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UNCOVERED INTEREST PARITY IN ASEAN COUNTRIES WITH ARDL BOUNDS TESTING APPROACH

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LIST OF ABBREVIATIONS

Term	Abbreviation
U.S. Dollar	USD
Vietnamese Dong	VND
Malaysian Ringgit	MYR
Philippine Peso	PHP
Indonesian Rupiah	IDR
Thai Baht	THB
Toda-Yamamoto Granger Causality	T-Y Procedure
Exchange Rate Returns	ERR
Interest Rate Differentials	IRD
Akaike Information Criterion	AIC
Schwarz Information Criterion	SC

INTRODUCTION

The abundant potential profitability of carry trade in the current global markets highlights a puzzle in international finance – the persistent deviation from Uncovered Interest Parity (hear by UIP). The theory posits that, under highly integrating market conditions, between two countries, the with higher interest rates will experience currency depreciation. The amount depreciated will equal to the interest rate differential between them, thereby eliminating arbitrage opportunities. While UIP holds valid in theory, there is only scarce evidence of the hypothesis, especially in the emerging world. Such deviation attracts opportunistic carry traders to borrow in country with lower interest rate to invest in location with higher rates. From the government and central bank perspective, UIP could estimate the level of financial integration, guiding central banks in managing exchange rates and inflation targets.

The actuality of the research is based on the fact, that despite the growing body of literature examining UIP in developed economies, there is a scarcity of studies focusing on Southeast Asia.

Firstly, a noteworthy characteristic of empirical studies on UIP is that a large portion of them relies heavily on largely similar database of developed markets. While Chaboud and Wright (2005; Lothian, 2016; Sarantis, 2006) have proven the alignment between interest rate differentials and expected exchange rate movements in certain cases, other authors including Afat and Frömmel (2021; Bagdatoglou and Kontonikas, 2009; Chinn and Meredith, 2005; King, 1998; Macchiarelli, 2011) rejected the UIP hypotheses. It cannot, however, ruled out the possibility of UIP validity in a scarcely tested regions, particularly ASEAN in this case, especially when income levels of countries are a sensitive factor of UIP (Orellana and Pino, 2021). Given the heterogeneity between developed and developing economies, as noted by Flood & Rose (2002) and Frankel and Poonawala (2010), it is important to investigate UIP in a separate context for developing regions like ASEAN.

Secondly, among few existing studies in ASEAN countries, Tang (2011) has provided mixed evidence of UIP for ASEAN-5 nations confirming the validity of UIP for Singapore, an integrated market with the U.S while strongly rejected the condition for other nations (Indonesia, Malaysia, Philippines, Thailand). Nevertheless, Tang's study did not fully account for time-series dynamic on recent economic developments or the region's evolving financial integration within the global economy. Given the significant changes in global capital markets and the rising integration of

ASEAN into the global economy, there is a pressing need for updated studies that incorporate recent data and focus on middle-income countries in the region.

Thirdly, Orellana and Pino (2021) emphasized developing level as a heterogeneity and the the need to test various assumptions behind the invalidity of UIP, especially for middle-income countries. As emerging markets possess several limitations that could hinder UIP, the study also intend to examine closely potential causes in the ASEAN region. The author is particularly interested in whether central bank intervention a disruption of UIP in the region.

In light of these factors, this research aims to (1) test the validity of UIP in 5 middle-income ASEAN countries, including Vietnam, Thailand, Malaysia, Indonesia and Philippines by employing time series analysis (ARDL Bounds Testing and Granger Causality) incorporating updated data from 2010 to 2023.

At the same time, extending beyond Tang (2011), this study aims to (2) provide a comprehensive examination of the regional financial integration efforts and the impact of recent global capital movements on these countries. Specifically, the research will (3) explore how recent U.S. interest rate hikes have influenced the exchange rate dynamics of ASEAN countries, offering insights into one of the potential explanations for UIP deviations – central bank intervention.

The contribution of this paper to the literature is threefold. first, I will test the UIP's validity in five middle-income ASEAN nations (Vietnam, Thailand, Indonesia, Malaysia and the Philippines) catching up with the region's integration efforts and international capital movement in the recent years. Secondly, I will examine if the central bank intervention is a cause behind UIP's failure. Thirdly, I will extend beyond Tang (2011) to identify empirical factors influencing UIP.

The author aims to address those gaps by answering the following questions:

1. Does the Uncovered Interest Parity (UIP) hypothesis hold in the five middle-income ASEAN countries?
2. What is the nature of the dynamic causal relationships between exchange rate returns and interest rate differentials?
3. How do recent U.S. Federal Reserve interest rate hikes influence capital flows in the region?

The paper is structured with 6 main sections. Section one contains the theoretical background of Uncovered Interest Parity, overview of previous empirical studies in both developed and emerging markets, and the specific challenges facing the ASEAN region. Section 2 outlines the theoretical model, the selection of countries, data collection, and the methodology used, including Toda-Yamamoto Granger Causality test, ARDL bounds testing approach and error correction mechanism. Section 3 entails the empirical results of UIP and examine central bank intervention during the recent U.S. Federal Reserve interest hikes. Section 4 extends the findings further, in light of regional economic integration and central bank interventions. Finally, Section 5 and 6 concludes key insights derived from the research, thus suggest potential approach countering this study's own limitations.

1. THEORETICAL BACKGROUND AND LITERATURE REVIEW

1.1. The uncovered interest parity hypothesis

Interest rate parity is a fundamental yet influential concept in macroeconomic as it posits a foundational relationship between the two crucial players – interest rate and exchange rate. It asserts that differences in interest rates between two countries should correspond to the movement of exchange rates, eliminating opportunities for arbitrage. IRP has two primary forms:

Using a "forward contract" to lock in future currency exchange rates, investors can eliminate the risk of exchange rate. Covered Interest Parity suggests that after hedging using forward contracts, the return on investment of the two currencies will balance out, leaving no arbitrage opportunities. CIP is typically more empirically robust than UIP because it involves no exchange rate risk.

In contrast, Uncovered Interest Parity, without forward contract to cover the potential risk, predicts that differences in interest rate can naturally and automatically adjust themselves through currency appreciation or depreciation over time. UIP hypothesis is believed to hold under a certain set of setting: rational expectations, competitive markets and unrestricted capital mobility. In reality, such ideal environment is hardly found, especially in emerging markets. This open scenario creates opportunity for carry traders. This condition allows UIP to hold, as it equalizes returns on capital investments across borders, removing any opportunity for risk-free profit. Mathematically, UIP hypothesis is expressed as:

$$S_{t+1}^{e} - S_t = i_t - i_t^*$$

Where:

i_t: Domestic interest rates

i_t^*: Foreign interest rates

S_t: Spot exchange rate

S_{t+1}^{e}: Expected exchange rate

In a competitive market, if UIP does not initially hold, arbitrage opportunities arise. Investors become arbitragers, borrowing from market with cheaper capital and invest it in another market with higher interest rates to earn a profit on the difference of interest rate between the two nations. This constant inflow of capital to the promising country increases the supply of capital, leading to

a gradual reduction in interest rates in the destination country. Simultaneously, the capital outflow from the lower-interest-rate country reduces its capital availability, causing interest rates to rise there. This process of arbitrage and capital adjustment continues until interest rates equalize between the two countries, effectively aligning returns and achieving UIP equilibrium.

In additional the existence of arbitrage, UIP holds under three implicit assumptions, which are rational (unbiased) expectation, free capital mobility, and risk neutrality. Without one or many of the mentioned conditions, UIP may not hold.

UIP has several important implications:

(1) Interest rate differentials cause corresponding currency appreciation or depreciation. If a country registers a higher interest rate, it would expect a depreciation in its currency. Liekwise, a lower interest rate leads to appreciation. In ASEAN, deviations from this theoretical prediction may reflect regulatory barriers and market imperfections, which can hinder the free capital flows necessary for UIP to hold.

(2) A declining uncovered interest rate differential may indicate increasing capital mobility;

(3) Combined with Purchasing Power Parity (PPP), UIP supports the notion of real interest rate parity, whereby inflation-adjusted interest rates should converge across integrated markets. This aspect of UIP is particularly relevant for ASEAN economies that are progressively aligning their financial systems to attract international investment and enhance market stability (Chinn and Meredith, 2005); and

(4) UIP supports the notion of forward rate unbiasedness, which asserts that the forward exchange rate accurately predicts the future spot rate, provided that there are no arbitrage opportunities. In well-functioning markets, forward rates incorporate all available information on expected currency movements, allowing investors to use forward contracts as effective hedging tools. However, if UIP fails, forward rates may not accurately predict future spot rates, limiting their utility for risk management in currency markets (Chaboud and Wright, 2005).

