two countries exhibited negative skewness for all periods. It suggests that more observations have higher values than in the normal distribution. The excess kurtosis for all sub-periods in the changes in stock market returns and exchange rates indicate that except for the silent period, the other sub-periods are more peaked than the normal distribution. Like the results for Taiwan's currency and equity markets, the stock returns exhibited negative skewness for all periods, suggesting that more observations have higher values than those in the normal distribution. The changes in the exchange rate are positively skewed for periods A and B, suggesting that the data has lower values than in the normal distribution. The excess kurtosis of the stock index returns for sub-periods except for the post-crisis period, while the excess kurtosis on the exchange rate returns showed that they are more peaked than the normal distribution during pre-crisis, crisis, and post-crisis periods. These excess kurtosis values

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

in these markets in the two countries are consistent with the Jarque Bera test of normality, where all normality assumptions are rejected at 0.01 level of significance; results indicate that the dataset is typically distributed.

Table 2. LJUNG Box Q-Statistics Test Results

Country	Taiwan			Thailand		
Period	Lag	Q	P-value	Lag	Q	P-value
2004 - 2013	6	10.878	0.092	3	4.328	0.2282
2004 - 2008	6	12.453	0.053	3	2.038	0.5646
2009 - 2013	6	7.1441	0.308	3	3.032	0.3868
2014 - 2018	24	29.54	0.201	12	17	0.1498

Table 2 shows the Ljung-Box Q-statistic and their respective p-values with lags ranging from 6 lags to 24 lags for Taiwan and 3 lags to 12 lags for Thailand. It tests the null hypothesis for the absence of serial correlation and homoskedasticity in the residual sets. In this study, it was tested up to the lag order of 12 and 24 for Taiwan and Thailand, respectively. Federova and Saleem (2010) further note that such a test would show if results were random, have no serial autocorrelation and are asymptotically distributed. As shown in the table above, these assumptions are supported and are applicable for the variables used in the study, as all p-values of the BEKK-Garch Model, with a confidence level of 95% in Taiwan and Thailand for the four sub-periods are recorded as over 5% (p-values > 0.05). It also indicates that there are no autocorrelations in the stock and foreign exchange returns and the results are characterized as random walk processes.

Table 3. Unit Root Test

Period	Variables	Taiwan			Thailand		
		ADF Test	Lag Order	p-value	ADF Test	Lag Order	p-value
2004-2013	Exchange rate returns	-11.539	13	0.01	-11.821	13	0.01
	Stock market returns	-15.434	13	0.01	-11.522	13	0.01
2004-2008	Exchange Rate Returns	-9.5489	10	0.01	-10.661	10	0.01
	Stock Market Returns	-12.565	10	0.01	-10.212	10	0.01
2009-2013	Exchange rate returns	-9.7268	10	0.01	-9.0897	10	0.01
	Stock market returns	-11.143	10	0.01	-10.633	10	0.01
2014-2018	Exchange rate returns	-10.298	10	0.01	-10.89	10	0.01
	Stock market returns	-10.695	10	0.01	-10.816	10	0.01

Table 3 shows the results of the Augmented Dickey-Fuller (ADF) test that was conducted on the stock market returns and foreign exchange rate returns of Taiwan and Thailand for

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

the sub-periods using all-time series data. Test results revealed that the USD/TWD and stock market returns in TAIEX show a p-value of 1 percent significance. The same results were generated for USD/THB and SET 100's stock market returns. It only proves that the four-time series data are stationary, and there is sufficient evidence to conclude that USD/TWD returns, TAIEX stock market returns, USD/THB return changes, and SET 200 stock market returns do not contain unit root at 1 percent level of significance. It is noteworthy that the null hypothesis of having a unit root is rejected for all periods.

Table 4. Shock and Volatility Transmission between Foreign Exchange Rate Returns and Stock Market returns in Taiwan

