

Available online at
www.heca-analitika.com/eje



Ekonomikalia Journal of Economics

Vol. 3, No. 2, 2025



Energy Dependence, Trade Balance, and Current Account Sustainability: Evidence From ASEAN-5

Maulidar Agustina¹, M. Shabri Abd. Majid¹, Zia Thahira^{1,*}, Lid yana Dinda², Aulia Khairullah³ and Dwita Sakuntala⁴

¹ Department of Economics, Faculty of Economics and Business, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; maulidar.agustina@usk.ac.id (M.A.); mshabri@usk.ac.id (M.S.A.M.); ziathahira@usk.ac.id (Z.T.)

² Financial Analyst Study Program, Politeknik Kutaraja, Aceh, Indonesia; lidyanadinda@poltekkutaraja.ac.id (L.D.)

³ Department of Accounting, Faculty of Economics and Business, Universitas Syiah Kuala, Banda Aceh 23111, Indonesia; aulia.khairullah@usk.ac.id (A.K.)

⁴ Development Economics Department, Universitas Pembangunan Panca Budi, Medan, Indonesia; sakuntaladwita@gmail.com (D.S.)

* Correspondence: ziathahira@usk.ac.id

Article History

Received 16 August 2025
 Revised 14 October 2025
 Accepted 23 October 2025
 Available Online 30 October 2025

Keywords:

Current account sustainability
 Energy trade balance
 Trade balance
 Panel ARDL
 ASEAN-5

Abstract

This study investigates how energy dependence and trade structure influence current-account sustainability in the ASEAN-5 (Indonesia, Malaysia, Thailand, the Philippines, and Vietnam) over 2014–2023. Focusing on the region's vulnerability to energy price volatility and evolving trade patterns, the analysis evaluates long- and short-run relationships between the current account, energy trade balance, overall trade balance, real GDP per capita, and exchange rate movements. A panel Autoregressive Distributed Lag (ARDL) model with a Pooled Mean Group (PMG) estimator is applied, and long-run robustness is verified using panel Fully Modified Ordinary Least Squares (FMOLS). The results confirm a stable long-run equilibrium in which both energy and non-energy trade balances significantly and positively contribute to current-account positions. Higher real income and a depreciated exchange rate are also associated with sustained current-account improvements, reflecting capacity expansion and expenditure-switching effects. Short-run adjustments differ across countries, shaped by their import dependence, energy mix, and external balance-sheet conditions. Robustness checks affirm the stability of the estimated long-run relationships. These findings highlight the importance of strengthening energy trade resilience, enhancing non-energy tradable sectors, and maintaining prudent exchange-rate flexibility to support external sustainability in the ASEAN-5.



Copyright: © 2025 by the authors. This is an open-access article distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License. (<https://creativecommons.org/licenses/by-nc/4.0/>)

1. Introduction

The sustainability of a country's current account has long been regarded as a barometer of external stability and economic resilience [1–3]. In a global economy characterized by interconnected trade and capital flows, the ability of nations to maintain a sustainable current

account is essential for reducing exposure to financial fragility [4]. Historical evidence shows that prolonged and unsustainable current account deficits can quickly erode investor confidence, trigger capital flight, and undermine long-term growth prospects. This pattern has been observed during major economic crises, including the Latin American debt crisis of the 1980s and the Asian

financial crisis of 1997 [5–7]. The determinants of external sustainability are multidimensional and vary across countries. They reflect not only policy choices related to fiscal and monetary management but also structural factors such as production capacity, export competitiveness, and the degree of dependence on imported energy.

Among these structural dimensions, energy dependence has become increasingly important. Energy commodities, including oil, coal, and electricity, represent a significant portion of global trade flows, and fluctuations in their prices and volumes have direct implications for current account performance [8, 9]. Countries that rely heavily on imported energy are vulnerable to increases in global energy prices, which raise import costs and deteriorate current account balances [10, 11]. In contrast, energy-exporting economies are often exposed to volatility in international markets that can generate instability in external revenues and contribute to cyclical fluctuations in the current account [12, 13]. The balance between energy imports and energy exports is therefore a strategic indicator of external resilience and is a key determinant of how exposed a country is to external price shocks [14, 15].

The ASEAN-5 countries, namely Indonesia, Malaysia, Thailand, the Philippines, and Vietnam, provide a relevant setting to investigate how energy dependence interacts with current account dynamics. Although these economies differ in terms of income levels, industrial structures, and trade patterns, they are all highly integrated into regional and global production networks and are sensitive to developments in the international energy market. Indonesia and Malaysia have historically been net energy exporters; however, rising domestic consumption has narrowed their export surpluses over time [16–19]. Thailand and the Philippines remain structurally dependent on imported energy, and their current account positions are highly affected by fluctuations in global energy prices [20–22]. Vietnam presents a mixed profile. It has transitioned from being a net energy exporter to an importer as industrialization has accelerated, creating increasing pressure on its external energy balance [23]. These differences make the ASEAN-5 an ideal case for examining the role of energy trade in shaping external equilibrium [24, 25].

Recent statistics from the Asian Development Bank illustrate the extent of external vulnerability associated with energy trade in the ASEAN-5 [26]. In Indonesia, energy exports have exceeded imports each year since 2014, but the net surplus has trended downward as domestic demand for coal and petroleum has grown, consistent with earlier findings on rising energy intensity

and weakening surplus capacity in Indonesia [16, 17]. Malaysia, once a strong net exporter of natural gas and crude oil, recorded net energy trade deficits in 2019 and 2020 due to declining offshore production and increased import dependence, a trend also highlighted in its shifting energy structure [18]. Vietnam briefly recorded a small energy trade surplus in 2020, but the deficit re-emerged in 2022 alongside rapid manufacturing growth, in line with evidence that industrial expansion has increased energy demand faster than domestic supply capacity [23]. Thailand has consistently recorded large energy trade deficits due to structural reliance on imported fossil fuels, a pattern linked to its long-term energy security challenges [21]. The Philippines has experienced persistent deficits in energy trade throughout the sample period because of limited domestic resource potential and dependence on imported fuels [20]. These patterns confirm that energy dependence has become a binding constraint on current account positions in both energy-importing and formerly energy-exporting ASEAN economies, reinforcing the argument that energy trade has macroeconomic and external balance implications [10, 11, 27, 28].