1.2. The UIP model

Considering an example scenario of a Vietnamese investor living in Vietnam. They could either choose to invest in their domestic nation or opt for a common option in ASEAN region, the USA.

For they, under the assumption of no additional risk in investment and everything is known in advance, terms are defined as follow:

- i_t: interest rate in Vietnam
- i_t^*: interest rate in the USA
- S_t: Spot exchange rate
- S_{t+1}^e: Expected exchange rate
- X: the amount of Vietnamese dong (VNĐ) the investor has to invest

Everyday, the investor have been facing two investing options:

Firsyly, they could invest domestically. Vietnamese investor can borrow an amount **X** in VND and invest domestically in an interest-bearing asset in Vietnam at the current interest rate in Vietnam $\boldsymbol{i_t}$**.** With time, they will receive **X(1+**$\boldsymbol{i_t}$**)** VND.

Alternatively, they can also convert amount of **X** VND to USD at the spot exchange rate $\boldsymbol{S_t}$, which give them $\frac{\boldsymbol{X}}{\boldsymbol{S_t}}$ USD. Investing this amount to an interest-bearing asset $\boldsymbol{i_t^*}$ in the USA. With time, the investment can grow to $\frac{\boldsymbol{X(1+i_t^*)}}{\boldsymbol{S_t}}$ USD. If they convert back to VND using the future expected exchange rate S_{t+1}^e. The final amount in VND is: $\frac{\boldsymbol{X(1+i_t^*)S_{t+1}^e}}{\boldsymbol{S_t}}$

For the condition of UIP to hold (no arbitrage):

$$\frac{X(1+i_t^*)S_{t+1}^e}{S_t} = X(1+i_t)$$

Cancelling **X** from both sides, the UIP condition can be written as:

$$\frac{S_{t+1}^e}{S_t}(1+i_t^*) = (1+i_t)\ (1)$$

Then, we can take logarithms of both sides of Equation (1). Where log(S) = S. Equation (2) indicates that the disparity in interest rates serves as an approximation for the anticipated variation in the exchange rate.

$$S_{t+1}^e - S_t = i_t - i_t^*\ (2)$$

We could measure S_{t+1}^e. By definition,

$$S_{t+1}^e = S_{t+1} + \varepsilon_{t+1}$$

With ε_{t+1} as the expected error. However, future exchange rate cannot be directly defined, UIP is normally tested under the condition of participants' rational expectation – that $E(\varepsilon_{t+1}) = 0$. Therefore, equation (2) is transformed to:

$$\Delta S_t = S_{t-1} - S_t = i_t - i_t^* \ (2)$$

1.3. Empirical evidence on UIP in Developed Markets

Existing empirical research on UIP has yielded mixed evidence, conducting with a variation of time periods, countries and methodologies. In fact, a large amount of discussion in this topic have been focusing on the developed countries. Researchers often found the UIP hypothesis to be myth with many evidenced its invalidity. This is the "Forward premium puzzle", that countries with higher interest rate, actually experience appreciating curries rather than depreciating. (Lothian, 2016)

A significant body of literature challenged UIP, including a recent sophisticated study by Afat & Frommel (2011), who strongly refute the UIP hypothesis across two substantial panel data: Panel 1 of U.S dollars against currencies of 18 countries and panel 2 of 32 cross currencies in total 9 countries. Even when it comes to Asia and the Pacific (Australia, China, Hongkong, New Zealand and more), the evidence for UIP is scarce (Chantapacpedong et al., 2017). Unconventional monetary policies in these advanced economies such as Quantitative easing (QE) and negative interest rate policies (NIRP) in the U.S and Japan exacerbated the deviation of UIP, leading to more carry trade activities. Studies such as Afat and Frömmel (2021; Bagdatoglou and Kontonikas, 2009; Chinn and Meredith, 2005; King, 1998; Macchiarelli, 2011) also have rejected UIP under various methodologies and sample condition.

However, many studies suggest the otherwise, However, many other studies the otherwise, pinpointing that UIP is not a theoretical fallacy but can be empirically justified under certain contexts. King (1998) found that the UIP holds between New Zealand and Australia, thanks to their high level of capital mobility between the two countries. No evidence was found for other countries. Another aspect that might verify UIP is the time horizon. While UIP is generally rejected over a long-run time horizons, it holds validity in a very short windows that coincide with the time of discrete interest payments (Chaboud and Wright, 2005). Aligning with them, the study by Aziz (2024) indicates that when examining intermediate and short-term interest rates, the UIP is actually

empirically valid. However, it is only true when accounting for the exchange rate regime and capital control. However, Chinn and Meredith (2005); Lothian, (2016); Lothian and Wu (2011) suggest the opposite. Analyzing a multi-country panel with 17 countries, the findings suggest short-term anomalies may distort empirical results but it tends to assert itself over longer period (Lothian (2016).

Amidst various discussing aspects of UIP, the study focus on testing UIP in the most fundamental approach due to a lack of studies in the region by employing monthly interest and exchange rate.

Table 1: Summary of literature papers

Author	Period	Region	Methodology	Key causality/findings
Aziz (2024)	1995 to 2017	18 OECD countries	Panel estimation techniques (pooled OLS and FEM)	UIP holds under floating exchange rates and capital controls for short-term interest rates.
Lothian and Wu (2011)	1791 to 1999	USA, The UK and France	forward-premium regressions, rolling window regressions, and alternative tests	UIP is stronger over long periods and with large interest differentials; deviations often due to market frictions.
Chinn and Meredith (2005)	1980Q1 to 2000Q4	United States, Germany, Japan, Canada	Generalized Method of Moments (GMM) estimators	UIP fails at short horizons but approaches unity over longer periods, attributed to variable endogeneity.
Orellana and Pino (2021)	1992Q2 to 2011Q4	45 countries, (35 high-income; 10 middle-income)	Gravity panel model	UIP holds in high-income economies, not in middle-income countries, influenced by macroeconomic variables.
Lothian (2015)	different duration	17 countries (developed)	Multi-country panel analysis	UIP is supported over the long term for bond yields,

	for each country			indicating a positive relationship across currencies.
Chaboud and Wright (2005)	1988 to 2022	United States, Japan, Germany, Switzerland, and the UK	Uncovered interest parity (UIP) regression	UIP holds during short intervals around interest payments but fades over longer periods except for large differentials.
King (1998)	1987Q2 to 1995Q4	New Zealand	Ordinary Least Squares (OLS) regression	UIP holds between New Zealand and Australia but is rejected for other major currencies due to risk premiums.
Macchiarelli (2011)	1975 to 2008	USA, UK, and Japan.	Vector Autoregression (VAR) approach	UIP is currency-dependent with forward premium bias, highlighting macroeconomic influences over time horizons.
Afat and Frömmel (2021)	2009M1 to 2016M10	Panel 1: USD against 18 currencies Panel 2: 32 cross currency rates of 9 countries	Panel ARDL estimator and the Westerlund cointegration test	Both UIP and AUIP are unsupported, with deviations not solely due to risk premiums.
Bagdatoglou and Kontonikas (2009)	1970 to 2008	G7 countries	Autoregressive Distributed Lag (ARDL) bounds approach	RIP shows weak-form support but lacks strong-form, due to incomplete recovery from past instabilities.
Dąbrowski and Janus (2024)	1999 to 2019	Central and Eastern Europe (CEE)	Structural break analysis, GARCH error terms, Augmented	UIP inconsistencies in CEE economies are due to FX interventions and limited resilience to rare disasters.

			models with risk measures	
Chantapacpedong et al. (2017)	2001M1 to 2016M10	Asia and the Pacific	Fama regression model	Unconventional monetary policies affect UIP, with QE and NIRP leading to Fama beta changes and carry trade shifts.
Mehl and Cappiello (2009)	Early 1983 to mid-2006	Mature and emerging market Malaysia, Thailand, and Taiwan.	Standard Fama (1984) equation; Generalized Method of Moments (GMM)	UIP holds for dollar vs. mature economy currencies at long horizons; political and exchange risks affect emerging markets.
Tang (2011)	1978Q1 to 2008Q4	ASEAN-5	Fynamic OLS (DOLS); Fully modified OLS (FMOLS)	UIP holds only for Singapore among ASEAN-5, indicating varying financial integration levels and arbitrage opportunities.