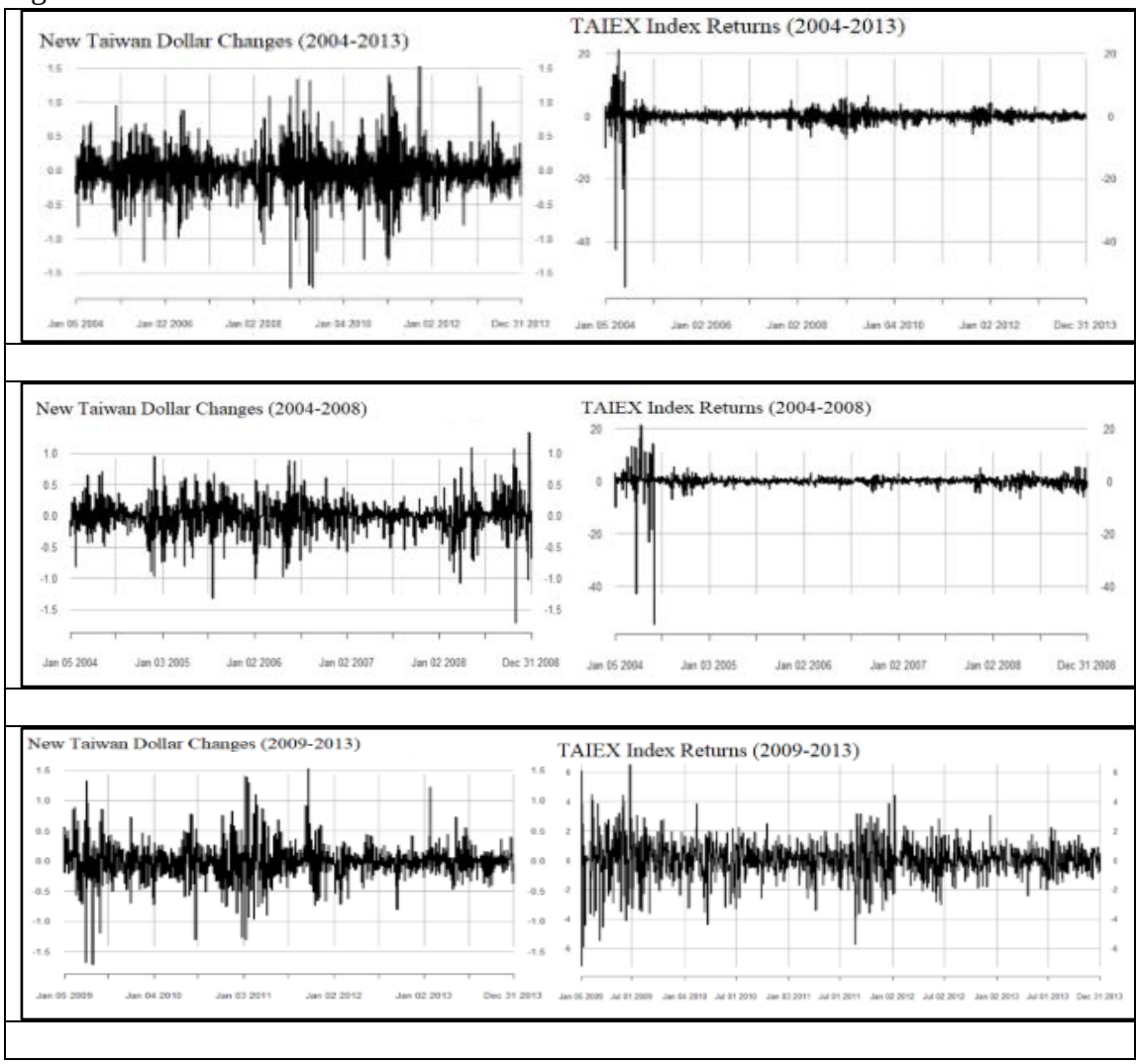
Volatility Transmission					
Stock Market Return to Exchange Rate Returns			Exchange Rate Returns to Stock Market Returns		
Period Covered	β	SE	Period Covered	β	SE
2004-2013	0.01	0.039	2004-2013	0.003***	0.001
2004-2008	0.051*	0.03	2004-2008	0.010***	0.001
2009-2013	0.051*	0.03	2009-2013	0.010***	0.001
2014-2018	0.051**	0.025	2014-2018	0.010***	0.002
Shock Transmission					
Stock Market Return to Exchange Rate Returns			Exchange Rate Returns to Stock Market Returns		
2004-2013	-0.140	0.113	2004-2013	-0.005***	0.002
2004-2008	0.020	0.145	2004-2008	0.020***	0.007
2009-2013	0.020	0.145	2009-2013	0.020***	0.007
2014-2018	0.020	0.114	2014-2018	0.020**	0.01