Beyond energy trade, the overall trade balance relative to gross domestic product also influences the sustainability of the current account [27]. A surplus in non-energy trade, for example, can help offset the current account impact of energy import dependence, while a persistent structural trade deficit can worsen external vulnerabilities [29–31]. Macroeconomic fundamentals such as real income growth and exchange rate movements also play a role in determining external balances [32–34]. Real income growth reflects the productive capacity of an economy and the ability to compete in international markets, while the exchange rate acts as a key price mechanism that shapes trade flows. Depreciation of the exchange rate may improve export competitiveness, but it can also increase the domestic cost of energy imports, particularly for net importers of energy [35, 36]. Understanding how these factors interact with energy dependence is therefore essential for assessing the sustainability of the current account in emerging economies such as those in the ASEAN-5.

Prior research links the sustainability of the current account to both macroeconomic policies and structural features of trade. Foundational studies show that prolonged external deficits heighten the risk of financial crises, while structural adjustments and competitiveness improvements support sustainability [1–3]. Energy has emerged as an important transmission channel in this context. Global energy trade is strongly integrated with

production and consumption patterns [8, 9], which makes national positions in oil and coal trade central to external balances. For countries that rely on imported energy, increases in global energy prices raise import bills and weaken the current account [10, 11]. For energy-exporting economies, dependence on commodity exports exposes them to cycles of price volatility that can destabilize external balances [12, 13]. In addition to energy trade dynamics, the overall trade balance and relative prices play a crucial role. Stronger non-energy trade surpluses improve current account positions [27, 35], while movements in the exchange rate affect both export competitiveness and the domestic cost of imported goods and inputs [14].

Evidence for Southeast Asia is growing but remains fragmented. Country-specific studies have documented Indonesia's constraints in domestic energy supply and policy coordination [17], Malaysia's changing power generation mix and the relationship between emissions and energy trade [18], the Philippines' persistent exposure to imported energy and vulnerability to energy price shocks [20, 21], and Vietnam's rapid industrialization that has intensified energy demand [23]. These findings highlight the heterogeneity of energy-related external vulnerability within the region. However, much of this empirical literature treats energy as an exogenous price shock or uses only partial indicators, and most contributions focus on single-country settings. Few studies distinguish between the role of net energy trade and overall trade balance within a unified econometric framework.

There is also a methodological gap in the literature. Many previous studies do not jointly assess energy trade, trade balance dynamics, and macroeconomic controls in explaining current account sustainability. In addition, relatively few studies employ an estimation framework capable of separating short-run adjustment from long-run equilibrium effects. Panel autoregressive distributed lag models are particularly suitable for this purpose, but they remain underutilized in this field of research. This study addresses these gaps by modeling current account sustainability in the ASEAN-5 through a comparative regional framework that incorporates both energy and non-energy trade positions. The analysis is based on a balanced post-2014 panel dataset that captures recent external shocks, including the global pandemic and the 2022 energy price realignment. A pooled mean group autoregressive distributed lag estimator is applied to obtain both short-run and long-run estimates while accounting for mixed integration orders and cross-sectional dependence. The results provide a clear explanation of how energy dependence and trade

structure jointly influence the sustainability of the current account in the ASEAN-5.

The study offers two main contributions. First, it extends the discussion on current account sustainability by treating energy dependence not simply as a price shock but as a structural component of external balance, measured through the net energy trade position. This perspective strengthens the analytical link between energy systems and macroeconomic stability, which has received limited attention in previous work. Second, the study provides comparative empirical evidence for the ASEAN-5 based on a consistent regional framework. The heterogeneity of energy profiles in these economies allows meaningful contrasts between net energy exporters and importers, offering insights that go beyond single-country analyses. The results are relevant for policy because they highlight the need to manage external vulnerability through energy diversification, stronger tradable sectors, and prudent exchange rate management. At the same time, the findings contribute to the academic literature by connecting discussions in international trade, external accounts, and energy economics within a single empirical setting.

The paper proceeds as follows. The next section sets out the data sources, variable construction, and econometric strategy used in the analysis. Section three presents the results and interprets them in the context of ASEAN-5 realities. The final section concludes with a discussion of key policy implications and suggestions for future research.

2. Materials and Methods

2.1. Data

This study uses balanced annual panel data for the five ASEAN economies: Indonesia, Malaysia, Thailand, the Philippines, and Vietnam, covering the period 2014 to 2023. The chosen time frame reflects both data availability and economic relevance, as it includes major external shocks that affected the region, such as the global oil price decline from 2014 to 2016, rising energy import dependence, and the post-pandemic recovery dynamics. Although the sample period is relatively short, it remains suitable for panel Autoregressive Distributed Lag (ARDL) estimation because this technique can be applied to moderate time dimensions, and the cross-sectional variation helps reduce concerns related to overfitting. The dependent variable is the current account balance as a percentage of GDP, which reflects external sector sustainability. The main explanatory variable is the energy trade balance, calculated as the difference between energy exports and energy imports, including

Table 1. Variable description and measurement.

Symbol	Variable	Measurement	Source
CAB	Current Account Balance	% of GDP	ADB & WDI
ETB	Energy Trade Balance	Difference between energy exports and imports (oil, coal, electricity)	ADB & WDI
TRB	Trade Balance	Total trade balance as % of GDP	ADB & WDI
RGDP	Real GDP per capita	Real GDP per capita (constant USD)	WDI
AER	Average Exchange Rate	Average annual exchange rate (local currency per USD)	WDI & NSOs

crude oil, coal, and electricity. This net measure captures the structural role of energy dependence while reducing multicollinearity problems that might arise if energy exports and imports were included separately. The overall trade balance as a percentage of GDP is included to distinguish the effects of energy trade from the broader trade position. Two additional macroeconomic control variables are incorporated. Real GDP per capita is used as a proxy for economic capacity, and the average exchange rate (local currency per US dollar) reflects the impact of exchange rate movements on trade competitiveness and import costs.

All data are obtained from reliable international and national sources, including the Asian Development Bank (ADB), World Development Indicators (WDI), and National Statistical Offices (NSOs). Table 1 provides a detailed summary of the variables used in this study, including their definitions and data sources.

2.2. Methods

This study investigates the short-run and long-run relationships between energy trade balance, overall trade balance, and current account sustainability in the ASEAN-5. The empirical strategy begins with the general functional form of the model, as shown in Equation 1.

$$CAB_{i,t} = f(ETB_{i,t}, TRB_{i,t}, RGDP_{i,t}, AER_{i,t}) \quad (1)$$

where $CAB_{i,t}$ is the current account balance of country i at time t , $ETB_{i,t}$ is the energy trade balance, $TRB_{i,t}$ is the overall trade balance, $RGDP_{i,t}$ is real GDP per capita, and $AER_{i,t}$ is the average exchange rate.

