Volatility of Exchange Rate and Foreign Trade in Asia

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Abstract

The paper investigates the empirical relationship between exchange rate volatility and foreign trade in 12 Asian countries, covering the period from January 2013 to December 2019. The study employs the Pedroni test, Pooled Mean Group method, and Dumitrescu-Hurlin test to analyze this relationship. The findings reveal that for the majority of variable pairs, particularly in the case of exchange rate volatility and foreign trade, there exists both cointegration and correlation. An exception is observed in the pair involving foreign trade and currency per USD, which, however, demonstrates a significant long-term equilibrium adjustment. The analysis further reveals a positive correlation between exchange rate volatility and international trade. Although a few variable pairs display either uni- or non-directional causality, in most instances, there is a noteworthy bi-directional causal relationship. The magnitude of the impact of exchange rate volatility on foreign trade surpasses that in the reverse direction.

Keywords: *exchange rate volatility, foreign trade, Asian countries*
JEL classification: F19, F31, F33, Q17

1. Introduction

Since 1973, when the Bretton Woods system was abandoned, exchange rates between currencies have been allowed to float, resulting in increased uncertainty for stakeholders in the market. This has had a significant impact on international trade between countries and regions worldwide. In response, numerous publications have emerged to scrutinize the relationship between exchange rate volatility and foreign trade. These studies have employed various methodologies and yielded diverse results. The lack of consensus among these studies emphasizes the necessity for further research to cultivate a comprehensive understanding in this field.

The exchange rate is a pivotal component of foreign trade, exerting a substantial influence on its dynamics. This relationship has garnered the attention of several scholars. For example, Tan et al. (2019) studied the effect of the exchange rate on exports in sub-national economies in India. Chaudhary et al. (2016) compared the impact of the exchange rate volatility on foreign trade between South Asian and South-East Asian regions. Poon and Hooy (2013) researched the effect of exchange rate volatility on foreign trade in countries belonging to the Organization of the Islamic Conference. Aristotelous (2001) examined the impact of exchange rate volatility on British exports to the United States, along with many other studies. However, most studies have focused on investigating the relationship between the exchange rate and foreign trade of individual countries (Kotil, 2019; Onafowora and Owoye, 2008), or between two countries (Aristotelous, 2001; Barseghyan and Hambardzumyan, 2018). Moreover, only a few studies have utilized time-series data to investigate the relationship between the exchange rate volatility and foreign trade within groups of countries (Asteriou et al., 2016; Choudhry, 2008; Din, 2004). To the best of our knowledge, an analysis of panel datasets in this context has not yet been undertaken. Thus, we assert that conducting such a study is imperative, as it will provide a novel dimension of understanding the relationship between exchange rate volatility and foreign trade.

In recent years, the utilization of panel datasets comprising cross-sectional observations and extensive time-series data for estimating dynamic panel models has piqued the interest of scholars across various fields. This is particularly evident when employing panel datasets that span across nations, states, and industries over extended periods. For instance, in the realm of econometric theory, Hadri (2000), Hurlin (2004), Im et al. (2003), and Pedroni (2004) have developed models for testing variables in panel datasets. Sadikov et al. (2020) employed a panel dataset comprising 20 post-communist countries from 1990 to 2018 to investigate the relationship between pollution, energy, and growth. In the context of the relationship between foreign direct investment and growth, Hansen and Rand (2006) collected data from 31 developing countries spanning from 1970 to 2000. Additionally, a panel dataset encompassing 31 provinces in China from 2000 to 2015 was used to explore the relationship between transportation and economic growth (Tong and Yu, 2018). Building on this foundation, our objective is to construct a panel dataset to investigate the relationship between exchange rate volatility and foreign trade, which constitutes a fundamental theory in macroeconomics.

The Asian continent, known for having the second-largest share of GDP among all continents (following Europe), is home to numerous emerging economies experiencing rapid growth. Foreign trade plays a pivotal role in the economies of Asia, contributing to the transformation of the Chinese economy (Lardy, 1995), the growth of South Asian economies (Din, 2004), and the development of economies in East and Southeast Asia (Jongwanich, 2010). Hence, our strategy involves collecting data from Asian countries to construct a panel dataset for examining the causal relationship between exchange rate volatility and foreign trade.

2. Research framework

2.1. Fundamental theory

The fundamental theory that underlies the relationship between exchange rate volatility and foreign trade is the risk aversion theory. This theory is a cornerstone concept in international economics, positing that individuals, businesses, and governments tend to be risk-averse when making economic decisions (Dellas and Zilberfarb, 1993). In the context of international trade, this means that uncertainty and volatility in exchange rates can have a significant impact on trade patterns (Arize et al., 2000; Broil and Eckwert, 1999; Dellas and Zilberfarb, 1993).