Table 4 provides the results of the shock and volatility transmissions between the foreign exchange and equity markets in Taiwan. There is a statistically significant shock and volatility transmission from the foreign exchange market to the stock market for all four sub-periods (p-values < 0.01). This corroborates the findings of Rakshit and Neog (2020) in measuring the volatility transmission between the two markets in selected emerging market economies. Except for the period 2004-2013, the impact of the stock market on the foreign exchange market is significant at 0.10, 0.10, and 0.05 for the periods 2004-2008, 2009-2013, and 2014-2015, respectively. Thus, bidirectional volatility transmission between the two markets is evident during the pre-crisis, post-crisis, and tranquil periods, while a unidirectional impact from the foreign exchange to the stock market is seen between 2004-2013. On the other hand, there is unidirectional transmission seen from the foreign exchange market to the stock market for all sub-periods at 95 percent confidence intervals, respectively. Hsu (2013) and Hsu and Huang (2010) reported that massive foreign capital was poured into Taiwan's stock market when the emerging market opened its equity market in the early 2000s, where foreign investment rose to roughly 600%, and the aggregation value of the stock market doubled during mid-2007. This resulted in insignificant shock transmission from the equity market to the stock market. The shock and shock transmissions from the foreign exchange market to the stock market are in line with the findings of Jebran & Iqbal (2016) on the evidence of asymmetric response during

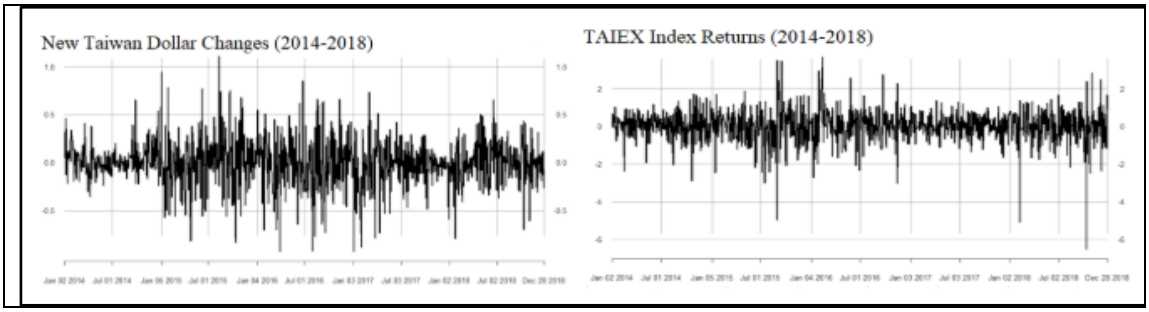
ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

the post-crisis period in the forex market in the Indian stock market. Despite Taiwan's significantly high foreign exchange reserves, volatility and shock spillovers were evident. There are seemingly some patterns of currency sensitivities against global volatility. However, the insignificant results generated by the shock and volatility transmissions from the stock market to the foreign exchange market justify the large amount of international reserves in Taiwan (Central Intelligence Agency, 2017; Larus & Wu, 2010). Despite the stable exchange rate regime, the outflow of foreign funds from the stock market was evident, which led to the reaction of both markets to volatility effects. Our findings are also in line with the results generated by Lu (2018) which showed that despite the appreciation of the Taiwan Dollar during this period, the effects of the volatility from the stock market to forex were evident.

Figure 1. Plots of New Taiwan Dollar Returns and Stock Index Returns in Taiwan



ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)



As shown in Figure 1, there is considerable volatility in the USD/TWD returns in the four sub-periods and it is quite high during the global financial crisis. Likewise, the tranquil period (2014-2018) was not also spared in Taiwan's currency return volatility which resulted in bidirectional volatility and shock transmission during the crisis, post-crisis, and tranquil periods. Despite the very high volatility in the pre-Global Crisis stock market returns, it did not provide a significant volatility transmission effect to the foreign exchange market. Liu and Chou (2016) also confirmed this where they noted that the foreign exchange volatility affects the returns of the Taiwanese equity market which can be ascribed from the effects of the short and long-run volatility components instead of the other way around. Huang (2014) indicated the relatively low trading volumes in the equity markets in the emerging economies are easily influenced by the stock market fluctuations and the foreign portfolio investment flows from their respective trading partners. Foreign portfolio investors bring their funds to the stock market of emerging countries by providing leverage to support local economic development.