To estimate this relationship, the study applies the panel ARDL model as developed by Pesaran et al. [37] and extended by Pesaran et al. [38]. The panel ARDL framework is appropriate because it simultaneously estimates long-run equilibrium relationships and short-run adjustments, accommodates relatively small sample sizes, and allows regressors with different integration orders, specifically $I(0)$ and $I(1)$ but not $I(2)$ [39, 40]. The suitability of this approach for panels with heterogeneous dynamics [41, 42]. The general ARDL(p , q) specification for panel data is given in Equation 2.

$$Y_{i,t} = \sum_{j=0}^p \lambda_{ij} Y_{i,t-j} + \sum_{j=0}^q \delta_{ij} X_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (2)$$

where $Y_{i,t}$ is the dependent variable, $X_{i,t-j}$ is the vector of explanatory variables, μ_i represents country-specific fixed effects, and $\varepsilon_{i,t}$ is the error term. Furthermore, reparameterizing the model into an error-correction form (ECM) yields Equation 3.

$$\Delta Y_{i,t} = \phi_i (Y_{i,t-1} - \beta_i X_{i,t-1}) + \sum_{j=1}^{p-1} \lambda_{ij}^* \Delta Y_{i,t-j} + \sum_{j=0}^{q-1} \delta_{ij}^* \Delta X_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (3)$$

where ϕ_i is the error-correction term, which indicates the speed of adjustment toward long-run equilibrium, while β_i captures the long-run effects of explanatory variables on the dependent variable.

This study employs the Pooled Mean Group (PMG) estimator proposed by Pesaran et al. [38], which constrains long-run coefficients to be homogeneous across countries while allowing heterogeneity in short-run dynamics and error variances [41]. This is appropriate for the ASEAN-5, which share structural similarities but may adjust differently to shocks in the short run. The panel ARDL specification used in this study is expressed in Equation 4.

$$CAB_{i,t} = \alpha_i + \sum_{j=0}^p \lambda_{ij} CAB_{i,t-j} + \sum_{j=0}^{q_1} \beta_{1ij} ETB_{i,t-j} + \sum_{j=0}^{q_2} \beta_{2ij} TRB_{i,t-j} + \sum_{j=0}^{q_3} \beta_{3ij} RGDP_{i,t-j} + \sum_{j=0}^{q_4} \beta_{4ij} AER_{i,t-j} + \varepsilon_{i,t} \quad (4)$$

The corresponding error-correction representation of our model is given in Equation 5.

$$\Delta CAB_{i,t} = \phi_i (CAB_{i,t-1} - \theta_1 ETB_{i,t-1} - \theta_2 TRB_{i,t-1} - \theta_3 RGDP_{i,t-1} - \theta_4 AER_{i,t-1} - \alpha_i) + \sum_{j=1}^{p_i-1} \psi_{i,j} \Delta CAB_{i,t-j} + \sum_{j=0}^{q_1-1} \gamma_{1i,j} \Delta ETB_{i,t-j} + \sum_{j=0}^{q_2-1} \gamma_{2i,j} \Delta TRB_{i,t-j} + \sum_{j=0}^{q_3-1} \gamma_{3i,j} \Delta RGDP_{i,t-j} + \sum_{j=0}^{q_4-1} \gamma_{4i,j} \Delta AER_{i,t-j} + \varepsilon_{i,t} \quad (5)$$

Before estimating Equation 5, the order of integration of the variables is tested using the Cross-sectionally Augmented Im, Pesaran, and Shin (CIPS) test of Pesaran et al. [43], which accounts for cross-sectional dependence. The results show that the variables are integrated of mixed orders $I(0)$ and $I(1)$, validating the panel ARDL approach. The existence of cointegration is