When exchange rates exhibit instability and undergo rapid fluctuations, it introduces a level of uncertainty for businesses engaged in foreign trade. This uncertainty can act as a deterrent, causing businesses to hesitate or even refrain from participating in international transactions.

The fear of potential losses due to unfavorable exchange rate movements prompts businesses to adopt more conservative strategies, such as hedging or sourcing from domestic suppliers, in order to mitigate the risks associated with these fluctuations (Broil and Eckwert, 1999).

Furthermore, this risk-averse behavior can lead to a reduction in the overall volume of international trade (Arize et al., 2000; Tarakçı et al., 2022). If businesses perceive exchange rate volatility as too high, they may opt to focus on domestic markets or explore alternative markets with more stable currencies. This shift away from cross-border trade can have broader economic implications, affecting industries that rely heavily on international markets for growth and profitability (Bahmani-Oskooee et al., 2021).

In addressing the implications of exchange rate volatility on foreign trade, it is imperative for governments and policymakers to play a proactive role (Tarakçı et al., 2022). They can implement measures aimed at stabilizing exchange rates through monetary and fiscal policies. Additionally, providing transparent and reliable information about exchange rate movements can help mitigate uncertainty for businesses engaged in foreign trade (Arize et al., 2000).

In summary, the risk aversion theory underscores the pivotal role of exchange rate stability in influencing international trade. Exchange rate volatility can induce risk-averse behavior among businesses, potentially leading to a reduction in cross-border transactions. Policymakers must be aware of this dynamic and take steps to foster a stable and predictable exchange rate environment, ultimately promoting a healthy and robust global trade system.

2.2. Review of empirical studies

Numerous studies have illuminated the complex interplay between exchange rate volatility and international trade. Sugiharti et al. (2020) utilized a GARCH model and ARDL approach to examine the effects of exchange rate volatility on Indonesia's key exports to major destinations (China, India, Japan, South Korea, and the United States) from 2006 to 2018. They found substantial impacts on various commodities, particularly in India. The Index of Industrial Production notably influenced exports to Asian nations, indicating an adverse effect on Indonesian exports due to exchange rate fluctuations. Vo and Vo (2023) emphasized the pivotal role of a nation's currency value in its economic framework. They highlighted how exchange rate fluctuations affect exporters' profitability, consumer prices, and the intricacies of economic comparisons. Drawing on five decades of data post-Bretton Woods, they affirmed the enduring significance of purchasing power parity despite currency volatility and trade barriers. Their study further delved into key themes in international economics, emphasizing the vital connection between exchange rates and prices. Truong et al. (2022) delved into the repercussions of exchange rate volatility on Vietnam's trade. Employing the NARDL model, they discerned those positive changes in exchange rate volatility initially detriment the trade balance but subsequently yield benefits in the long term. Conversely, negative changes in exchange rate volatility showed no significant impact. Tarakçı et al. (2022) scrutinized Turkey's surge in exports amidst heightened exchange rate volatility.

Their analysis of the impact on exports to major partners unveiled asymmetry, country-specific effects, and diverse impacts on goods. These findings offered crucial insights for policymakers. Köse and Aslan (2023) applied the SVAR model to data spanning from January 2002 to December 2017 to assess the impact of exchange rate uncertainty on Turkey's trade. Their findings underscored the influential roles of domestic income and imports on exports, as well as the reliance of imports on exchange rate factors.

Various empirical studies have been conducted to explore the relationship between exchange rates and foreign trade. These studies have yielded diverse findings, which can be summarized as follows. Firstly, in Turkey, Kotil (2019) identified a positive relationship between the exchange rate and foreign trade. In studies investigating the effect of exchange rates on foreign trade between the UK and Canada, Japan and New Zealand, Choudhry (2008) confirmed a positive link between the two variables. In OIC countries, Poon and Hooy (2013) found a positive connection between the exchange rate and exports. Secondly, a negative correlation between exchange rates and foreign trade was observed. Onafowora and Owoye (2008) indicated that an increase in the exchange rate adversely affects exports, while Poon and Hooy (2013) revealed a negative relationship between the exchange rate and imports in OIC countries. In India, Tan et al. (2019) concluded that exchange rate volatility had a negative effect on foreign trade. Foreign trade between the USA and Canada, as well as the USA and Japan, was negatively correlated with exchange rate volatility (Choudhry, 2005). Additionally, for East Asian countries, Chit et al. (2010) confirmed the negative effect of exchange rates on exports. Finally, there is no conclusive evidence regarding the relationship between exchange rates and foreign trade, as indicated by Aristotelous (2001) in the context of exchange rates and export volume between Britain and the USA. In the long term, Asteriou et al. (2016) argued that there is no link between exchange rates and foreign trade in Mexico, Indonesia, and Nigeria.