Table 5. Volatility and Shock Spillover between Foreign Exchange Rate Returns and Stock Market returns in Thailand

Volatility Transmission					
Stock Market Return to Exchange Rate Returns			Exchange Rate Returns to Stock Market Returns		
Period Covered	β	SE	Period Covered	β	SE
2004-2013	0.051**	0.025	2004-2013	0.010***	0.001
2004-2008	0.051*	0.03	2004-2008	0.010***	0.002
2009-2013	0.051	0.065	2009-2013	0.010***	0.003
2014-2018	0.051*	0.027	2014-2018	0.010***	0.003
Shock Transmission					
Stock Market Return to Exchange Rate Returns			Exchange Rate Returns to Stock Market Returns		
2004-2013	0.020	0.103	2004-2013	0.020***	0.006
2004-2008	0.020	0.141	2004-2008	0.020**	0.008
2009-2013	0.020	0.157	2009-2013	0.020**	0.009
2014-2018	0.020	0.096	2014-2018	0.020	0.012

Table 5 shows the volatility and shock spillovers between the two markets in Thailand. As can be gleaned above, it shows that there were bidirectional volatility transmissions

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

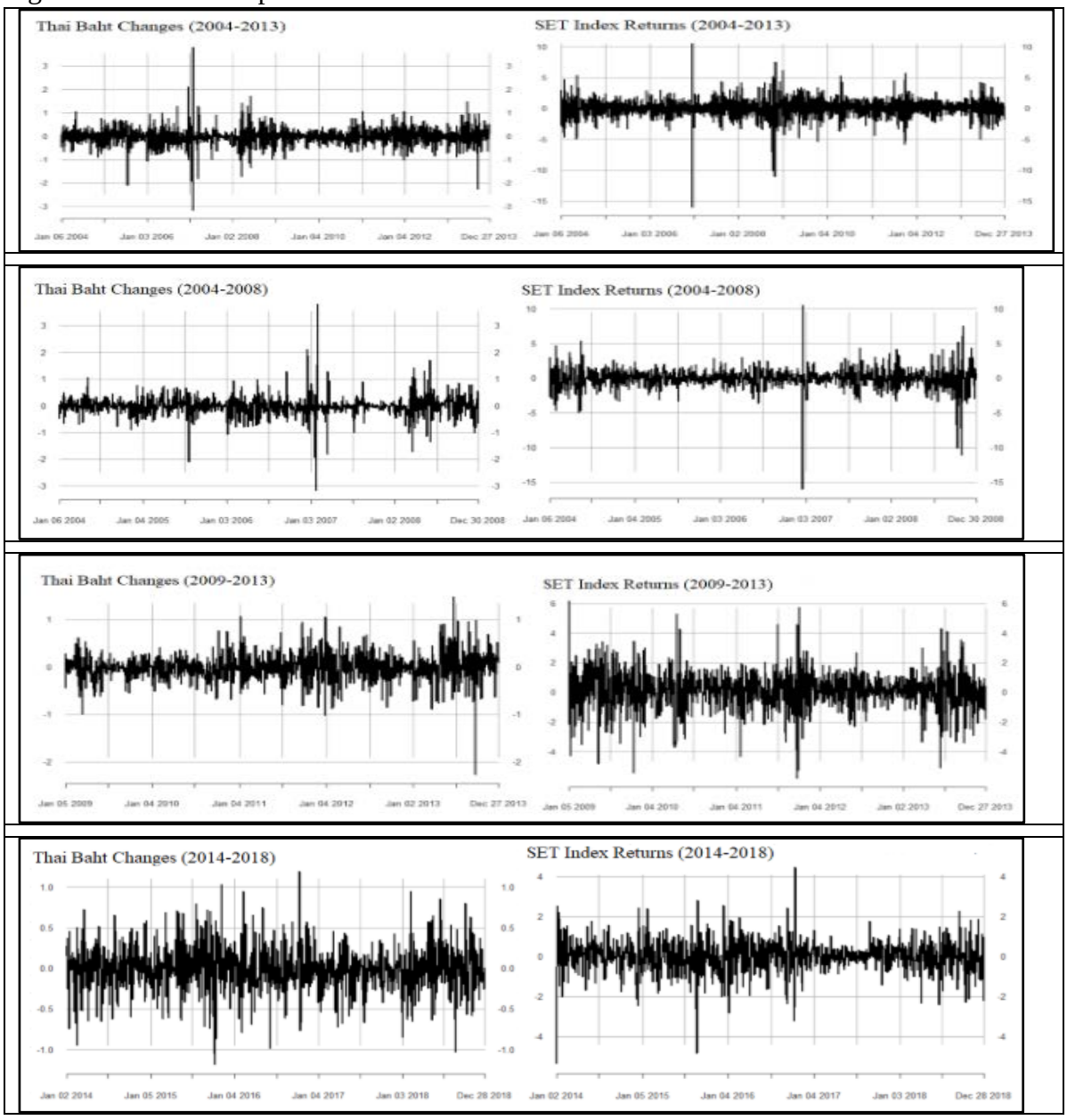
between the two markets during 2004-2013, 2004-2008, and the tranquil period while a unidirectional volatility transmission was evident after the crisis. The results confirm the findings of Gyntelberg *et al.* (2009), in which they noted that foreign exchange returns in Thailand are almost as volatile as the Thai stock market. There is also a possibility that the price elasticity of foreign exchange rate supply is higher in Thailand compared to other industrial economies (Bank of Thailand, 2005), and a higher level of foreign investors' risk aversion in the foreign exchange rate vis-à-vis industrial-country's currency markets caused further instability (Hau & Rey, 2006). Except for the tranquil period, a unidirectional shock transmission from the foreign exchange market to the stock market was evident, which is consistent with the findings for the shock transmission in Taiwan. This means, that during the tranquil period, both the foreign exchange market and the stock market did not provide any shock spillover to each other.