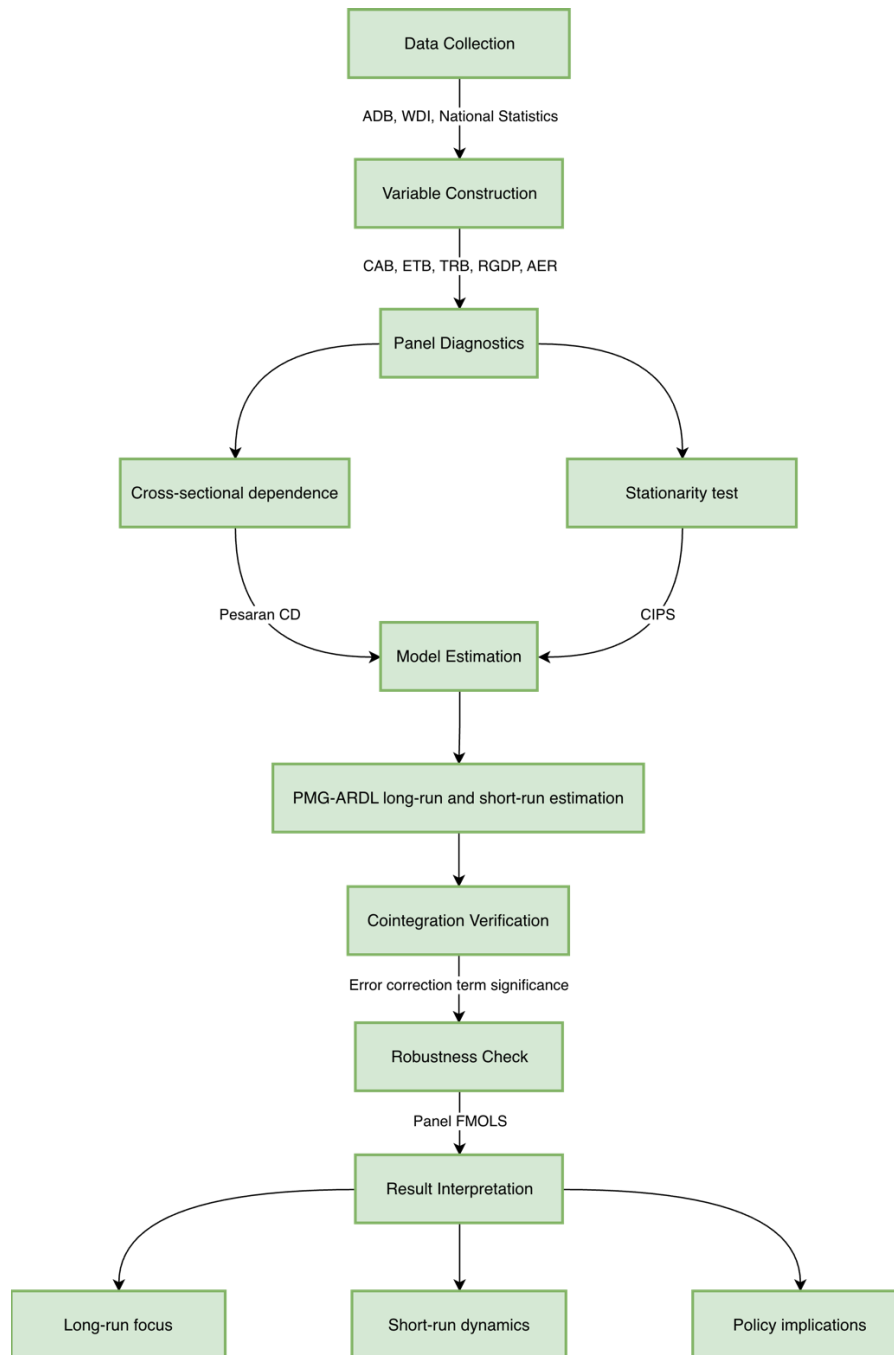


Figure 1. Empirical research flow of the study.

confirmed through the significance and negativity of the error-correction term.

Finally, to ensure robustness, the study also estimates long-run coefficients using the panel Fully Modified Ordinary Least Squares (FMOLS) estimator, following Pedroni [44], and compares the long-run signs and statistical significance with the PMG results.

2.3. Flow of the Study

To provide a clear overview of the analytical procedure and guide the reader through the empirical strategy, the sequence of data preparation, diagnostic testing, model

estimation, and robustness validation is summarized in Figure 1. This visual flow enhances methodological transparency and clarifies how the findings reported in the results section are systematically derived.

3. Results and Discussion

3.1. Descriptive Statistics

Before estimating the panel ARDL, we summarize the distribution of all variables for ASEAN-5 over 2014–2023 to highlight cross-country heterogeneity and potential outliers. Table 2 reports the main moments (mean, median, minimum, maximum, and standard deviation).

Table 2. Descriptive statistics.

Variable	Mean	Median	Max.	Min.	Std. Dev.	Obs.
CAB	19.32	7.07	878	-72.67	125.73	50
ETB	-250.24	-5.8	1388.98	-1,345.9	709.26	50
TRB	29,216.29	1,752.85	256,197.88	-57,647.01	72,501.96	50
RGDP	4.2	5.04	8.65	-9.52	3.52	50
AER	7,328.2	50.01	23,787.32	3.27	9,463.32	50

Table 3. Cross-sectional dependence test (Pesaran CD) results.

Variable	CD-stat.	P-Value
CAB	0.12	0.901
ETB	-2.03**	0.043
TRB	-0.36	0.718
RGDP	8.4***	0.000
AER	5.59***	0.000

Note: The null hypothesis is cross-sectional independence. The CD statistic is asymptotically distributed as $N(0,1)$. ***, ** indicate significance at the 1% and 5% levels, respectively.

Across 50 country-year observations (ASEAN-5, 2014 to 2023), the distributions are wide and asymmetric, reflecting very different external and energy profiles, as shown in [Table 2](#). CAB has a mean of 19.32 but a much lower median of 7.07, which indicates that a few very large surplus episodes pull up the average. The panel shows one extreme spike close to 878, while the lower tail reaches -72.67. This confirms that sharp deficits do occur in the sample. ETB is negative on average (-250.24) with a median close to zero (-5.80), which is consistent with country patterns reported earlier: persistent deficits for the Philippines and frequent shortfalls for Thailand, large deficits for Indonesia in several years, and occasional surpluses for Vietnam. The range from -1345.90 to 1388.98 and the high dispersion (standard deviation 709.26) reflect the mix of net importers and intermittent net exporters in the region.

TRB is positive on average (29,216.29) but shows very high dispersion (standard deviation 72,501.96), spanning deep deficits of -57,647.01, which aligns with Philippine trade shortfalls in some years, to very large surpluses of 256,197.88, which correspond to strong Malaysian trade performance in several periods. For the control variables, real RGDP has a mean of 4.20 with a wide range from -9.52 to 8.65. This captures the contraction during the 2020 pandemic, especially in the Philippines and Thailand, and the subsequent rebound in countries such as Malaysia. AER has a mean of 7,328.20 and a wide spread (standard deviation 9,463.32), which primarily reflects differences in currency scales. The upper end near 23,787 reflects the VND per US dollar exchange rate in Vietnam, while the lower end around 3.27 reflects the Malaysian ringgit per US dollar, and the median near 50 corresponds to the Philippine peso per US dollar.

3.2. Cross-sectional dependence test

Before proceeding to unit-root testing, we assess cross-sectional dependence (CSD) because common shocks and regional spillovers are likely in ASEAN-5. Ignoring CSD can bias first-generation unit-root/cointegration tests and standard errors; therefore, we apply Pesaran’s CD test to each series.

As reported in [Table 3](#), Pesaran’s CD test indicates no evidence of cross-sectional dependence for CAB (CD = 0.12; $p = 0.901$) and TRB (CD = -0.36; $p = 0.718$). By contrast, ETB (CD = -2.03; $p = 0.043$), RGDP (CD = 8.40; $p = 0.000$), and AER (CD = 5.59; $p = 0.000$) do exhibit significant CSD. Economically, this is plausible for ASEAN-5: energy trade positions (ETB) co-move with common shocks to global fuel prices and regional supply chains; income dynamics (RGDP) share business-cycle and pandemic effects; and exchange rates (AER) respond jointly to US-dollar cycles and global risk sentiment. In contrast, country-specific policy settings and idiosyncratic non-energy trade structures help explain why CAB and TRB do not display statistically common movements across countries in this sample.

Given these diagnostics, first-generation unit-root tests that assume cross-sectional independence are inappropriate for ETB, RGDP, and AER. We therefore employ second-generation procedures and implement Pesaran’s [\[43\]](#) CIPS test, augmenting individual ADF regressions with cross-section averages to capture common shocks. CIPS is applied to levels and first differences (intercept-only and intercept-plus-trend), with lag lengths selected by SIC. The resulting integration orders guide the PMG-ARDL specification, which accommodates a mix of $I(0)/I(1)$ variables (and excludes $I(2)$).

3.3. CIPS Unit Root Test

Given the presence of common shocks across ASEAN-5, we assess the order of integration with a second-generation unit-root test. Specifically, we apply Pesaran’s [\[43\]](#) CIPS to each series in levels and first differences. The results in [Table 4](#) indicate whether each variable is stationary at level ($I(0)$) or becomes stationary after first differencing ($I(1)$).