Furthermore, the causal relationship between exchange rates and foreign trade has attracted the attention of many scholars. Three lines of findings regarding the causality between exchange rates and foreign trade emerge. Firstly, bi-directional causality was found by Mougoué and Aggarwal (2011) and Sekmen and Saribas (2007). Secondly, uni-directional causality was identified from exchange rates to export and import in Turkey (Kotil, 2019), from export to exchange rates in Nigeria, from exchange rates to foreign trade in Indonesia and Mexico, as well as in East Asian countries (Asteriou et al., 2016; Chit et al., 2010). Finally, non-directional causality between the two variables was observed in Turkey (Asteriou et al., 2016) and in India (Mousavi and Leelavathi, 2013).

2.3. Research Hypothesis

The research hypothesis suggests a significant and intricate relationship between exchange rate volatility and foreign trade within the macroeconomic framework, explored in a diverse panel dataset of Asian countries. Employing established volatility measurement equations, the study rigorously analyzes a few dimensions of exchange rate volatility.

The investigation utilizes the Pedroni panel cointegration test (Pedroni, 1999) to examine the potential long-term association between these variables. Additionally, the Pooled Mean Group approach (Pesaran et al., 1999) is employed to distinguish between short-term and long-term effects, providing insights into their nuanced dynamics. The research further probes the causal links between exchange rate volatility and foreign trade, using the Dumitrescu and Hurlin approach (Dumitrescu and Hurlin, 2012). It is anticipated that employing these multiple approaches will shed light on the relationship between exchange rate volatility and foreign trade, thereby enriching knowledge in this field.

3. Methodology

We aggregated data from the International Financial Statistics (IFS), available at https://data.imf.org. Our approach involved establishing a monthly balanced panel dataset, ensuring that data for each country was complete with no missing values. Out of the 48 countries in Asia, we selected 12 after filtering. The dataset comprises 12 Asian countries (Bangladesh, Cambodia, China (mainland), India, Indonesia, Japan, Kazakhstan, South Korea, Malaysia, Myanmar, Pakistan, Philippines, Singapore, and Thailand) spanning from January 2013 to December 2019.

Various measures can be employed to calculate exchange rate volatility, including the log exchange rate, the moving average standard deviation of the exchange rate, and ARCH/GARCH. Sadikov et al. (2020) and Salahuddin and Gow (2014) noted that to obtain the growth rate and mitigate non-linear modeling and heteroscedasticity, all variables should be transformed into their natural logarithmic form. Furthermore, we chose to utilize the moving average method for processing the monthly data. Therefore, we applied the recommended equations from Aristotelous (2001) and Barseghyan and Hambardzumyan (2018) as follows for measurement:

$$V_t = \left[\frac{1}{m}\sum_{i=1}^{m}(\ln e_{t+i-1} - \ln e_{t+i-2})^2\right]^{1/2} \quad (1)$$

Here, ln represents the natural logarithm, e stands for the exchange rate, and m denotes the order of the moving average. Aristotelous (2001) and Barseghyan and Hambardzumyan (2018) suggested using m = 4. The foreign trade volatility variable is calculated using the same equation.

Utilizing a robust balanced panel dataset comprising data from 12 countries spanning from January 2013 to December 2019, we aim to investigate the relationship between exchange rate volatility and foreign trade. Following the methodologies outlined by Kónya (2006), Maradana et al. (2017), and Salahuddin and Gow (2014), we outline the estimation process as follows: (1) Conduct unit root tests to identify appropriate panel data for each variable; (2) Investigate cointegration to validate the correlation between exchange rate volatility and foreign trade in the long term; (3) Examine the relationship between variables in both the short and long terms, and assess the speed of adjustment from disequilibrium in the short term to equilibrium in the long term using the Pooled Mean Group (PMG) approach; and (4) Apply the Granger causality test to robustly examine the causal relationship between pairs of variables. The estimation results are processed using the STATA software.

4. Results and Discussion

4.1. Descriptive statistics

To initiate the analysis in the following section, we conduct a descriptive statistical analysis to gain insight into the characteristics of the data. The standard deviations indicate that there is homogeneity in foreign trade (volatility of FOREV, EXPOV, and IMPOV ranges from 0.1170 to 0.1336), as well as in exchange rate volatility (volatility of SDREV, SDRAV, USDEV, and USDAV ranges from 0.0128 to 0.0157). However, in certain periods (months), the volatility of USDEV and USDAV remains constant (Table 1).