The results only prove that in Thailand, volatility transmission from the foreign exchange market is stronger for all periods other than the tranquil period. While the effect of the shock transmission from the stock market was stronger during 2004-2013, the impact of shock spillover was not as substantial for two sub-periods (2004-2008 and 2009-2013), especially during the post-crisis period where its impact was insignificant. During the period 2009-2013, there is a statistically significant volatility transmission from the foreign exchange market to the equity market (p-value < 0.01). On the other hand, insignificant shock and volatility transmission were evident from the equity market to the foreign exchange market in Thailand. The evidence of volatility transmission from the stock market to the exchange rate for the period 2004-2013 is explained through Thailand's market composition, which varies based on the said USD/THB volatility (Koosakul & Shim, 2017). During the said period, there were high volatility transmissions from the stock market to the foreign exchange as both the 2008 Global Financial Crisis and the 2013 Taper Tantrum were covered by this period. Likewise, Thailand's market composition varies depending on the level of volatility in the foreign exchange market. They further add that even if returns and market conditions continue to improve in the stock market and other money markets, they will still be unwilling to enter into the currency market, given their own market risk (Koosakul & Shim, 2017).

It can be deduced that volatility transmission from the foreign exchange market to the stock market is intensively high for all periods similar to the findings in Taiwan's volatility and shock transmission from the foreign exchange market to the equity market. It was also observed that in both countries, volatility spillover effects were the same for all periods, where the stock index return did not provide and volatility effect after the 2008 Global financial crisis (2009-2013). Additionally, volatility transmission is higher compared to shock transmission, except for the tranquil period (2014-2018) where no shock transmission was evident. This is in line with the findings of Muhammad *et al.* (2020) in examining shock and volatility transmissions between foreign and stock markets in the Pakistan Stock Exchange.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Figure 2. Time Series plots of Thai Baht returns and Stock Index Returns in Thailand



As shown from the plot in Figure 4, stock market returns are volatile in 2004, but significantly reduced in 2005 until 2014. There were some noted volatilities during the tranquil period, especially in 2015 and 2018; however, its impact is moderately significant at 10 percent. Our findings on the unidirectional and statistically significant volatility spillover from the foreign exchange rate returns to the stock market returns for all periods are consistent with the findings of Koosakul and Shim (2017) who found that that nearly half of the foreign investments account for Thai FX spot market especially those related to international trade transactions and the gross international reserves stood at 167.2 billion U.S. dollars at the end of December 2013 (Bank of Thailand, 2014). Moreover, Thailand's investment position is reflected in its international reserves where the Bank of Thailand

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

used these reserves to stabilize the exchange rate related to the overvaluations of the THB against any currency (Phisuthtiwatcharavong & Bouraoui, 2015).

Given the volatility of the stock market, investments must be able to hedge any risks associated with fluctuations in foreign currency and stock prices by making cross-market arbitrage strategies across various financial assets over time to protect their investments. They can also spread/distribute the risks associated with their investments.