(Source: author's own work)

1.4. UIP in the emerging markets and existing research gaps

Despite the vibrant, multi-facet conversation in the developed world, the opposite is true for the emerging economies. While there is limited discussion of UIP in developing world, many studies have highlighted the developmental level as a sensitive factor to be in consideration when testing UIP. When investigating the UIP theory in both high-income and middle-income economies, Orellana and Pino (2021) discovered the validity of UIP only in nations with high income levels, suggesting market inefficiencies and lack of information asymmetries as behind rejection for the other group. They indicated that the interest rate differential is heavily impacted by macroeconomic factors such as fiscal deficit, inflation, exchange rate regime and levels of economic freedom. Other studies also stressed the importance of testing different economical level independently as institutional and structural differences in emerging economies, such as poorer macro-economic fundamentals and higher political risk, could lead to deviation from UIP as factor such as higher

risk premiums, capital flow restrictions, and managed exchange rates in emerging markets may hinder UIP's validity. (Mehl and Cappiello, 2009)

It points out that findings from developed countries often do not translate well to emerging markets, indicating significant heterogeneity in UIP outcomes. Thus, it is of studying UIP in regions with developing financial market, such as ASEAN, where international capital flows and government interventions play a dominant role. (Ferreira and Kristoufek, 2020)

Among the few studies in the developing world, evidences are often found in larger economies with certain level of financial integration. (Afat and Frömmel, 2021; King, 1998; Mehl and Cappiello, 2009) examines UIP in both mature economies and emerging market with currencies from Malaysia, Thailand and Taiwan. Their study found the presence of UIP in case of U.S dollar rates against major economy currencies at long and medium horizon, while the evidence is much weaker for emerging currencies. Similarly, in South East Asia, evidence for UIP was only found for Singapore and not for other ASEAN nations (Indonesia, the Philippines, Singapore, and Thailand) (Tang, 2011). Tang implied the varying degrees of financial liberalization and market efficiency among the ASEAN-5 countries to be a behind the mixed result. However, Tang's study did not fully for time-series dynamics or recent economic developments, such as the increasing capital mobility within the ASEAN region. Given the recent efforts of the region in building a more nuanced financial market integration and capital mobility within the region and word wide, it is urgent to explore the dynamics the UIP in the region once again.

1.5. Factors behind UIP deviations

Several factors have been proposed to explain the failure of UIP, including time-varying risk premium, incomplete financial liberalization, market inefficiencies, structural breaks and economic volatility, non-rational expectation, transaction cost and carry trade strategies and more.

Firstly, various studies have cited time-varying risk premium as a the main behind UIP deviation (Afat and Frömmel, 2021; King, 1998; Mehl and Cappiello, 2009). In theory, UIP assumes risk neutrality among investors, with exchange rate expectations aligning directly with interest rate differentials. However, in practice, investors demand a risk premium to compensate for potential currency fluctuations and volatility in the local economy. For example, in developing economies like those in ASEAN, rapid economic shifts, policy changes, and external shocks create

an environment where risk premiums fluctuate frequently, causing deviations from the UIP condition.

Secondly, the degree of financial liberalization in a country can significantly impact the validity of UIP. Incomplete liberalization can restrict capital flows and limit the integration of domestic financial markets with international markets, resulting in a failure to achieve the expected parity. Under limited liberalization, financial market may be at risk of central banks' intervention in exchange rate management or capital controls can distort market-driven currency movements, preventing UIP from holding.

Thirdly, UIP also relies on the assumption of market efficiency; however, emerging markets like those in ASEAN often lack the market depth and liquidity found in developed economies. Market inefficiencies arise due to illiquidity, limited investor access, and the absence of fully developed financial instruments, which prevents asset prices from reflecting all available information (information asymmetry).

Fourthly, emerging markets like those in ASEAN also experience frequent structural breaks—sudden shifts in economic policy or global financial conditions that impact exchange rates. ASEAN countries, which have undergone extensive financial liberalization and institutional reforms in recent decades, face considerable volatility due to incomplete or inconsistent policy implementation. (Alper et al., 2009)

In this study, the author would like to focus on examining the factor of central bank intervention in the regional exchange market. While Vietnam has been following a managed float exchange rate regime and the remaining ASEAN countries utilize floating one, all these nations would tend to prioritize exchange rate stability or even depreciating exchange rate in order to attract foreign direct invest or avoid foreign debt shocks.

2. MODEL AND METHODOLOGY

2.1. Data

In order to verify whether the UIP is hold in ASEAN, this study harness data from International Monetary Fund (IMF). The author downloaded monthly data of interest rate and exchange rate for the period between January 2010 and December 2023 (13 years duration). The sample consist of five ASEAN middle-income countries: Vietnam, Thailand, Indonesia, Malaysia and the Philippines. The article conducts research on 5 countries with quite similar economies over a long period of time, in order to have more evidence and increase the reliability of the conclusions of the study.

Regarding exchange rate data, the study utilizes monthly exchange rates of domestic currencies against the US Dollars, as it is the not only a commonly traded coin in ASEAN but also world's dominant reserve currency in global trade.

Regarding interest rate data, money market rates are employed for most countries, as financial institutions are the primary arbitrageurs in these markets. For Indonesia and Vietnam, where interbank rate data is incomplete, deposit rates are used as proxies. These interest rates reflect short-term borrowing costs and are relevant for assessing potential arbitrage opportunities in the context of UIP.

2.2. Empirical model

Assuming rational expectations, the empirical model (2) can be written as:

$\Delta S_{t+1} = \alpha + \beta(i_t - i_t^*) + \epsilon_t$ (3)

Where:

- $\in_t$ represents a disturbance term
- i_t: Domestic interest rates
- i_t^*: Foreign interest rates (USD)
- ΔS_{t+1}: the exchange rate return

UIP holds when $\alpha = 0$ and $\beta = 1$

From equation (3) and provided data, we can calculate two main variables in our testing:

- The Interest rate differential x_t by subtracting domestic interest rate to foreign interest rate:

$$x_t = i_t - i_t^*$$

- The Exchange rate return y_t is the first difference in the exchange rate:

$$y_t = s_{t+1} - s_t = \Delta s_t$$

2.3.Estimation model

The empirical strategy begins with testing for stationarity of two variables utilizing two unit root root tests. Then, Toda-Yamamoto Granger causality test is conducted to estimate dependent variable in the next procedure – ARDL bounds test. This test will evaluate cointegration and test if condition of $\alpha = 0$ and $\beta = 1$ is satisfied for UIP validation.

2.3.1. Unit root test

While there exist various methods to test the stationarity level of time series, this study will make use of extended Dickey – Fuller (ADF) and Phillips – Person (PP) test. In Eviews12, the Unit Root Test is used to test the stationarity of time series based on the ADF test and PP test. Hypothesis pair is as followed:

H_0: Variable series is non-stationary (series has unit roots)

H_1: Variable series is stationary

The H_0 hypothesis is rejected under the conditions that the absolute statistical test value is greater than the critical value and p-value < α. The α significance level can be 1%,5% or 10%. If the vice versa is true, the H_0 hypothesis will be accepted, meaning the data series is not stationary. If the variable is stationary at level 0, it is denoted by I(0) or the variable is stationary at level 1, it is denoted by I(1).

According to Pesaran et al. (2001a) the ARDL model does not require the variables to be stationary series because the test is flexible and accept stationarity at level I(0), first difference I(1) or a combination of both. However, stationary level of second difference I(2) is not accepted. To ensure that the variables satisfied the testing condition, we execute the unit root tests.

2.3.2. Toda-Yamamoto Granger Causality

Introduced by Toda and Yamamoto in 1995, T-Y procedure is an adaptation of the standard Granger causality test that assess the direction of texting between the two variables without the need for prior testing for stationarity or cointegration.

The test involves two time series, with X representing the exchange rate returns and Y for interest rate differentials. X is said to Granger-cause Y if the future values of Y can be better predicted using the past values of both X and Y than it can by using the past values of Y alone.

In this research, the TY procedure is applied to explore the dynamic causal relationship between the two mentioned variables. By estimating a Vector Autoregression (VAR(p + $dmax$)) model, this approach can identify of whether changes in X results in changes in Y, or vice versa, or both. The outcomes of this test are subsequently used later to define the dependent variable in the ARDL approach.

Many studies confirm that the Toda- Yamamoto procedure offers several advantages over the traditional Ordinary Granger Causality test:

Reduced Risk of Asymptotic Bias: By estimating the VAR model at the maximum order of integration (d_{max}), the procedure avoids the need to transform the VAR model into a Vector Error Correction Model (VECM). This helps correct for potential asymptotic bias, which can occur when causality tests are conducted on non-stationary data or data without cointegration.

Flexibility with Arbitrary Integration Orders: The TY approach can handle variables with different levels of integration thus eliminates the risk of misidentifying the integration order of the variables.