Table 1. Statistical description for variables

Variable	Explanation	Obs.	Mean	SD	Min	Max
FOREV	The volatility of foreign trade	1040	0.1170	0.2709	0.0095	3.3686
EXPOV	The volatility of export	1040	0.1336	0.2765	0.0108	3.3925
IMPOV	The volatility of import	1040	0.1271	0.2688	0.0123	3.3419
SDREV	The volatility of currency per SDR the end of month	1040	0.0136	0.0120	0.0012	0.1377
SDRAV	The volatility of currency per SDR the average of month	1040	0.0159	0.0138	0.0017	0.1444
USDEV	The volatility of currency per USD the end of month	1040	0.0128	0.0125	0	0.1384
USDAV	The volatility of currency per USD the average of month	1040	0.0157	0.0144	0	0.1446

4.2. Unit root test

The dataset spans a long period (monthly from January 2012 to December 2019), potentially leading to variables exhibiting a stochastic trend and a cointegrating relationship in the long term (Neal, 2014; Pedroni, 2004). Following the approach of Sadikov et al. (2020), and Salahuddin and Gow (2014), we conduct a panel unit root test to assess the stationarity of variables, both in their level and first difference forms. For this, Im et al. (2003) and Levin et al. (2002) were employed. The null hypothesis posits that all panels contain unit roots.

The equation of the IPS test (Im et al., 2003) is expressed as below:

$$\Delta y_{it} = \alpha_i + \beta_i y_{i,t-1} + \varepsilon_{it} \quad (2)$$

The null hypothesis of the IPS test is β_i = 0 for all i, and the alternative hypothesis is β_i < 0 with i = 1,2, …, N_1, β_i=0, and i = N_1 + 1, N_1 + 2, …, N. The value of the IPS test is based on z-bar tilde statistics, which is followed by the standard normal distribution.

For the LLC test, Levin et al. (2002) proposed the equation as below:

$$\Delta y_{it} = \delta_i y_{i,t-1} + \sum_{L=1}^{p_i} \theta_{iL} \Delta y_{i,t-L} + \alpha_{mi} d_{mt} + \varepsilon_{it} \quad m = 1,2,3 \ (3)$$

The null hypothesis of the LLC test is $\theta_{iL} = 0$, both when $\delta_i = 0$ and when $\delta_i < 0$. The value of the LLS test is t-statistic, which has the standard normal distribution. However, Levin et al. (2002) permitted p_i to vary across individuals, thus the adjusted t-statistic is used for deciding the null hypothesis. The value of the LLC test and IPS test demonstrate that the null hypothesis is rejected which means some panels are stationary at significance level 1% for both the level form and the first difference form (Table 2).

Table 2. Panel unit root test

Variable	LLC test value	IPS test value	Stationary or not
FOREV	-11.4547***	-6.3363***	Stationary
d. FOREV	-15.9127***	-17.5071***	Stationary
EXPOV	-11.2784***	-6.1196***	Stationary
d. EXPOV	-16.3022***	-17.2771***	Stationary
IMPOV	-10.1636***	-5.7965***	Stationary
d. IMPOV	-15.4821***	-17.4707***	Stationary
SDRAV	-4.9111***	-4.6341***	Stationary
d. SDRAV	-13.1427***	-20.1470***	Stationary
SDREV	-4.8675***	-5.1705***	Stationary
d. SDREV	-14.1245***	-20.1841***	Stationary
USDAV	-6.3930***	-5.4470***	Stationary
d. USDAV	-14.2469***	-19.1844***	Stationary
USDEV	-6.2116***	-6.1267***	Stationary
d. USDEV	-15.3943***	-20.3270***	Stationary

*Note: *** significant at 1% level, and d. denotes the first difference*

4.3. Cointegration test

Next, in line with the approaches of Neal (2014), Pedroni (1999), Sadikov et al. (2020), and Salahuddin and Gow (2014), we utilize the Pedroni cointegration test to examine the long-term relationship between variables. Pedroni (1999) proposed the regression model below for testing cointegration:

$$y_{it} = \alpha_i + \sum_{m=1}^{M} \beta_{mi} x_{mit} + e_{it} \ (4)$$

Where, i = 1,2, …, N, t = 1,2, …, T, and m = 1,2, …, M are the number of individuals, the number of periods, and the number of regressors, respectively.

The Pedroni test report presents seven statistics: panel v-statistic, panel rho-statistic, panel t-statistic (non-parametric), panel t-statistic (parametric, ADF), group rho-statistic, group t-statistic (non-parametric), and group t-statistic (parametric, ADF) used to test the null hypothesis of no cointegration. All these test statistics follow the standard normal distribution. As per Neal (2014), the null hypothesis is rejected when the absolute majority (at least six out of seven statistics) of test statistics exceed the critical value of approximately 1.28.