6. CONCLUSIONS AND RECOMMENDATIONS

The findings revealed a linear relationship existing between the foreign exchange and equity markets since all sub-period elements are positive. While a bidirectional volatility transmission is evident in the pre-crisis and crisis periods, considerable volatility spillover effects exist in all sub-periods as contrasted to the shock spillover effects from the foreign exchange market to the stock market. Despite evidence of the existence of volatility and shock transmission during pre-crisis and tranquil periods in Thailand, the impact was not as strong as the foreign exchange's impact on the stock market. Investors are more sensitive to the exchange rate changes compared to the equity market, as this might have international trade transaction implications, especially since both countries are highly dependent on exports. Likewise, there is strong evidence of long-term spillover effect from the foreign exchange market as contrasted to the other way around. Investors overreact to the changes in the foreign exchange market which spills over to the stock market both in the short and long-run. The pre-crisis, crisis, and tranquil periods showed bidirectional volatility transmission from the foreign exchange market to the equity market. The findings further showed that volatility transmission in the foreign exchange market is erratic compared to the equity market. On the other hand, volatility transmission from the equity market to the foreign exchange market was stronger during the pre-crisis period as contrasted to the crisis and tranquil periods.

The policy implications of the findings of the study were implemented by Thai authorities during the Asian financial crisis when it put in capital controls to limit the flow of capital and stabilize the currency and shifted from a fixed exchange rate regime to a managed floating regime. This allowed the baht to fluctuate more freely but also provided the government with the ability to intervene in the currency market to manage volatility (Rajan, 2012). Although Thai baht experienced some depreciation during the global financial crisis, its impact was less severe than in 1997 due to the implementation of more flexible exchange rate policies, capital market development, prudential regulations, monetary easing policy and fiscal stimulus packages to support the economy (Sangsubhan, 2008; Jitsuchon & Sussangkarn, 2009). During the same crisis, the Taiwanese government intervened in the foreign exchange market to stabilize the Taiwanese dollar. The government implemented measures to support the stock market, including providing liquidity to investors, reducing trading fees, and encouraging institutional investors to buy stocks. The government implemented fiscal stimulus measures, such as increasing government spending and tax cuts, to boost economic activity and mitigate the negative impact of the crisis (Yang, 1998). Countries should adopt proactive measures to strengthen their financial systems and economic resilience before a crisis hits. Regional cooperation is essential to address financial contagion. Sharing information and coordinating policies can help prevent the spread of financial distress.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

Another distinct inference that can be drawn from the results is that foreign and local investors are more reactive to the foreign exchange market than the equity market. Equity investors are more sensitive to the activities in the stock market before and during the crisis, as shown in the volatility of the equity returns. This can be ascribed to the overreaction of the investors to the foreign exchange market despite the export-orientation of these countries. Investors exhibit biased expectations as the information is not fully reflected in the equity market. This only proves that the volatilities in the equity market cannot provide a market reaction on the foreign exchange market. Thus, the nexus between the foreign exchange and equity markets especially their dependencies with each other cannot be discounted. Hence, it is suggested that future studies be conducted to fully understand the underlying causes of these volatilities, such as the investigation of the moderating effects of the macroeconomic and financial indicators on both markets. The study can provide policymakers with an understanding of various transmission mechanisms that affect various financial markets, which will help them formulate regulatory policies or implement guidelines affecting financial markets. Investors must diversify their time-variant investments and respond to multiple shocks.

ACKNOWLEDGEMENT

The authors are thankful to the anonymous reviewer for his/her helpful comments and suggestions.

REFERENCES

[1] Adriano, A. J. M., Cagampan, M. L., Koa Lee, J. J., Ng Cha, A. M. G., Patiu, L. S., & Tiu, T. S. (2020). "Volatility Transmission Between the Foreign Exchange Rate and Stock Market From 2004-2018: An Empirical Analysis of Selected Emerging Markets of Asia-Pacific Region", *Philippine Academy of Management E-Journal*, 3(2), 57–77.

[2] Akay, A. B. (2017). "Volatility Spillover between the Foreign Exchange and the Stock", *IOSR Journal of Economics and Finance (IOSR-JEF)*, 8(6) Ver. II (Nov.-Dec .2017), 12-17.

[3] Amelot, L., Lamport, M., & Ushad, S. (2017). "Testing the Efficient Market Hypothesis in an Emerging Market: Evidence from Forex Market in Mauritius", *Theoretical Economics Letters*, 2104–2122.

[4] Sangsubhan, K. (2008). Managing Capital Flows: The Case of Thailand. Asian Development Bank (2008). ADB Institute Discussion Paper No. 95. Tokyo: Asian Development Bank Institute.