The Toda-Yamamoto procedure of Granger Causality starts with the estimation of Maximum Order of Integration (d_{max}). This can be done conducting unit roots test (ADF and PP tests) for variables' stationary level. If both variables are stationary at their levels I(0), $d_{max} = 0$. In case of a combination between I(0) and I(1), d_{max} will be 1.

At the same time, the optimal lag length (p) is identified by 4 information criteria tests (AIC, FPE, SC, HQ). To make a valid model, k should be greater than or equal to d_{max} ($k \geq d_{max}$). With d_{max} and p established, Toda-Yamamoto procedure can be tested with the Wald test in the following bivariate VAR (p+d_{max}) model:

$$X_t = \alpha_0 + \sum_{i=1}^{p+d_{max}} \alpha_i X_{t-i} + \sum_{j=1}^{p+d_{max}} \beta_j Y_{t-j} + \mu_t \quad (4)$$

$$Y_t = \gamma_0 + \sum_{i=1}^{p+d_{max}} \gamma_i Y_{t-i} + \sum_{j=1}^{p+d_{max}} \delta_j X_{t-j} + \vartheta_t \quad (5)$$

In the formula:

- α_0 and γ_0 are the intercepts
- α_i, β_j, γ_i and δ_j are the coefficients for the lags of X_t and Y_t
- μ_t and ϑ_t are error terms

Hypothesis for Causality from X_t to Y_t are as follows:

- Null hypothesis (H_0): $\beta_1 = \beta_2 = \cdots = \beta_p = 0$
  The interest rate differential X_t does not Granger cause the exchange rate return Y_t
- Alternative hypothesis (H_A): $\beta_i \neq 0 \; for \; j = 1,2, \ldots, p$
  The interest rate differential X_t Granger causes the exchange rate return Y_t

Hypothesis for Causality from Y_t to X_t is similar:

- Null hypothesis (H_0): $\gamma_1 = \gamma_2 = \cdots = \gamma_p = 0$
  The interest rate differential Y_t does not Granger cause the exchange rate return X_t
- Alternative hypothesis (H_A): $\gamma_i \neq 0 \; for \; i = 1,2, \ldots, p$
  The interest rate differential Y_t Granger causes the exchange rate return X_t

The results can be either unidirectional causality (one-sided causality), bidirectional causality or no causality at all.

2.3.3. ARDL bound test

Once the integration order is confirmed, the ARDL model can be established to explore the potential long-run relationship and cointegration between X and Y.

Although the ARDL (Auto-Regressive Distributed Lag) model has been used for several decades, only recently has it become more popular in studies estimating long-run relationships among financial and macroeconomic variables. In addition, ARDL model is also used to test for cointegration relationships, estimate short-run and long-run relationships. It becomes particularly useful in cases where the model has variables that are a mixture stationary level smaller than I(2). ARDL bound test (F Bound test) is used to assess whether a long-run relationship exists.

ARDL model is a combination of the VAR (vector autoregression) model and the OLS (ordinary least squares regression) model. According to Aydin (2000), the ARDL model is recognized for its success, flexibility, and user-friendliness in analyzing multivariate time series

data. Furthermore, it facilitates the assessment of how independent variables influence the dependent variable (Chen, 2007; Pesaran et al., 2001a).

General form of ARDL model:

$$\Delta Y_t = \alpha + \sum_{i=1}^{p_0} \beta_{i0} \Delta Y_{t-i} + \sum_{j=1}^{p_1} \beta_{j1} \Delta X_{t-j} + \gamma_0 Y_{t-1} + \gamma_1 X_{t-1} + \epsilon_t \quad (6)$$

According to Pesaran and Pesaran (1997), the ARDL model has several advantages:

(1) Comparing to Joahansen cointegration technique, the ARDL approach is a more statistically robust method for testing cointegration in small samples.

In contrast to traditional models that seek to identify long-term relationships, the ARDL model focuses on estimating a single equation rather than a system of equations.

While various cointegration methods require the regressors to be included with identical lags, the ARDL model allows for the regressors to have different optimal lag lengths

If there is no guarantee of unit roots or usability of the data series, the level of linkage I(0) or I(1) then applying the ARDL procedure is most suitable for empirical research.

In order to carry out the ARDL method, the first step is to assess the stationarity of variables. Once the variables are confirmed to be suitable, Bound test can be conducted to test the existence of a cointegration relationship between variables, that if there is a long-run relationship between the two variables. The hypotheses are as follows:

H_0: There is no long-term relationship between the variables

H_1: There is a long-term relationship between the variables

Comparing the F statistic value to lower bound value I(0) and the upper bound value I(1), there are three possible outcome: if the F-statistic is below the lower bound (I(0)), the null hypothesis of no long-term relationship is accepted; if it exceeds the upper bound (I(1)), the null hypothesis is rejected, confirming a long-term relationship; if the F-statistic falls between the bounds, the results are inconclusive.

Next, determine the optimal lag length for the model by applying criteria like Akaike Information Criterion (AIC) or Schwarz-Bayesian Criterion (SBC), which help ensure the residuals are normally distributed and free from autocorrelation and heteroscedasticity. The smaller the value of AIC (SBC), the better the model fits.

After that, the main stage of the approach – Bound test is analyzed to see if the long-term cointegration exists in the dataset. In case of the existence of long-term relationship, an error correction model (ECM) must also avail to capture short-term adjustments towards the long-run equilibrium. In addition, to be sure of the adjustment, the ECM term must have significant p-value ($p<0.05$) and a negative coefficient (ranging from -1 to, indicating the speed at which the model corrects back to equilibrium after a short-term deviation.

3. EMPIRICAL RESULTS

3.1. Descriptive graph

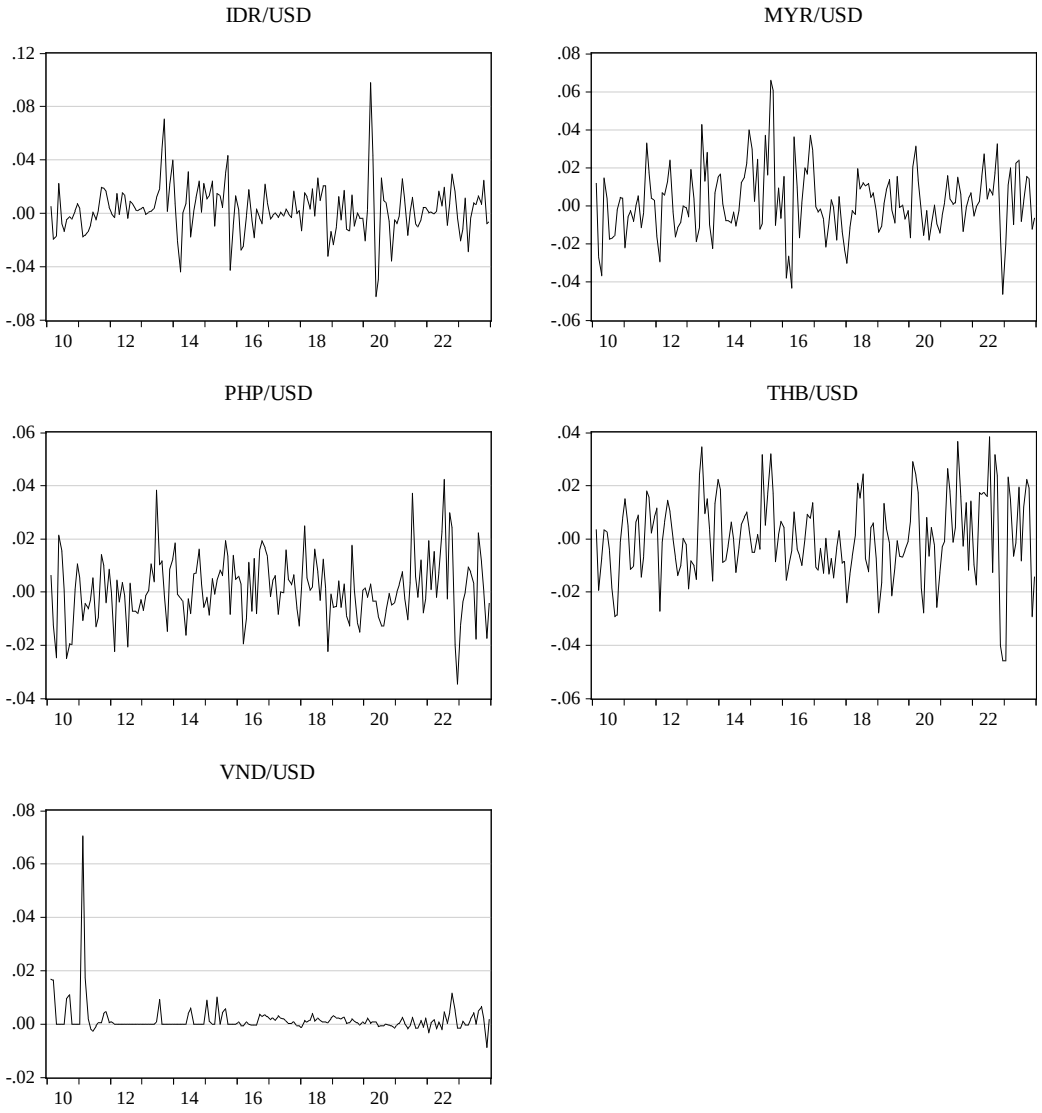

Figure 1: The monthly exchange rate return between 2010-2023

(Source: author's calculations with Eviews12)

We observe varying levels of volatility across the ASEAN countries from 2010 to 2023. Indonesia, Malaysia, the Philippines, and Thailand show significant fluctuations, indicating a higher sensitivity to market changes and external shocks. These fluctuations may be attributed to economic events, trade imbalances, and varying degrees of market intervention and capital flow management within each country. Vietnam, on the other hand, appears more stable than the others.