Table 3 illustrates that, for most pairs of variables, six out of seven test statistics surpass the critical value. Consequently, the null hypothesis of no cointegration is rejected, with the exception of the pairs involving FOREV→USDAV, FOREV→USDEV, EXPOV→USDEV, IMPOV→USDAV, and IMPOV→USDEV. The panel and group ADF statistics are computed using the augmented Dickey-Fuller method for conducting the unit root test. However, the values of both the panel and group ADF statistics do not reach the critical threshold, as indicated by Neal (2014). Furthermore, in line with the estimation results in Table 2, it is observed that only a few panel variables exhibit a unit root. Moreover, although most pairs of variables provide evidence supporting the cointegration between exchange rate volatility and foreign trade at both the individual country and group levels, the volatility of the national currency per USD at the end and average of the month is not cointegrated with the volatility of foreign trade. This pertains specifically to the total volume of export and import, as well as exports and imports in a few countries. We hypothesize that this phenomenon may be attributed to the emergence of other influential currencies (such as the Chinese Yuan) as alternatives to the USD in international trade, as well as the unique characteristics of internal foreign trade in Asian countries (Chen, 2016; Kwack et al., 2007). Furthermore, the value of the group rho statistic suggests the presence of long-run cointegration between exchange rate volatility and foreign trade. This implies that conducting a panel structural break analysis may not be necessary (Gutierrez, 2003).

Table 3. The panel cointegration test

No.	Pair of variables	Panel				Group			Null hypothesis
		v	rho	t	ADF	rho	t	ADF	
1	SDRAV → FOREV	12.82	-12.18	-7.627	-3.594	-9.546	-7.69	-3.149	Reject
2	FOREV → SDRAV	9.159	-7.473	-5.116	-1.497	-5.625	-4.976	-1.651	Reject
3	SDREV → FOREV	12.73	-12.05	-7.567	-3.935	-9.433	-7.621	-3.572	Reject
4	FOREV → SDREV	9.117	-7.544	-5.178	-2.102	-5.595	-4.997	-2.006	Reject
5	USDAV→ FOREV	13.13	-12.25	-7.667	-3.799	-9.628	-7.747	-3.404	Reject
6	FOREV → USDAV	7.603	-6.058	-4.301	-0.576	-4.754	-4.291	-0.565	Fail to reject
7	USDEV → FOREV	13.09	-12.21	-7.641	-3.831	-9.571	-7.708	-3.407	Reject
8	FOREV → USDEV	7.2	-6.377	-4.549	-0.912	-4.945	-4.516	-0.679	Fail to reject
9	SDRAV → EXPOV	12.41	-11.55	-7.276	-2.833	-8.964	-7.294	-2.115	Reject
10	EXPOV → SDRAV	9.093	-7.433	-5.089	-1.958	-5.547	-4.922	-2.127	Reject
11	SDREV → EXPOV	12.32	-11.4	-7.218	-2.93	-8.842	-7.227	-2.234	Reject
12	EXPOV → SDREV	9.04	-7.479	-5.143	-2.317	-5.515	-4.947	-2.298	Reject

No.	Pair of variables	Panel				Group			Null hypothesis
		v	rho	t	ADF	rho	t	ADF	
13	USDAV → EXPOV	12.75	-11.61	-7.3	-2.987	-9.035	-7.326	-2.329	Reject
14	EXPOV → USDAV	7.556	-6.007	-4.262	-1.931	-4.658	-4.214	-1.651	Reject
15	USDEV → EXPOV	12.7	-11.6	-7.294	-2.949	-8.996	-7.306	-2.24	Reject
16	EXPOV → USDEV	7.152	-6.298	-4.496	-1.134	-4.857	-4.446	-0.859	Fail to reject
17	SDRAV → IMPOV	12.66	-12.15	-7.612	-3.739	-9.553	-7.68	-3.559	Reject
18	IMPOV → SDRAV	9.224	-7.506	-5.128	-1.509	-5.625	-4.974	-1.636	Reject
19	SDREV → IMPOV	12.73	-12.14	-7.618	-3.955	-9.548	-7.684	-3.813	Reject
20	IMPOV → SDREV	9.213	-7.634	-5.232	-1.921	-5.696	-5.068	-1.638	Reject
21	USDAV → IMPOV	12.95	-12.18	-7.634	-4.313	-9.611	-7.724	-4.191	Reject
22	IMPOV → USDAV	7.611	-6.038	-4.286	-0.554	-4.723	-4.269	-0.535	Fail to reject
23	USDEV → IMPOV	13.12	-12.25	-7.668	-3.981	-9.667	-7.764	-3.836	Reject
24	IMPOV → USDEV	7.279	-6.442	-4.59	-0.354	-5.041	-4.588	-0.174	Fail to reject