[5] Bank of Thailand. (2005). "Foreign exchange policy and intervention in Thailand, in foreign exchange market intervention in emerging markets: Motives, techniques and implications". Proceedings of the BIS Deputy Governors' meeting held on 23 December 2004, BIS Papers.

[6] Bank of Thailand. (2014). "The International Banking Crisis: Impact on Thailand's Financial System and Policy Responses". BIS Papers No. 54, Bank for International Settlements. Retrieved on October 22, 2019 from https://www.bis.org/publ/bppdf/bispap54x.pdf

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[7] Bensaïda, A. (2023) "The linkage between Bitcoin and foreign exchanges in developed and emerging markets", *Financial Innovation*, 9(38). http://doi: 10.1186/s40854-023-00454-w
[8] Charanssangsomboon, B., & Puapan, P. (2014). "Asia-Pacific Economies After the Global Financial Crisis: Lessons Learned and the Way Forward", Chapter 8 (pp.147-164). Retrieved from https://www.unescap.org/sites/default/files/AP-economi es-after-crisis-final.pdf
[9] Central Intelligence Agency. (2017). Brazil. *In The world factbook*. Retrieved from https://www.cia.gov/the-world-factbook/countries/taiwan/#economy
[10] Emenike K. (2014). "Volatility Transmission between Stock and Foreign Exchange Markets: Evidence from Nigeria". *Journal of Banking and Financial Economics* 1(1)2014, 59–72. http:// doi: 10.7172/2353-845.jbfe.2014.1.4
[11] Engle, R. F., & Kroner, K. F. (1995). Multivariate Simultaneous Generalized Arch, *Econometric Theory*, 11(1), 122-150.
[12] Fama, E. (1965). "The Behavior of Stock Prices", *The Journal of Business*, 38(1), 34-105.
[13] Fama, E. (1970). "Efficient Capital Markets: A Review of Theory and Empirical Work", *The Journal of Finance*, 25(2), 383-417.
[14] Fauzi, R., & Wahyudi, I. (2016). "The effect of firm and stock characteristics on stock returns: Stock market crash analysis", *The Journal of Finance and Data Science*, 2 (2*)*,1–13.
[15] Federova, F., & Saleem K. (2010). "Volatility Spillovers between Stock and Currency Markets: Evidence from Emerging Eastern Europe", *Finance a úvěr-Czech Journal of Economics and Finance*, Charles University Prague, Faculty of Social Sciences, 60(6), 519-533
[16] Fu, T. Y., Holmes, M. J., & Choi, D. F. S. (2008). "Volatility transmission and asymmetric linkages between the stock and foreign exchange markets A sectoral analysis", *Studies in Economics and Finance*, 28(1), 36–50. http://doi: 10.1108/10867371111110543
[17] Global Banking & Finance (2018). "Global imports and exports: Interesting facts and economic effects". Retrieved from https://www.globalbankingandfinance.com/global-imports-and-ex ports-interesting-facts-and-economic-effects/
[18] Gyntelberg, J., Loretan, M., Subhanij, T., & Chan, E., (2009). "International portfolio rebalancing and exchange rate fluctuations in Thailand". *Bank for International Settlements*, BIS Working Paper 287. Retrieved on October 1, 2019 from https://www.bis.org/repofficepubl/arpresearch200902.4.pdf.
[19] Hau, H., & Rey, H. (2006). "Exchange rates, equity prices, and capital flows", *Review of Financial Studies*, 19(1), 273–317.
[20] Hsu, C. P., & Huang, C. W. (2010). "How Foreign Portfolio Investment Affects Stock Markets in the Host Country: An Empirical Study of Taiwan", The 2010 Proceedings of the Northeast Business & Economics Association, October, 298–302.
[21] Hsu, C. P. (2013). "The influence of foreign portfolio investment on domestic stock returns: experience from Taiwan", *International Journal of Business and Finance Research*, 7(3), 1–11.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[22] Huang, C. W. (2014). "Influence of external factors on the Taiwan Stock Exchange", *The International Journal of Business and Finance Research*, 8(4), 109-120.
[23] Jebran, K., & Iqbal, A. "Dynamics of volatility spillover between stock market and foreign exchange market: evidence from Asian Countries", *Financial Innovation*, 2(3), 1-20. https://doi.org/10.1186/s40854-016-0021-1
[24] Jitsuchon, S. & Sussangkarn, C. (2009). "Thailand's Growth Rebalancing". ADBI Working Paper 154. Tokyo: Asian Development Bank Institute.
[25] Kakran, S., Sapra, N., Kumar, A., & Sidhu, A. (2024). "Interrelationship dynamics between stock markets of the nation under debt crisis and its major trading partners: evidence from Sri Lankan crisis", *Future Business Journal*. http://doi: 10.1186/s43093-024-00301-z
[26] Khan, M., Khan, M., Kayani, U.M., Mughal, K.S., & Mumtaz, R. (2023). "Unveiling Market Connectedness: Dynamic Returns Spillovers in Asian Emerging Stock Markets", *International Journal of Financial Studies,* 11 (112). https:// doi.org/10.3390/ijfs11030112
[27] Kisaka, S. & Mwasaru, A. (2016). "The Causal Relationship between Exchange Rates and Stock Prices in Kenya", *Research Journal of Finance and Accounting*, 3 (1), 121-130.
[28] Koosakul, J., & Shim, I. (2017). "The beneficial aspect of FX volatility for market liquidity". *BIS Working Papers* No. 629. Retrieved October 30, 2019.
[29] Larus, E. F., & Wu, J. (2010). *"Taiwan's Reaction to the Global Financial Crisis"*. Presented at the 2010 Annual Meeting of the American Political Science Association Conference Group on Taiwan Studies (CGOTS), September 4, 2010, Washington, D.C.
[30] Lien, D., Lee, G., Yang, L., & Zhang, Y. (2018). "Volatility spillovers among the U.S. and Asian stock markets: A comparison between the periods of Asian currency crisis and subprime credit crisis", *The North American Journal of Economics and Finance*, 46, 187-201.
[31] Liu, H., & Chou, R. (2016). "A Comparative Study of the Taiwan and Japan Equity and Foreign Exchange Markets: Modeling, Estimation, and Application of the Component Garch-in-Mean Model", *Asian Economic and Financial Review*. Retrieved from http://www.aessweb.com/pdf-files/AEFR-2016-6(5)-277-297.pdf
[32] Lu, S. M. (2018). "Global Outlook for 2018: Economy, Finance, and Monetary, with a Particular Case Study of Taiwan", *International Journal of Economics and Finance,* 10(3). http://doi:10.5539/ijef.v10n3p133
[33] Muhammad S., Bhatti, G.A., & Raheman, A. (2020). "Modelling Stock Prices and Exchange Rates during Turbulent Periods: New Insights from Multivariate GARCH Parameterizations", NUML *International Journal of Business & Management*, 15(2), 1–17.
[34] Muthama, N., & Mutothya, N. (2013). "An Empirical Investigation of The Random Walk Hypothesis of Stock Prices on The Nairobi Stock Exchange", *European Journal of Accounting Auditing and Finance Research*, 1(4), 33–59.
[35] Nyopa, T. & Khumalo, S.A. (2021). "Volatility spillovers in equity and foreign exchange markets: Evidence from emerging economies", *Journal of Economic and Financial Sciences*, 15(1), 1–14.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)