This relative stability can likely be explained by Vietnam's managed or partially fixed exchange rate system, where the Vietnamese central bank intervenes to reduce large fluctuations, thereby maintaining more stable exchange rate returns.

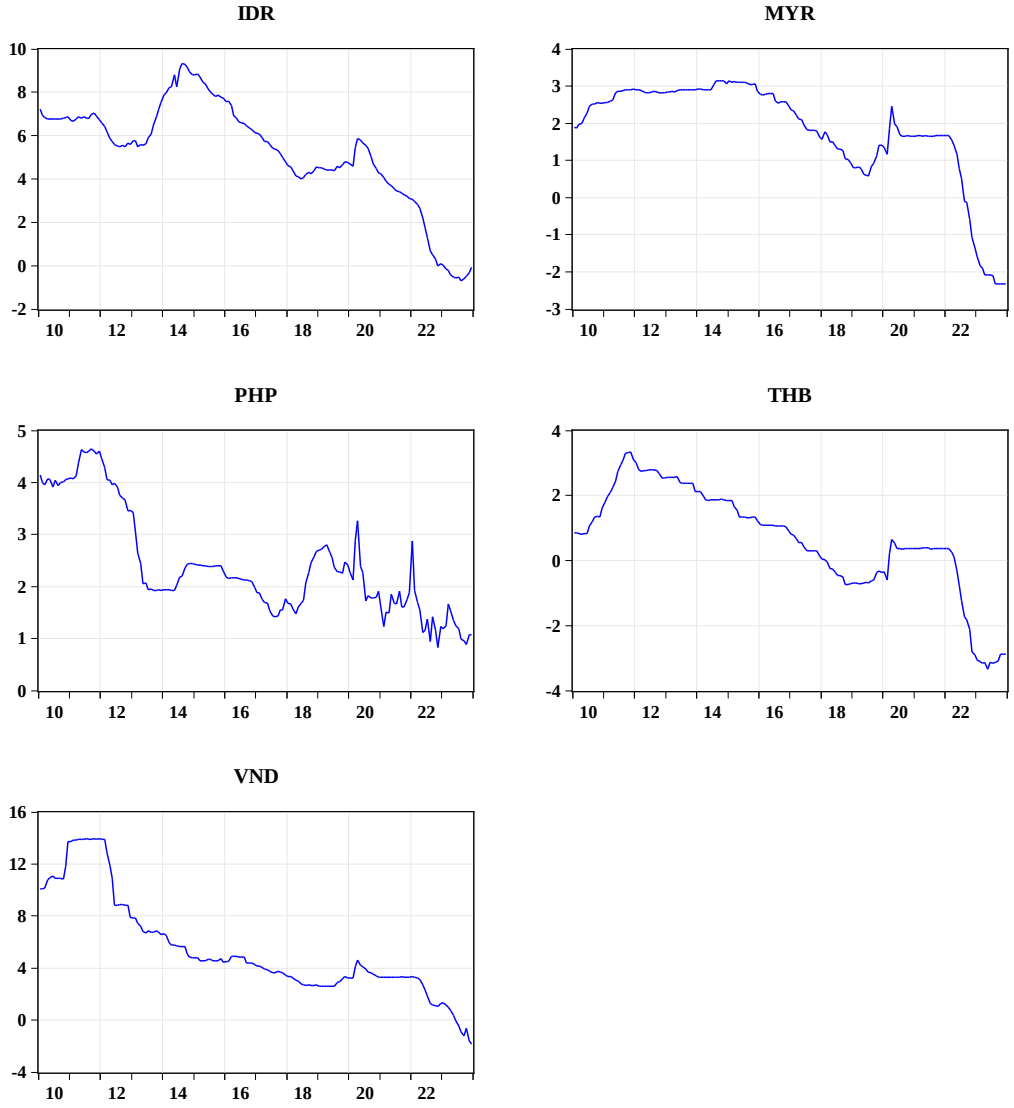

Figure 2: The interest rate differential of local currency against US dollars
(Source: Author's calculations with Eviews12)

Figure 2, which shows the interest rate differential between each ASEAN currency and the U.S. dollar, several trends align with key periods of U.S. Federal Reserve policy shifts. Notably, during periods of monetary policy tightening by the Federal Reserve—such as in 2015–2018 and the recent interest rate hikes starting in 2022—the interest rate differential tended to widen, as U.S.

interest rates increased to counter inflationary pressures. This tightening made U.S. assets relatively more attractive, likely affecting capital flows and increasing pressure on ASEAN currencies, as seen in rising differentials. Conversely, during periods of monetary easing, such as the aftermath of the 2008 financial crisis and again in response to the COVID-19 pandemic in 2020, the Federal Reserve lowered interest rates to stimulate economic growth. These easing phases generally narrowed the interest rate differential, as ASEAN countries either maintained stable rates or adjusted their own policies.

3.2. Unit Root Tests

Our investigation begins with tests for stationarity level of the two time series. In order to increase the robustness of the variables, two types of unit root tests, ADF and PP are performed. Although it might not compulsory to test stationarity for TY Granger procedure, the results are used for determining the order of integration ($dmax$) in the VAR(p+$dmax$) model. Also, it ensures no variable is at second difference stationarity I(2) to execute the ARDL model.

Table 2: Result of Unit Root Tests

Variables	ADF test		PP test		Order of Integration
	Level	First Difference	Level	First Difference	
The exchange rate return $y_t = s_{t+1} - s_t$					
Δln(IDR/USD)	-10.588(1)***	-	-10.044(5)***	-	I(0)
Δln(MYR/USD)	-8.263(1)***	-	-8.775(5)***	-	I(0)
Δln(PHP/USD)	-10.086(0)***	-	-9.997(4)***	-	I(0)
Δln(THB/USD)	-8.847(1)***	-	-8.405(10)***	-	I(0)
Δln(VND/USD)	-10.347(1)***	-	-9.625(10)***	-	I(0)
The interest rate differential ($x_t = i_t - i_t^*$)					
$r^{IDR} - r^{USD}$	-0.481(3)	-4.853(2)***	-0.139(8)	-11.832(7)***	I(1)
$r^{MYR} - r^{USD}$	-0.521(6)	-3.036(1)**	-1.392(6)	-11.512(6)***	I(1)
$r^{PHP} - r^{USD}$	-1.406(0)	-12.577(0)***	-1.425(4)	-12.574(6)***	I(1)
$r^{THB} - r^{USD}$	-1.271(6)	-3.033(5)**	-0.085(7)	13.162(7)***	I(1)
$r^{VND} - r^{USD}$	-0.332(1)	-9.033(0)***	-0.298(5)	-8.996(3)***	I(1)

Note: ** and *** denote significant at 5% and 1% levels

(Source: author's calculation in Eviews 12)

Table 2 compiles the stationarity test results of two time series series from January 2010 to December 2023. Comparing with critical values, the test results provide evidence that ERR are stationary at its level, yt ~$I(0)$ while the IRD are stationary at first difference, xt ~$I(1)$. Given this hybrid integration order, both I(0) and I(1), our data is suitable for applying both the Toda-Yamamoto Granger causality test and ARDL bounds tests in the next sections.

ARDL bounds testing is employed to investigate cointegration and dynamic causal relationships between yt and xt (Pesaran et al., 2001b). T-Y procedure are applied to specify the dependent variable in the ARDL model.