Note: Null hypothesis is no cointegration

4.4. Estimation of the short-term and long-term effect

We utilize the Pooled Mean Group (PMG) approach, which was originally proposed by Pesaran et al. (1999), to estimate both the long-term and short-term coefficients. This method was employed in many studies such as Ditzen (2018), Sadikov et al. (2020), Salahuddin and Gow (2014), and Sadikov et al. (2020). Furthermore, the PMG approach can be conceptualized as the Autoregressive Distributed Lag (ARDL) model, as outlined below:

$$\Delta y_{it} = \sum_{j=1}^{p-1} \gamma_j^i \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \delta_j^i \Delta x_{i,t-j} + \varphi^i\left(y_{i,t-1} - \beta_1^i x_{i,t-1}\right) + \beta_0^i + \mu_t + \varepsilon_{it} \quad (5)$$

Where, γ_j^i and δ_j^i are the short-term coefficients, if $\delta_j^i = 0$ there would be no evidence for a short-term relationship between dependent variable and independent variable; φ^i is the error correction term, which expresses the speed of adjustment term, if $\varphi^i = 0$, there would be no evidence for a long-run relationship; β_1^i is the long-term coefficient, which contains the long-term relationship between variables; and β_0^i, μ_t, and ε_{it} are individual-specific effect, time-specific effect, and stochastic error term, respectively.

Table 4 indicates that the coefficients of error correction term is over zero ($\varphi^i > 0$) and significant at level 1%, which means there is evidence of the long-term relationship between exchange rate volatility and foreign trade, and the speed of adjustment term between two pairs variables are fluctuation around 80% (φ^i is from 0.757 to 0.820), or the 80% of long-term disequilibrium dissipated after the period (Choudhry, 2005, 2008). Most of the long-term coefficients are both positive and statistically significant, ranging from 10% to 1%, with the exception of the relationship between SDREV and FOREV, which is not statistically significant. This reinforces the robustness of the long-term relationship between exchange rate volatility and foreign trade. Conversely, the majority of short-term coefficients are positive and statistically significant, ranging from 10% to 1%, except for the short-term coefficients of FOREV-USDAV, EXPORV-USDAV, EXPORV-USDEV, and IMPOV-USDAV, which are not statistically significant. This suggests that in the short term, the volatility of the currency per USD does not have a significant impact on foreign trade profit, especially in terms of the monthly average currency per USD. Even within the Asian region, where different exchange rate regimes exist, the short-term impact on foreign trade is negligible. This finding aligns with the research conducted by Asteriou et al. (2016) and Kotil (2019).

Table 4. The estimation results of the PMG approach

No.	Variables		Coefficients			
	Dep.	Indep.	Long-term	Error correction term	Short-term	Constant
1	FOREV	SDRAV	4.830*** (10.37)	0.762*** (73.94)	4.835*** (2.58)	0.016 (1.28)
2	SDRAV	FOREV	0.015* (1.74)	0.819*** (42.87)	0.013** (2.37)	0.002*** (4.26)
3	FOREV	SDREV	4.070*** (9.60)	0.754*** (40.56)	6.422* (1.81)	-0.016 (-0.38)
4	SDREV	FOREV	0.017 (1.53)	0.789*** (24.17)	0.011* (1.85)	0.004*** (4.24)
5	FOREV	USDAV	3.742*** (8.21)	0.770*** (75.28)	1.073 (0.88)	0.041*** (2.83)
6	USDAV	FOREV	0.015* (1.90)	0.798*** (28.72)	0.011** (2.25)	0.002*** (4.41)
7	FOREV	USDEV	3.408*** (7.92)	0.772*** (74.77)	2.062** (1.96)	0.028** (2.36)
8	USDEV	FOREV	0.018* (1.84)	0.777*** (35.39)	0.014** (2.37)	0.003*** (4.40)
9	EXPOV	SDRAV	5.461*** (9.72)	0.765*** (51.78)	4.968** (2.53)	0.023 (1.60)
10	SDRAV	EXPOV	0.016** (2.25)	0.816*** (41.81)	0.016*** (3.60)	0.002*** (4.56)
11	EXPOV	SDREV	4.785*** (9.48)	0.757*** (36.02)	6.594* (1.90)	-0.008 (-0.20)
12	SDREV	EXPOV	0.018** (2.09)	0.787*** (24.36)	0.015*** (3.24)	0.003*** (5.07)