[36] Paul, M. T., Kimata, J., & Khan, M. G. M. (2017). "Purchasing Power Parity Theory and Applications for Solomon Islands", Journal of Economics and Public Finance. 3(4), 507-530. www.sholink.org/ojs/index.php/jepf

[37] Phisuthtiwatcharavong, A., & Bouraoui, T. (2015). "On the determinants of the THB/USD exchange rate", *Procedia Economics and Finance*, 30, 137-145.

[38] Rajan, R. S. (2012). "Management of exchange rate regimes in emerging Asia", *Review of Development Finance*, 2(2), 53-68.

[39] Rakshit, B. & Neog, Y. (2022) 'Effects of the COVID-19 pandemic on stock market returns and volatilities: evidence from selected emerging economies', 39(4), pp. 549–571. doi: 10.1108/SEF-09-2020-0389

[40] The Big Mac Index. (2019, January 10). Retrieved from The Economist: https://www.economist.com/news/2019/01/10/the-big-mac-index

[41] The World Bank, PPP Calculation and Estimation. Retrieved from https://www.worldbank.org/en/programs/icp/brief/methodology-calculation#.

[42] Yang, Y-H. (1998). "Coping with the Asian Financial Crisis: The Taiwan Experience", *Seoul Journal of Economics*, 11(4), 423-444.

ISSN: 2304-1013 (Online); 2304-1269 (CDROM); 2414-6722 (Print)