Table 4. Results of the CIPS unit-root tests.

Variable	Level I(0)		First Difference I(1)		Decision
	Z t	Prob.	Z t	Prob.	
CAB	-1.513	0.065	-2.905***	0.002	I(1)
ETB	-1.034	0.151	-1.922**	0.027	I(1)
TRB	-1.272	0.102	-1.887**	0.029	I(1)
RGDP	-2.214**	0.013**	-2.754***	0.003	I(0)
AER	-0.907	0.182	-2.137**	0.016	I(1)

Note: The null hypothesis tests for a unit root. Rejection at the level indicates stationarity (I(0)); rejection only after first differencing indicates non-stationarity (I(1)). ***, ** denote significance at the 1% and 5% levels, respectively.

Table 5. Kao panel cointegration test results.

Test statistic	Value	Prob.
Modified Dickey-Fuller	-0.3992***	0.0000
Unadjusted modified Dickey-Fuller	-5.1437***	0.0000
Unadjusted Dickey-Fuller t	-6.7646***	0.0000

Note: *** denotes significance at the 1% level; H₀: no cointegration.

The CIPS outcomes show a mixed integration order: RGDP is stationary in levels (I(0)), while CAB, ETB, TRB, and AER are stationary only after first differencing (I(1)). This pattern meets the preconditions for a PMG-ARDL framework, which accommodates combinations of I(0) and I(1) regressors. Accordingly, subsequent estimation models the long-run relationship in levels and short-run dynamics in differences, with cointegration assessed via the error-correction term.

3.4. Panel Cointegration Test

To verify the existence of a common long-run relationship among the variables, the Kao [45] residual-based panel cointegration test is applied. The null hypothesis is no cointegration; rejection implies that the residuals from the level regression are stationary and an error-correction representation is valid. Table 5 reports the modified and unadjusted Dickey-Fuller test statistics, their p-values, and the corresponding decisions.

As shown in Table 5, all three Kao statistics are large in magnitude and negative with $p < 0.01$, leading to a consistent rejection of the null of no cointegration. This indicates that CAB, ETB, TRB, RGDP, and AER move together in a stable long-run equilibrium over 2014–2023 in ASEAN-5. Consequently, a PMG-ARDL specification with an error-correction term is warranted: long-run coefficients can be interpreted as equilibrium effects, and short-run dynamics capture the speed of adjustment back to equilibrium.

3.5. Panel ARDL Test

With cointegration established (Table 5), the PMG-ARDL panel is estimated for ASEAN-5 over 2014–2023. Long-run coefficients are constrained to be common across countries, while short-run dynamics and the error-correction speed are allowed to differ by country. Table 6

reports (i) the pooled long-run elasticities of CAB with respect to the ETB, TRB, RGDP, and AER; and (ii) country-specific short-run responses together with the error-correction term (ECT(-1)).

3.5.1. Energy Trade Balance-Current Account Nexus

As reported in Table 6, the energy trade balance (ETB) displays a positive and statistically significant long-run coefficient (0.0210; $p = 0.0066$), implying that a structurally stronger net energy position, whether larger energy surpluses or narrower energy deficits, is associated with a higher current account balance (CAB) in equilibrium. The mechanism is straightforward. Sustained improvement in ETB augments the trade component of the current account, reduces foreign currency financing needs, and lowers pressure on reserves and the exchange rate, thereby enhancing external resilience and creditworthiness. This finding aligns with prior evidence that places energy flows at the core of external adjustment. Global input-output studies show tight links between energy trade and cross-border value creation [8], comparative analyses document that net energy exporting cushions external shocks over longer horizons [9], and work on emerging markets links energy import dependence to macro instability and weaker external positions [11].

The panel results also show heterogeneous short-run dynamics across ASEAN-5 members. Short-run ETB shocks improve the current account in Indonesia and the Philippines, and to a lesser extent in Malaysia, while Thailand experiences a negative response in the short run and Vietnam shows no significant effect. These differences reflect variation in energy import intensity, domestic energy structure, and price pass-through in each economy. The findings are consistent with country-specific evidence. In Indonesia, external balances are

Table 6. Results of the PMG-ARDL panel estimation.

Group	Variable	Coeff.	Std. Err.	t-stat.	Prob.
<i>Long-run Estimation</i>					
Panel	ETB	0.0210***	0.0067	3.1151	0.0066
	TRB	0.5476***	0.0118	46.155	0.0000
	RGDP	1.0750***	0.0404	26.547	0.0000
	AER	0.0036***	0.0004	88.324	0.0000
<i>Short-run Estimation</i>					
Indonesia	ECT(-1)	-3.7599***	-0.0070	-534.02	0.0000
	ΔETB	27.6365***	0.4823	57.295	0.0000
	ΔTRB	5.7954***	0.0172	336.51	0.0000
	ΔRGDP	6.3816***	0.0332	192.12	0.0000
	ΔAER	0.0072***	0.0003	238.63	0.0000
Thailand	ECT(-1)	-0.9774**	0.1847	-5.2916	0.0132
	ΔETB	-0.4083***	0.0140	-29.032	0.0001
	ΔTRB	0.4197**	0.1073	3.9107	0.0297
	ΔRGDP	-1.5971**	0.3898	-4.0963	0.0263
	ΔAER	1.5595***	0.2649	5.8853	0.0098
Malaysia	ECT(-1)	-0.6523**	0.2012	-3.2428	0.0150
	ΔETB	0.4210**	0.1889	2.2284	0.0493
	ΔTRB	0.2187*	0.1227	1.7820	0.0987
	ΔRGDP	1.7456*	0.8324	2.0964	0.0580
	ΔAER	-0.1340*	0.0652	-2.0561	0.0612
Philippines	ECT(-1)	-1.1604***	0.0002	-575.09	0.0000
	ΔETB	0.0648***	0.0001	635.79	0.0000
	ΔTRB	1.4525***	0.0036	396.61	0.0000
	ΔRGDP	0.7480***	0.0003	226.67	0.0000
	ΔAER	1.4290***	0.0010	133.86	0.0000
Vietnam	ECT(-1)	-1.3712***	0.0771	-17.775	0.0004
	ΔETB	0.4750	1.3570	0.3500	0.7494
	ΔTRB	-0.1642	1.2176	-0.1349	0.9012
	ΔRGDP	-1.0779	2.5523	-0.4223	0.7012
	ΔAER	-0.0006***	0.0004	-15.311	0.0006

Note: ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

shaped by policy and supply constraints in the energy sector [17]. Malaysia’s changing fuel and electricity mix influences the interaction between energy trade and industrial activity [18]. The Philippines faces persistent energy security challenges that amplify import bills [20, 21]. Vietnam’s rapid industrial development has altered energy demand and trade flows [23]. Taken together, the evidence shows that ETB influences the current account in both the long run and the short run. The long-run relationship provides the sustainability anchor, while short-run responses determine how quickly and in what direction economies adjust toward equilibrium.