No.	Variables		Coefficients			
	Dep.	Indep.	Long-term	Error correction term	Short-term	Constant
13	EXPOV	USDAV	4.319*** (8.17)	0.773*** (51.16)	0.912 (0.68)	0.046*** (3.13)
14	USDAV	EXPOV	0.016*** (2.73)	0.800*** (33.68)	0.013*** (3.07)	0.002*** (4.95)
15	EXPOV	USDEV	3.697*** (7.41)	0.773*** (50.79)	1.815 (1.51)	0.034*** (2.60)
16	USDEV	EXPOV	0.019*** (2.84)	0.773*** (36.63)	0.014*** (3.42)	0.003*** (6.01)
17	IMPOV	SDRAV	5.113*** (10.12)	0.783*** (46.19)	5.503*** (3.03)	0.014 (1.14)
18	SDRAV	IMPOV	0.017** (2.04)	0.820*** (43.31)	0.015*** (3.47)	0.002*** (4.17)
19	IMPOV	SDREV	4.384*** (9.89)	0.778*** (32.89)	7.091** (2.00)	-0.019 (-0.46)
20	SDREV	IMPOV	0.019* (1.79)	0.795*** (24.11)	0.016*** (2.81)	0.003*** (4.48)
21	IMPOV	USDAV	3.984*** (8.87)	0.791*** (47.22)	1.719 (1.55)	0.040*** (2.65)
22	USDAV	IMPOV	0.017** (2.19)	0.798*** (29.85)	0.012** (2.37)	0.002*** (4.21)
23	IMPOV	USDEV	3.449*** (8.12)	0.795*** (45.02)	2.334** (2.53)	0.027** (2.43)
24	USDEV	IMPOV	0.020** (2.01)	0.779*** (34.89)	0.015** (2.37)	0.003*** (4.68)

*Note: *** significant at 1% level, and d. denotes the first difference*

Additionally, both in the long term and short term, the influence of exchange rate volatility on foreign trade appears to be more substantial compared to the impact in the opposite direction. Specifically, the long-term and short-term coefficients of exchange rate volatility are greater than the long-term coefficients of foreign trade volatility.

4.5. Causality test

As per Lopez and Weber (2017), the DH test, Dumitrescu and Hurlin (2012) was employed to detect Granger causality in panel datasets and formulated the model for the Granger causality test as follows:

$$y_{it} = \alpha_i + \sum_{k=1}^{K} \gamma_i^k y_{i,t-k} \sum_{k=1}^{K} \beta_i^k x_{i,t-k} + \varepsilon_{it} \quad (6)$$

To test for causality, the x and y variables must be swapped in the opposite direction. The null hypothesis states that x does not Granger-cause y (H0: $\beta_i^1 = \beta_i^2 = \cdots \beta_i^K = 0$, where K is the optimal number of lags), while the alternative hypothesis suggests that x does Granger-cause y for at least one panel.

There are two statistics, Z-bar and Z-bar tilde, used to assess Granger causality between variables. Both follow a standard normal distribution. In this study, employing a dataset spanning 12 countries on a monthly basis from January 2013 to December 2019, and following the recommendations of Lopez and Weber (2017) and Sadikov et al. (2020) regarding the use of Z-bar and Z-bar tilde for panel datasets, we argue that the Z-bar tilde statistic is suitable for evaluating causality between variables.

Furthermore, Dumitrescu and Hurlin (2012) and Lopez and Weber (2017) proposed that the number of lags (K) must be consistent across all individuals and panels. The Stata user-written command “xtgcause” provides the option to select the number of lags using the Akaike (AIC), Bayesian (BIC), and Hannan-Quinn (HQIC) information criteria. Therefore, we intend to employ “xtgcause” for testing causality and determining the appropriate number of lags. However, for monthly data, Ivanov and Killian (2001) suggested that the AIC criterion is superior to others. As a result, in this study, we plan to opt for the AIC option for selecting the lags in the Vector Auto Regression (VAR).

The DH test estimation results, which remain robust from the PMG estimation approach. The optimal number of lags is determined to be twenty-four (24). The statistical values of the DH test indicate the presence of six pairs of bi-directional causality between the variables FOREV↔SDRAV, EXPOV↔SDRAV, EXPOV↔USDAV, EXPOV↔USDEV, IMPOV↔SDREV, and IMPOV↔USDEV. Additionally, there are three pairs demonstrating uni-directional causality: SDREV→FOREV, USDEV→FOREV, and SDREV→EXPOV. Lastly, three pairs show non-causality between variables: USDAV↔FOREV, SDRAV↔IMPOV, and USDAV↔IMPOV (Table 5).

In summary, it can be inferred that there exists a causal relationship between the paired variables concerning exchange rate volatility and foreign trade.

Table 5. Panel Granger Causality Test

No.	Null hypothesis (H_0)	Z-bar tilde	Z-bar	Lag (AIC)	Consider H_0	Outcomes
1	SDRAV does not Granger-cause FOREV	6.06***	31.36***	24	Reject	Bi-directionalcausality
2	FOREV does not Granger-cause SDRAV	6.30***	32.42***	24	Reject	
3	SDREV does not Granger-cause FOREV	7.05***	35.68***	24	Reject	Uni-directional causality
4	FOREV does not Granger-cause SDREV	0.99	9.32***	24	Fail to reject	