3.3. Toda-Yamamoto Granger Causality Tests

The T-Y Granger approach is applied to determine the direction of causality between x_t (interest rate differential) and y_t (exchange rate return).

The first step in the Toda-Yamamoto procedure is to estimate the maximum order of integration ($dmax$) is relevant to augment VAP(p) to derive the augmented VAR(p+$dmax$). The results presented in Table 2 indicated the highest order of integration is one (1). This implies

$dmax$ = 1; the VAR model will on extra lag.

Next, in order to estimate the optimal lag order p, Lag order selection criteria including LR, FPE, AIC, SC, and HQ is employed. Table 3 below summarize the lag length selection result.

Table 3: Lag length selection results.

Country	Indonesia	Malaysia	Philippines	Thailand	Vietnam
Lag length p	4	1	1	3	3

(Source: author's calculation in E-Views 12)

Applying the Wald Tests for the bivariate VAR (p+d_{max}) model (4) and (5) and conduct the interference on Granger Causality. The test follows the chi-square distribution with corresponding degrees of freedom in accordance with chosen lag length. **T**able 4 summarized the findings

Two null hypotheses are tested including:

(1) The IRD does not Granger cause the ERR ($x_t \rightarrow y_t$).
(2) The ERR does not Granger cause the IRD ($y_t \rightarrow x_t$).

Table 4: Result of Granger Non-Causality Wald Tests

Null Hypothesis (H0): The interest rate differential does not Granger cause the exchange rate return

	Chi-square	p-value	Conclusion
Indonesia	3.556(4)	0.470	Fail to reject
Malaysia	0.003(1)	0.959	Fail to reject
The Philippines	5.020(1)	0.025	Reject
Thailand	10.850(3)	0.013	Reject
Vietnam	9.482(3)	0.024	Reject

Null Hypothesis (H0): The exchange rate return does not Granger cause the interest rate differential

	Chi-square	p-value	Conclusion
Indonesia	12.427(4)	0.014	Reject
Malaysia	2.717(1)	0.099	Fail to reject
The Philippines	1.707(1)	0.191	Fail to reject
Thailand	2.092(3)	0.554	Fail to reject
Vietnam	3.582(3)	0.310	Fail to reject

Based on the results shown in the table 4, the first hypothesis can be rejected for the Philippines, Thailand and Vietnam, suggesting that the interest rate differential x_t Granger cause the ERR y_t. However, the second hypothesis could not be rejected, thus rejecting the existence of Granger-causality of ERR to interest rate differential. In short, for Philippines, Thailand and Vietnam, the results indicate a unidirectional causality ($x_t \rightarrow y_t$). In Indonesia, the first hypothesis could not be rejected while the second one is rejected, indicating a unidirectional causality ($y_t \rightarrow x_t$) that the exchange rate return Granger cause the IRR. However, neither of the two null hypothesis is rejected in the case of Malaysia, suggesting no causality relationship between two variables in this case.

In short, the Granger causality runs from x_t to y_t but not vice versa in Philippines, Thailand and Vietnam. The Granger causality runs from y_t to x_t but not vice versa in Indonesia. No Granger causality in either direction in Malaysia The findings are utilized to specify the dependent variable for the ARDL approach in the next section.

3.4. ARDL Bound Tests

3.4.1. Bound tests

As the stationarity level of x_t (IRD) and y_t (ERR) is a combination of stationarity level I(0) and first difference I(1), ARDL Bound tests is suitable to examine this dataset.

According to T-Y Granger causality test result, because the exchange rate return (y_t) Granger-causes the IRR (x_t) in Indonesia, x_t is the dependent variable in the bound test (7). On the opposite, since the IRR Granger-causes the exchange rate return in the Philippines, Thailand and Vietnam, y_t is the dependent variable in equation (7'). In case of Malaysia, we consider x_t as the dependent variable at default.

From the original model (6), the error correction form of the ARDL for Indonesia can be written as:

$$\Delta x_t = \alpha_0 + \theta_0 \tau + \sum_{i=1}^{p-1} \alpha_i \Delta x_{t-i} + \sum_{j=0}^{q-1} \beta_{j1} \Delta y_{j-i} + \theta_1 y_{t-1} + \theta_2 x_{t-1} + \mu_t \quad (7)$$

The error correction form of the ARDL for the Philippines, Thailand and Vietnam:

$$\Delta y_t = \alpha_0 + \theta_0 \tau + \sum_{i=1}^{p-1} \alpha_i \Delta y_{t-i} + \sum_{j=0}^{q-1} \beta_{j1} \Delta x_{j-i} + \theta_1 y_{t-1} + \theta_2 x_{t-1} + \mu_t \quad (7')$$

Where:

- p = 0,1,2,…,i; q = 0,1,2,…,j
- Δ is first difference
- τ is trend variable
- μ_t is white noise

Bounds test hypothesis is as followed:

$H_0: \theta_1 = \theta_2 = 0$ $(no\ cointegration)$
$H_1: At\ least\ one\ \theta_i \neq 0$

Since the ARDL model is estimated by the OLS regression method, the selection of the optimal model must be based on different model selection criteria. In this study, the AIC criterion is used to decide the model with the optimal lag for each variable if the AIC value of that model is the smallest. Based on the AIC criterion to select the optimal lag of the model, the optimal lag result of the ARDL model is as follow:

Table 5: AIC criterion of 5 model corresponding to 5 countries

Indonesia	Malaysia	The Philippines	Thailand	Vietnam
ARDL(4,0)	ARDL(4,0)	ARDL(1,1)	ARDL (2,0)	ARDL(1,3)

(Source: author's own calculation with Eviews 12)

Bound test results are shown in Table 5. It can be inferred that computed F statistic for Indonesia, the Philippines, Thailand, and Vietnam exceeds both the lower critical value I(0) and the upper critical value I(1) at the 5% significance level. Consequently, H_0 is rejected in these countries and it can be derived that there exists a long-run relationship between x_t and y_t. However, Malaysia does not demonstrate a significant cointegration based on the bounds test as its F-stat is lower than both bound barriers.

Table 6: Results of Bound Tests

	With restricted constant			With restricted trend		
	Computed F-stat.	The 5% critical value		Computed F-stat.	The 5% critical value	
		I(0)	I(1)		I(0)	I(1)
x_t as the dependent variable						
Indonesia				6.517	6.290	6.290
Malaysia				2.550	6.290	6.290
y_t as the dependent variable						
The Philippines	50.843	3.020	3.510			
Thailand				31.037	6.290	6.290
Vietnam				25.888	6.290	6.290

(Source: author's calculation)

3.4.2. Cointegration relationship

It is highlighted that the study wants to test UIP's validity among ASEAN-5 countries with the null hypothesis of $\alpha = 0$ and $\beta = 1$. However, it is denied in all countries. The coefficients in the long-run equations reflect how IRD impact ERR or vice versa in each country.

For the Philippines, the equation with coefficient −0.2019 implies that a 1% increase in ERR leads to a 0.2019% decrease in the IRR, indicating an inverse relationship between these variables. This negative relationship may reflect the influence of external shocks or interventions that offset IRD with opposite adjustments in exchange rates, dampening the UIP mechanism. The

positive coefficient on τ (0.5467) suggests a slower adjustment rate towards equilibrium, with only about 54.7% of the adjustment occurring per period.

Table 7: Cointegrating Relationship

Indonesia	x_t	=	$2.0730y_t$	$-\ 0.0530\tau$
			(1.2309)	(0.0188)
Malaysia	NA			
The Philippines	y_t	=	$-0.2019\ x_t$	$+\ 0.5467$
			(0.0288)	(0.2426)
Thailand	y_t	=	$0.2223\ x_t$	$+\ 0.0085\tau$
			(0.1400)	(0.0045)
Vietnam	y_t	=	$-0.0543\ x_t$	$-\ 0.0040\tau$
			(0.0263)	(0.0020)

(Source: Author's own calculation with Eviews 12)

For Indonesia, the coefficient of 2.0730 indicates that, over the long term, a 1% rise in the IRR between Indonesia and the United States is associated with a 2.073% increase in the returns on Indonesia's exchange rate. This suggests a strong sensitivity of ERR to interest rate disparities, meaning that higher domestic interest rates relative to the U.S. could lead to appreciable gains in ERR, potentially reflecting capital inflows attracted by the higher yield in Indonesia's financial market. The negative coefficient on τ (-0.0530) indicates the speed of adjustment toward equilibrium, meaning that about 5.3% of any disequilibrium error is corrected each period, guiding the exchange rate back to the long-run relationship.