The findings imply that current-account sustainability in ASEAN-5 is materially improved by durable gains in ETB. For policymakers, the positive long-run ETB effect argues for a dual strategy of lowering net energy import dependence and stabilizing export capacity. For net importers (e.g., the Philippines; often Thailand), priorities include supplier diversification and longer-tenor contracts, accelerated renewables and energy efficiency, regional power/LNG interconnections, and judicious FX/commodity hedging to smooth price shocks and limit pass-through. For mixed or episodic exporters (e.g.,

Indonesia and Malaysia), emphasis falls on upgrading midstream/refining capacity to curb product-import leakages, safeguarding reliable upstream supply, and adopting stabilization/savings frameworks to manage commodity cycles without distorting domestic availability. Cross-cutting actions for all ASEAN-5 members include tracking ETB as a policy KPI (preferably as % of GDP), running oil/gas price stress tests on the current account, and coordinating energy policy with trade and industrial upgrading so that non-energy exports reinforce external resilience when ETB is negative or volatile.

3.5.2. Trade Balance-Current Account Nexus

As shown in Table 6, the trade balance (TRB) has a large, positive, and highly significant long-run coefficient (0.5476; $p < 0.001$). This means that stronger non-energy trade surpluses are associated with higher current account balances (CAB) in the long run. The explanation is straightforward. Persistent gains in merchandise and services trade increase net exports, improve the saving-investment balance, and reduce reliance on foreign financing, which strengthens external resilience and

creditworthiness. This result is consistent with earlier evidence emphasizing the role of goods and services trade in sustaining external balances [30], and it aligns with more recent findings linking trade positions to energy and environmental outcomes in open economies [27]. In short, aside from the energy channel, non-energy trade stands as a primary driver of current account sustainability in the ASEAN-5.

The country-level results reveal heterogeneous short-run effects. Positive TRB shocks improve the current account in Indonesia, Thailand, and the Philippines, have a marginal effect in Malaysia, and are statistically insignificant in Vietnam during the sample period. These differences likely reflect variations in export structure, import intensity in production, and participation in global supply chains. Economies with strong manufacturing bases and tradable service sectors experience quicker transmission of trade gains to the current account. In contrast, where production is heavily dependent on imports or domestic absorption dominates, the short-run impact is weaker.

The policy implications follow clearly from these findings. Efforts to increase tradable production capacity and reduce trade costs will reinforce the long-run link between TRB and current account sustainability. Practical steps include improving logistics performance, simplifying trade procedures, increasing the use of rules of origin, diversifying export products and destinations, strengthening services exports, and upgrading positions in global value chains. This can be done through investment in ports and trade corridors, streamlining customs processes and non-tariff measures, making better use of free trade agreements, supporting firm-level upgrading and certification, and expanding participation in digital trade and backbone services. When combined with macroprudential safeguards, these measures enable non-energy exports to act as a stabilizing force, particularly when the energy trade balance is negative or volatile.

3.5.3. Real GDP per Capita Growth–Current Account Nexus

As reported in Table 6, real GDP per capita growth (RGDP) has a positive and highly significant long-run coefficient (1.0750; $p < 0.001$). This indicates that stronger and sustained economic growth is associated with a higher current account balance (CAB) in equilibrium. This result is consistent with intertemporal models of the current account, which argue that growth improves the external position when the export-capacity and saving effects outweigh import absorption [1–3]. Productivity gains and scale effects expand the supply of tradable goods and

services, while rising income increases national saving relative to investment. Both channels support the saving–investment balance that underlies current account improvements. In the ASEAN-5 context, periods of sustained growth tend to coincide with deeper global value chain participation, quality upgrading in manufacturing, and the expansion of services exports. These mechanisms reinforce the long-run link between the trade balance and the current account that was discussed in the previous subsection. The main point concerns the direction and statistical significance of the long-run relationship rather than the magnitude, since RGDP is expressed as a growth rate and the CAB as a percentage of GDP.

The short-run effects vary by country. Short-run growth shocks have a positive and significant impact on the current account in Indonesia and the Philippines, a small positive effect in Malaysia, a negative effect in Thailand, and no significant impact in Vietnam. These mixed responses likely reflect differences in the import intensity of growth, the composition of domestic demand, and supply chain constraints. When expansions are driven by import-dependent investment or consumption, short-run growth may worsen the trade balance before structural capacity adjusts. Over time, however, countries with stronger tradable sectors and higher domestic savings tend to align with the long-run positive RGDP–CAB relationship.

The policy implications are clear. To maintain the long-run positive contribution of growth to external sustainability, policymakers should channel growth toward expanding tradable capacity and strengthening national savings. Priority areas include logistics efficiency, human capital and skills upgrading, innovation, quality standards, and support for services exports. Well-designed medium-term fiscal frameworks can also raise public savings without undermining productive investment. At the same time, short-run leakages can be managed through macroprudential tools that curb credit-driven import surges and through industrial strategies that reduce reliance on imported inputs by building domestic intermediate and midstream industry capacity. Taken together, the results support a growth strategy that is oriented toward competitiveness and external resilience, ensuring that higher economic growth improves, rather than weakens, the current account position over time [2, 3].

3.5.4. Exchange Rate–Current Account Nexus

As reported in Table 6, the average exchange rate (AER) has a positive and highly significant long-run coefficient (0.0036; $p < 0.001$). Because a higher AER indicates

Table 7. Robustness results from the panel FMOLS estimation.

Variable	Coeff.	Std. Err.	t-stat.	Prob.
ETB	0.2551***	0.0938	2.7178	0.0100
TRB	0.4599**	0.1879	2.4472	0.0194
RGDP	1.0613***	0.0438	24.2213	0.0000
AER	0.0037***	0.0005	57.0412	0.0000
R ²	0.8829			
Adj. R ²	0.7387			

Note: ***, ** denote significance at the 1% and 5% levels, respectively.