No.	Null hypothesis (H_0)	Z-bar tilde	Z-bar	Lag (AIC)	Consider H_0	Outcomes
5	USDAV does not Granger-cause FOREV	1.62	12.04***	24	Fail to reject	Non-causality
6	FOREV does not Granger-cause USDAV	-0.47	2.94***	24	Fail to reject	
7	USDEV does not Granger-cause FOREV	2.10**	14.13***	24	Reject	Uni-directional causality
8	FOREV does not Granger-cause USDEV	0.91	8.97***	24	Fail to reject	
9	SDRAV does not Granger-cause EXPOV	2.34**	15.17***	24	Reject	Bi-directional causality
10	EXPOV does not Granger-cause SDRAV	3.55***	20.46***	24	Reject	
11	SDREV does not Granger-cause EXPOV	6.79***	34.56***	24	Reject	Uni-directional causality
12	EXPOV does not Granger-cause SDREV	1.08	9.68***	24	Fail to reject	
13	USDAV does not Granger-cause EXPOV	5.84***	30.43***	24	Reject	Bi-directional causality
14	EXPOV does not Granger-cause USDAV	2.46**	15.71***	24	Reject	
15	USDEV does not Granger-cause EXPOV	3.08***	18.39***	24	Reject	Bi-directional causality
16	EXPOV does not Granger-cause USDEV	1.79*	12.81***	24	Reject	
17	SDRAV does not Granger-cause IMPOV	0.82	8.55**	24	Fail to reject	Non-causality

No.	Null hypothesis (H_0)	Z-bar tilde	Z-bar	Lag (AIC)	Consider H_0	Outcomes
18	IMPOV does not Granger-cause SDRAV	0.68	7.96***	24	Fail to reject	
19	SDREV does not Granger-cause IMPOV	4.48***	24.49***	24	Reject	Bi-directional causality
20	IMPOV does not Granger-cause SDREV	2.83***	17.30***	24	Reject	
21	USDAV does not Granger-cause IMPOV	1.11	9.83***	24	Fail to reject	Non-causality
22	IMPOV does not Granger-cause USDAV	0.34	6.47***	24	Fail to reject	
23	USDEV does not Granger-cause IMPOV	3.66***	20.93***	24	Reject	Bi-directional causality
24	IMPOV does not Granger-cause USDEV	1.66*	12.24***	24	Reject	

*Note: *** significant at 1% level, and d. denotes the first difference*

When combination between the estimation results of Table 4 and Table 5, we find some interesting. Firstly, the strong interaction between pairs variables: FOREV↔SDRAV, EXPOV↔SDRAV, IMPOV↔SDREV, and IMPOV↔USDEV. We argue that although the SDR is not used in foreign trade, it is considered a trusted currency for evaluating national currency because it is not affected by the exchange rate regime or monetary policy (Poon and Hooy, 2013). Secondly, we find long-term and short-term cointegration between FOREV and USDEV, as well as EXPOV and SDREV, but non-cointegration between FOREV and SDREV. However, the causality test indicates unidirectional causality from exchange rate volatility to foreign trade. Thirdly, there is non-cointegration in the short term between EXPOV and USDAV, and EXPOV and USDEV. Nevertheless, the causality test suggests bidirectional causality between the volatility of currency per USD and export volatility. Fourthly, there is no causality between exchange rate volatility and import profit, despite the significant short-term and long-term coefficients of the variables. Finally, the measurement of exchange rate volatility using the average method seems not to have an influence on foreign trade. We discuss that this might be a signal for exporters and importers to consider using financial derivatives to protect their interests (Allayannis and Ofek, 2001; Kozarevic et al., 2014).

5. Conclusion

Through the panel data analysis process, we uncover some noteworthy findings. Firstly, although most pairs of variables between exchange rates and foreign trade show cointegration, the cointegration between foreign trade and currency per USD is observed to be driven by the influence from foreign trade to exchange rate, as confirmed by the insignificant short-term coefficient of the currency per USD variable. Secondly, we find significant long-term effects between pairs of variables related to exchange rate volatility and foreign trade. Thirdly, we observe evidence of a positive relationship between exchange rate volatility and foreign trade. However, in a few cases, the relationship displays uni- and non-directional causality. Finally, we determine that the intensity of the effect of exchange rate volatility on foreign trade is higher than the effect of foreign trade volatility on exchange rate volatility.

Based on the findings of the panel data analysis, several policy recommendations emerge. Firstly, policymakers should focus on bolstering foreign trade, as it plays a pivotal role in influencing exchange rates. Secondly, measures to mitigate exchange rate volatility are imperative, given the significant long-term effects identified. This could involve implementing hedging strategies or adopting more stable exchange rate policies. Additionally, fostering policies that promote stability in foreign trade can help maintain a positive relationship with exchange rate volatility. Lastly, it's crucial to acknowledge that exchange rate volatility has a more pronounced impact on foreign trade compared to the reverse scenario. Hence, policies should be tailored to address this higher sensitivity.

Conflict of Interest

The authors declare no conflict of interest.

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