The cointegration equation for Thailand shows a positive coefficient for x_t, meaning that a 1% increase in ERR is associated with a 0.2223% increase in the IRR. This relationship aligns more closely with the UIP theory, where higher expected returns on exchange rates (ERR) are accompanied by an increase in interest rate differential (IRD). The adjustment term τ (0.0085) is small, indicating a very slow adjustment process towards the long-term equilibrium.

The equation for Vietnam presents a negative coefficient for x_t , suggesting that a 1% increase in ERR causes IRR to reduce by 0.0543%. Similar to the Philippines, this inverse relationship may imply that other economic factors, such as central bank intervention or external capital flows,

counterbalance the effect of IRD on exchange rates. The small negative adjustment term τ (-0.0040) suggests a minimal adjustment towards equilibrium each period, indicating a stable long-term relationship with limited short-term fluctuation.

To sum up, in Indonesia and Thailand, a positive relationship between ERR and IRD aligns more closely with UIP predictions, indicating that exchange rates increase in response to rising domestic interest rates relative to U.S. rates.

Meanwhile, for Philippines and Vietnam, negative relationship suggests that factors such as capital controls, central bank interventions, or external shocks may drive exchange rates in the opposite direction of what UIP would predict, reflecting unique economic dynamics or policy interventions in these countries.

The τ coefficients vary widely, with Indonesia showing faster adjustment and Vietnam showing slower correction of deviations. Faster adjustments indicate more efficient markets or less intervention, while slower adjustments might point to capital controls or deliberate policy interventions to stabilize exchange rates

3.4.3. Error Correction Model

Since there exists a long-term cointegration between variables for 4 countries: Indonesia, Vietnam, Thailand, the Philippines, an error correcting model (ECM) must be established to demonstrate the short-term relationship. From ECF equation (7) and (7'):

ECM for Indonesia can be written as:

$$\Delta x_t = \alpha_0 + \sum_{i=1}^{p-1} \alpha_i \Delta x_{t-i} + \sum_{j=0}^{q-1} \beta_{j1} \Delta y_{j-i} + yz_{t-1} + \mu_t \quad (8)$$

The error correction form of the ARDL for the Philippines, Thailand and Vietnam:

$$\Delta y_t = \alpha_0 + \sum_{i=1}^{p-1} \alpha_i \Delta y_{t-i} + \sum_{j=0}^{q-1} \beta_{j1} \Delta x_{j-i} + yz_{t-1} + \mu_t \quad (8')$$

When:

- $y_t = (s_{t+1} - s_t)$
- $x_t = (i_t - i_t^*)$
- $z_{t-1} = (\theta_0 \tau + + \theta_1 y_{t-1} + \theta_2 x_{t-1})/y$
- μ_t: white noise

From the estimates result presented for the short run in Table 8, generally, there exist short-term relationships between IRR and exchange rate return. (Exchange rate returns in Malaysia follow an AR(2) process).

The error correction term, z_{t-1} indicate how long does it take to adjust back to long-term equilibrium until the next term. Except for Malaysia, for the other four countries, the coefficients z_{t-1} are negative and with absolute value smaller than 1. They are also highly significant with p-value of 0.0000, indicating it is statistically significant. The Philippines, Thailand, and Vietnam exhibit a faster adjustment speed of y_t, with over 80% of disequilibrium corrected within a month. Therefore, investors must stay informed and adaptable to the frequent changes.

Applying these results, the existence of a long-run cointegration relationship suggests that UIP holds in a limited form for some ASEAN countries (such as Thailand, the Philippines, and Vietnam). This finding implies that IRRs can, over the long term, be balanced by exchange rate movements, aligning with UIP theory. However, deviations in the short term indicate that factors such as market imperfections, capital controls, or central bank interventions might prevent UIP from holding perfectly in the short run. Thus, while UIP may approximate long-run behavior, in practice, short-term fluctuations and interventions disrupt its validity, requiring further investigation into structural or policy-driven reasons behind these deviations.

In term of model diagnostics, the Adjusted R^2 indicates the proportion of short-term variation that can be explained by the model. The adjusted R^2 is high for Vietnam (0.760), medium for Thailand (0.454), Philippines (0.516) and low in the other two nations, suggesting that the model explains 75%, 45.4% and 51.6% of the variation in Δy_t

Serial correlation LM Test is also conducted to check for autocorrelation in the residuals. The p-value for the LM test is high in all nations, indicating no evidence for serial correlation. It can be concluded that the model is relatively stable.

Table 8: Error Correction Form of the ARDL UIP Equation in 5 countries

Indonesia

Dependent variable: Δx_t

Regressor	Coefficient	Standard Error	p-value
z_{t-1}	-0.020	0.005	0.000
Δx_{t-1}	0.024	0.076	0.748
Δx_{t-2}	0.326	0.071	0.000
Δx_{t-3}	0.217	0.075	0.004
Δy_t	0.020	0.008	0.016
c	0.377	0.091	0.000

Adjusted $R^2 = 0.210$; Serial Correlation L.M. Test: Prob. F(6,153) = 0.662

Malaysia

Dependent variable: y_t

Regressor	Coefficient	Standard Error	p-value
y_{t-1}	0.331	0.076	0.000
y_{t-2}	-0.157	0.074	0.035
c	0.099	0.121	0.417

Adjusted $R^2 = 0.221$; Serial Correlation L.M. Test: Prob. F(6,156) = 0.353

Vietnam

Dependent variable: Δy_t

Regressor	Coefficient	Standard Error	p-value
z_{t-1}	-0.812	0.092	0.000
Δy_{t-1}	0.067	0.061	0.280
Δy_{t-2}	-0.071	0.051	0.164
Δx_t	0.013	0.111	0.904
Δx_{t-1}	-0.281	0.130	0.032
Δx_{t-2}	0.050	0.124	0.689
Δx_{t-3}	0.271	0.111	0.016
Δx_{t-4}	-0.172	0.110	0.121
Δx_{t-5}	0.001	0.107	0.994
Δx_{t-6}	-0.053	0.105	0.618
Δx_{t-7}	0.280	0.101	0.006
c	1.228	0.145	0.000

Adjusted $R^2 = 0.760$; Serial Correlation L.M. Test: Prob. F(6,142) = 0.966

Thailand

Dependent variable: Δy_t

Regressor	Coefficient	Standard Error	p-value
z_{t-1}	-0.849	0.087	0.000
Δy_{t-1}	0.172	0.075	0.023
Δx_t	0.383	0.566	0.500
Δx_{t-1}	-0.856	0.568	0.134
Δx_{t-2}	-1.701	0.560	0.003
c	-2.061	0.237	0.000

Adjusted $R^2 = 0.454$; Serial Correlation L.M. Test: Prob. F(6,150) = 0.755

The Philippines

Dependent variable: Δy_t

Regressor	Coefficient	Standard Error	p-value
z_{t-1}	-0.864	0.069	0.000

Adjusted $R^2 = 0.516$; Serial Correlation L.M. Test: Prob. F(6,154) = 0.390

(Source: Author's own calculations with Eviews 12)

3.5.What can explain UIP deviations in ASEAN?

As discussed in Kin-Boon Tang's research paper, the failure of UIP hypothesis can be attributed to various causes, such as market inefficiencies, exchange rate premium, incomplete financial liberalization, structural changes or time-varying risk premia. These factors collectively highlight the challenges in achieving a more integrating financial market in such emerging market like ASEAN. Among the aforementioned factors, the author chose to further investigate the financial liberalization factor, specifically central bank intervention.

Incomplete financial liberalization refers to the process of limiting, eventually dismantling regulatory control over different agents in the financial sector. As a region of varied political regimes, liberalizing the financial market completely might need more time and efforts as most nations in the region would prioritize exchange rate stability and capital controls for the sake of foreign direct investment or shielding domestic markets from external shocks. A clear sign of incomplete financial liberalization would be the intervention of authority and central bank.

To further test if central bank intervention is presence in the region, the study examines a period of FED's rate hike after the Covid-19 pandemic. In early 2022, driven by factors such as disrupted supply chain, labor shortages and high consumer demand, inflation accelerated in the U.S and spreading worldwide. In order to curb inflation, the Fed initiated a series of aggressive rate hikes. Over 2022 and 203, the Federal Open Market Committee raised the federal funds rate to over 5%.