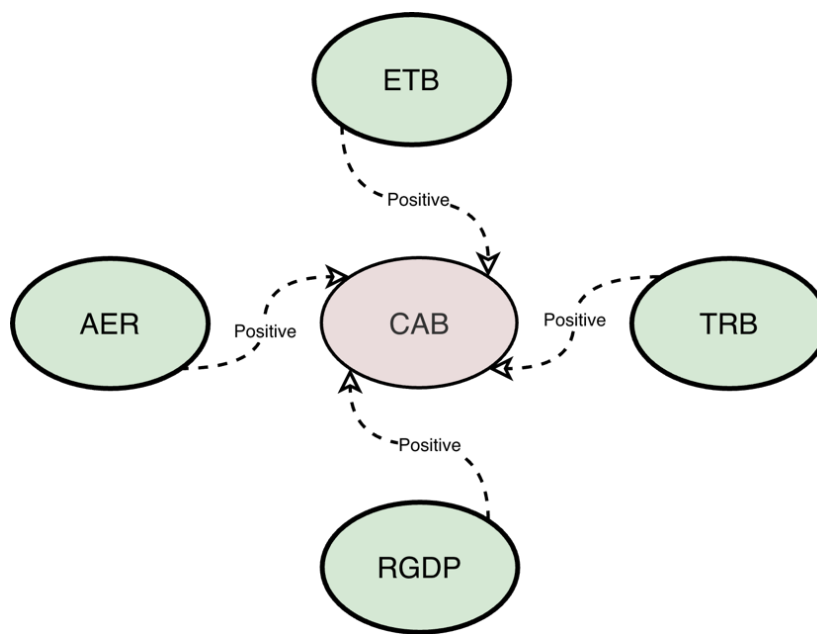


Figure 2. Graphical visualization of the panel long-run impact.

domestic currency depreciation, the estimate suggests that, in the long run, depreciation is associated with an improvement in the current account balance (CAB). This result is consistent with the standard expenditure-switching mechanism. After contracts adjust and prices respond, depreciation raises the relative price of imports and strengthens export competitiveness. When trade elasticities meet the conditions of the Marshall–Lerner framework, the trade balance and therefore the current account improve. Over longer horizons, the competitive effect of depreciation tends to dominate adverse price pass-through, which supports external rebalancing. This interpretation is consistent with evidence that exchange rate movements play an important role in shaping trade flows and competitiveness in emerging economies [14].

The short-run effects differ across ASEAN-5 economies. Short-run depreciation AER improves the current account in Indonesia, Thailand, and the Philippines, indicating a pattern similar to the J-curve where the initial adjustment leads to a quick gain in competitiveness. Malaysia shows a small negative response that is only marginally significant, and Vietnam records a negative and significant short-run effect. These country differences likely reflect variation in the import intensity of

production and the degree of currency mismatch in corporate and public balance sheets. When production relies heavily on imported inputs or when foreign currency liabilities are large, the immediate impact of depreciation can worsen external positions before trade volumes adjust.

The policy implications follow directly from these findings. To ensure that exchange rate flexibility contributes to long-run external stability, policymakers must enhance trade elasticities through improvements in logistics, export diversification, expansion of services exports, and reductions in import dependency within production systems. At the same time, short-run vulnerabilities must be managed. This includes limiting unhedged foreign currency borrowing, developing deeper local currency capital markets, encouraging hedging for critical imports such as energy, and calibrating monetary and macroprudential policy to control inflation pass-through.

3.6. Robustness Check with Panel FMOLS

To validate the long-run relations obtained from the PMG–ARDL, a residual-based Panel FMOLS estimator is employed. FMOLS corrects for (i) endogeneity arising

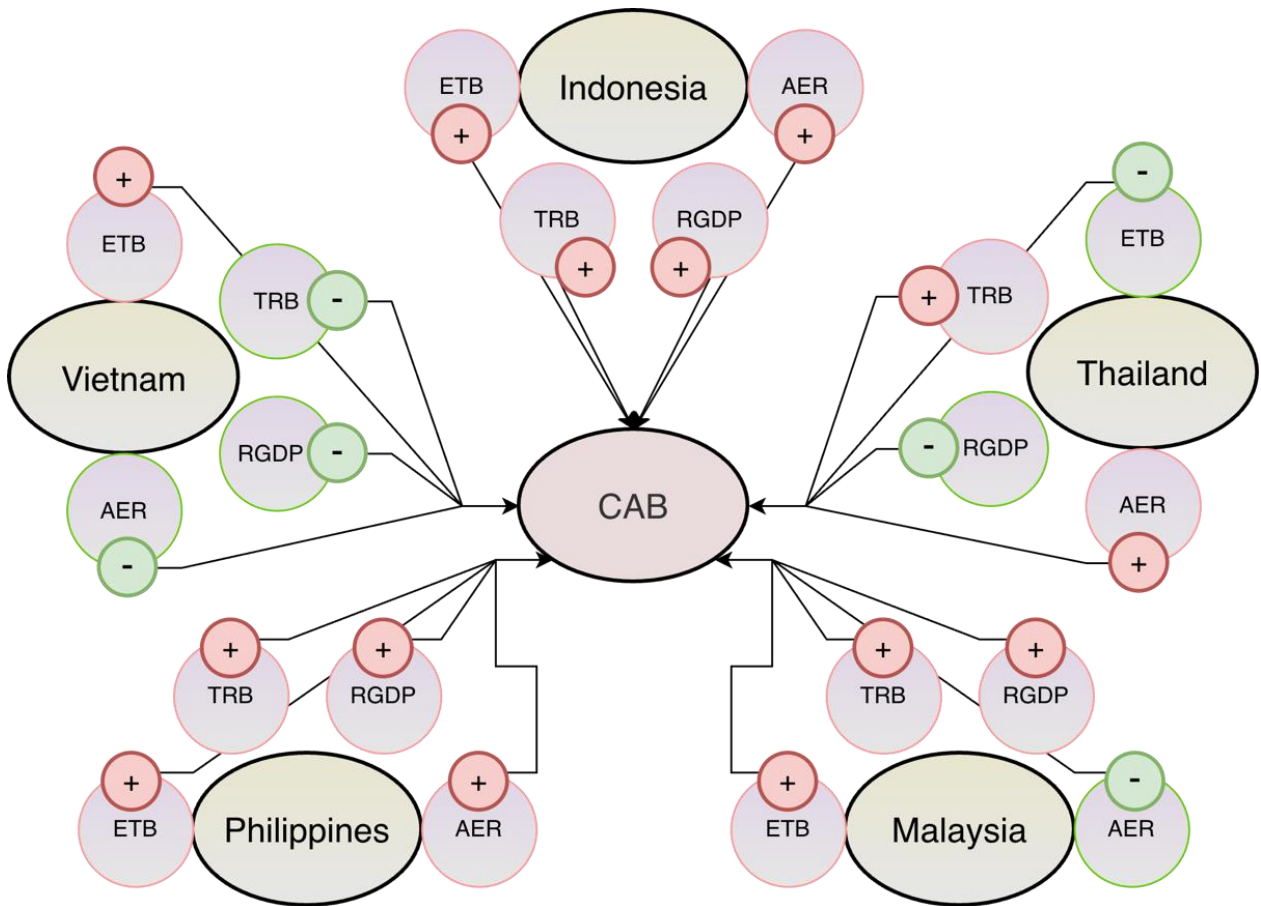


Figure 2. Graphical results of the short-run impact for each country.