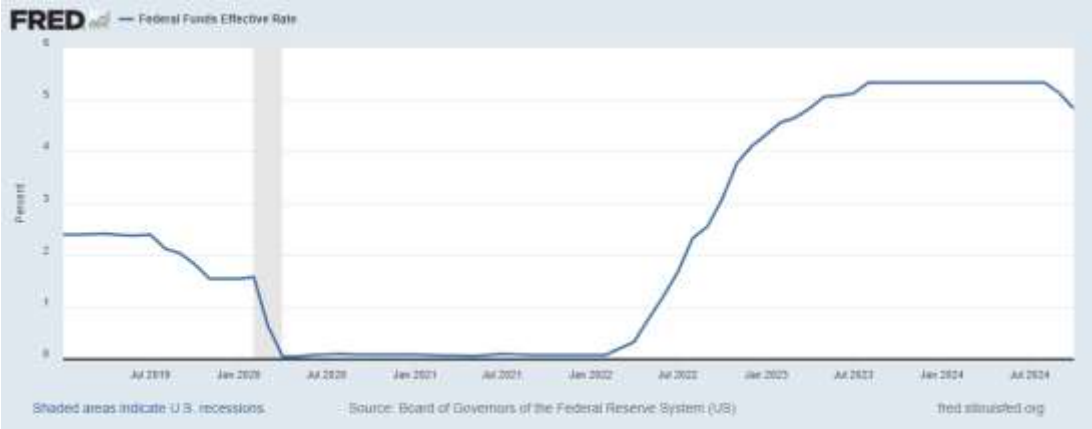

Figure 3: FED's rate hike

(Source: FRED website)

In response to the FED's rate hikes, central bank in ASEAN may possibly intervene in foreign exchange markets for the sake of currency and economic stability. To do that, central banks can use their foreign reserves to stabilize their currencies by selling U.S dollars and buying domestic currency, thus limiting currency depreciation. The change in Foreign Reserves can be used as a proxy representing the central bank's intervention.

Current account balance (CAB) can be utilized to measure the change in foreign reserves because it reflects the net flow of goods, services, income and current transfer into and out of an economy. When the FED raised interest rate, capital tends to flow from emerging markets like ASEAN to the U.S, driven by the appeal of higher yields. In such case, central bank would intervene by using foreign reserves.

Using 5 different approaches including Pooled OLS, Random Effect Model (REM), Cross-section fixed effects and Time-period Fixed effects the author run on panel data of foreign reserves as dependent variable and three independent variables, including current account balances (CA_{it}),

interest rate differentials (x_{it}), and its squared term ((x_{it}^2). The data is sourced from IMF from 2022 to 2024. The squared term of interest rate differential captures the non-linear relationship between interest rates and foreign reserves.

Result is presented in table 7. The Durbin-Watson (DW) test justified all models are reasonably well-specified without severe issues of serial correlation (all values are below 2, indicating positive autocorrelation). The CAB (CA_{it}) had positive and statistically significant effect across all models, suggesting that higher net exports and capital inflows correlate with increased foreign reserves. The IRR is positive and significant, suggesting that higher interest rates encourage capital inflows, thus boosting reserves. Its square coefficients are negative indicating diminishing returns, that extremely high IRRs may eventually reduce reserve accumulation, potentially due to capital outflow pressures or economic distortions.

Table 9: Regression results on foreign reserves

Dependent variable: *The change in foreign reserves*

Regressor	Pooled OLS	Random Effects	Cross-Section Fixed Effects	Time-Period Fixed Effects
c	-7400.321**	-6474.376**	-5171.806	-5159.757
	(3345.962)	(3605.433)	(4581.360)	(3455.083)
CA_{it}	0.458***	0.395***	0.502***	0.339***
	(0.096)	(0.090)	(0.093)	(0.091)
x_{it}	4238.391***	4000.583***	3269.502*	3595.447**
	(1412.367)	(1354.633)	(1918.584)	(1405.127)
x_{it}^2	-258.739**	-253.247**	-215.242*	-237.951**
	(117.031)	(106.190)	(125.605)	(104.474)
Adjusted R	0.252	0.215	0.269	0.497
DW-Stat.	1.483	1.655	1.882	1.844

(Source: author's calculation with E-Views12)

In conclusion, it is likely that ASEAN-5 central banks likely respond to the FED's rate adjustments, exacerbates the deviation of UIP.

The interventions from central bank may help maintain exchange rate and economic stability, which is particularly valuable for emerging economy's environment. By supporting the local currency and mitigating capital outflows, central banks of regions deduce inflationary pressures and provide more stable environment for investment. However, this approach also carries trade-offs. While stabilizing foreign reserves in the short term, persistent intervention could possibly strain reserves, especially for nations of lower reserve buffers, are vulnerable to Fed's rate hikes and may dampen economic growth due to increased borrowing costs. The significant and positive effect of the current account balance on reserves, as shown across all models, underscores the importance of trade surpluses and capital inflows in sustaining reserves, while diminishing returns of high IRRs highlight the limits of monetary tightening as a tool for reserve accumulation.

4. DISCUSSION

There exists a complex relationship between exchange rate returns and interest rate differentials across 5 ASEAN countries. However, aligning with Tang (2011), there is little empirical evidence for the existence of UIP. Despite the fact that the UIP condition does not hold for Indonesia, Malaysia, the Philippines, Thailand and Vietnam, implications for investors, policy makers and regional insights are significant.

Firstly, the observed interest rate differentials suggest that investors in these nations could potentially capitalize on profitable carry trade opportunities. By borrowing in local currencies of lower interest rate and investing in US financial assets yielding higher returns, investors can benefit from both the interest rate spread and potential currency appreciation. The strategy could enhance returns in environment where regional financial markets is inefficient.

Secondly, the rejection of UIP hypothesis could pinpoint the fact that the local financial markets in Indonesia, Malaysia, the Philippines, Thailand and Vietnam have not fully integrated with international markets, which potentially restrict capital mobility. In fact, the capital freedom and liberalized financial market are concerning in this region due to central bank interventions. It is understandable that, comparing to the developed economies, in an emerging region where the economies are more vulnerable towards external shocks like in ASEAN, the authority and central bank might take justified action to intervene with the natural financial order, the limited liberalization in the developing market may hinder even further their ability to attract foreign investment and fully participate in the global financial flows. Besides, perpetuating inefficiencies could be exploited by savvy investors as well.

From a policy perspective, the study underscores the need for 5 mentioned ASEAN country and the region in general to enhance their financial market integration and liberalization. While central bank intervention could jump in when uncertainties occur to alleviate the shocks, it comes with a trade-off, especially for countries with limited foreign reserves. Though short-term interventions may stabilize foreign reserves and different kinds of economic fluctuations, such practice in the long run may only strip off the market efficiency, making the economy even more vulnerable. In the context of emerging market, policymakers should be aware of the trade-off and consider both sides carefully, with an ultimate aim of financial integration in mind.

LIMITATIONS

The study while offering valuable insights into the realm of UIP and international financial market, it is not without limitations. Due to the time limit and knowledge limit, the author identifies several shortcomings that can be fueled by future research endeavors.

The dataset used for ARDL Bound test and Granger causality from the data site of International Monetary Fund contains few missing values. The author has filled in those values using linear interpolation method. Furthermore, in two countries, Vietnam and Indonesia, due to the intensive lack of interest market rate, deposit rate was used as a proxy. Future researchers should employ a complete dataset from Bloomberg or other potential sources in the case of imitating the methodology.

Furthermore, in the researched period, there exists multiple shocks in the market, such as the Covid-19 pandemic, spillover effects of China's Trade and more could have been a turbulence to the proposed research. Incorporating these factors the cointegration analysis will be beneficial to the research landscape.

In term of methodology, while time-series analysis is common, it will be ideal to employ Panel estimation techniques and structural break analysis for more accurate and comprehensive results.

Finally, futures studies could benefit from examining the long-term implications of financial liberalization and the integration of ASEAN market, as well as the impact of political and economic risks on the UIP condition.

CONCLUSION

The paper has investigated the empirical validity of uncovered interest parity for five ASEAN member countries including Indonesia, Malaysia, the Philippines, Thailand and Vietnam employing the ARDL Bound test and Toda-Yamamoto Granger Causality. The studies propose there exist a long-term relationship between the exchange rate return and the interest rate differential in all countries except for Malaysia. However, the UIP does not hold in ASEAN-5 countries. These findings highlight that carry traders can potentially earn a profit if leveraging U.S asset with regional currencies. When examining central bank intervention as a potential cause of the deviation, the study points out that central banks in all countries prioritize exchange rate stability and will likely respond to the U.S. Fed's rate hikes to manage capital outflows, contributing to UIP's invalidity. The policies also have potential drawbacks, especially for countries with limited Foreign Reserves; therefore, policymakers should carefully consider the trade-offs associated with the interventions. In addition, this paper also attests the regional's low market integration and incomplete market liberalization, suggesting policy makers to further focus on this matter.

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