from correlation between the regressors and the cointegrating error, and (ii) serial correlation in the disturbances by using a semi-parametric long-run covariance adjustment. In panel settings, the group-mean FMOLS estimator accommodates heterogeneous short-run dynamics and fixed effects across countries while delivering super-consistent estimates of the common cointegrating vector [44, 46]. This makes FMOLS a suitable robustness benchmark for the long-run coefficients.

The robustness test results using panel FMOLS, as presented in Table 7, confirm the consistency of the long-run relationships obtained from the PMG-ARDL model. The coefficients for ETB (0.2551; $p = 0.0100$), TRB (0.4599; $p = 0.0194$), RGDP (1.0613; $p < 0.0000$), and AER (0.0037; $p < 0.001$) remain positive and statistically significant. The signs and significance are preserved across both estimation methods. This convergence across estimators, even though FMOLS corrects for endogeneity and serial correlation, strengthens confidence in the empirical results. It indicates that energy trade balance, non-energy trade balance, income growth, and the exchange rate exert stable and economically meaningful effects on the current account balance in the ASEAN-5.

3.7. Graphical Results of All the Long-Run and Short-Run Findings

The long-run results obtained from the ARDL model, along with the robustness checks using FMOLS, are presented graphically in Figure 2. Furthermore, the short-run results derived from the cross-sectional ARDL estimations are illustrated in Figure 3. These visualizations provide a comprehensive overview of both the long- and short-run dynamics captured by the models.

4. Conclusions

This study examined how energy dependence and trade structure influence the sustainability of the current account in five ASEAN economies using a panel ARDL approach. The results confirm the existence of a stable long-run relationship among the current account, energy trade position, overall trade balance, national income, and exchange rate. A stronger energy trade position and a healthier non-energy trade balance are associated with improvements in the long-run current account, while a more competitive exchange rate supports external balance through expenditure switching. Higher real income also contributes positively to current-account sustainability by strengthening export capacity and

domestic savings. Robustness analysis using an alternative long-run estimator confirms the consistency of these long-run relationships.

The findings offer several policy implications. Reducing vulnerability to energy import shocks is essential, particularly through diversification of energy suppliers, gradual development of domestic energy capacity, and regional energy cooperation. Strengthening non-energy trade performance through logistics improvement, industrial upgrading, and participation in regional value chains is equally important. Exchange-rate flexibility can support external adjustment, but it must be managed alongside financial safeguards to limit exposure to foreign-currency debt and imported inflation. Policymakers should monitor the contribution of both energy and non-energy trade to external balances when designing macroeconomic and industrial policy frameworks.

This analysis has some limitations. The study covers a relatively short time period and a limited number of countries, which may restrict the generalization of the results. The measurement of the energy trade variable does not fully distinguish between price effects and volume effects. In addition, important determinants of the current account, such as fiscal policy, remittances, and international interest rates, were not included in the empirical model. Future research could extend the time dimension of the data, disaggregate the energy trade variable into fuel categories, and incorporate additional external sector components. Further extensions using non-linear or asymmetric models may also capture heterogeneous responses to positive and negative trade and exchange-rate shocks.

Author Contributions: Conceptualization, M.A. and Z.T.; methodology, M.S.A.M., L.D. and D.S.; software, M.A.; validation, M.S.A.M., L.D. and D.S.; formal analysis, M.A. and Z.T.; investigation, M.A., M.S.A.M., L.D. and D.S.; resources, M.S.A.M. and D.S.; data curation, M.A.; writing—original draft preparation, M.A.; writing—review and editing, L.D. and D.S.; visualization, M.A.; supervision, Z.T.; project administration, M.A. and Z.T. All authors have read and agreed to the published version of the manuscript.

Funding: This study does not receive external funding.

Data Availability Statement: The data supporting the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: The authors would like to express their appreciation to their respective institutions for the support and facilitation provided during the preparation of this study.

Conflicts of Interest: All the authors declare that there are no conflicts of interest.

References

- Roubini, N., and Wachtel, P. (1999). Current-Account Sustainability in Transition Economies, *Balance of Payments, Exchange Rates, and Competitiveness in Transition Economies*, Springer US, Boston, MA, 19–93. doi:10.1007/978-0-585-31346-7_2.
- Brissimis, S. N., Hondroyannis, G., Papazoglou, C., Tsaveas, N. T., and Vasardani, M. A. (2012). Current Account Determinants and External Sustainability in Periods of Structural Change, *Economic Change and Restructuring*, Vol. 45, Nos. 1–2, 71–95. doi:10.1007/s10644-011-9107-y.
- Singh, T. (2023). The Sustainability of Current Account in the BRICS Countries Depends on Economic Policies' Support to Structural Adaptation, *Journal of Policy Modeling*, Vol. 45, No. 3, 570–591. doi:10.1016/j.jpmod.2023.05.001.
- Jamal, A., Lamba, J., and Rai, S. (2024). Unraveling Complexity Global Capital Flow Determinants, *Global Economic Interconnectedness: International Trade and Finance*, 321–370. doi:10.4018/979-8-3693-5303-5.ch015.
- Kawai, M., and Rana, P. B. (2009). *The Asian Financial Crisis Revisited: Lessons, Responses and New Challenges*, Routledge.
- Roubini, N., and Mihm, S. (2010). *Crisis Economics: A Crash Course in the Future of Finance*, Penguin.
- Taskinsoy, J. (2023). Financial Instability: The Unsolved Mystery of Financial Folly, *SSRN Electronic Journal*. doi:10.2139/ssrn.4395171.
- Wu, X. F., and Chen, G. Q. (2017). Global Primary Energy Use Associated with Production, Consumption and International Trade, *Energy Policy*, Vol. 111, 85–94. doi:10.1016/j.enpol.2017.09.024.
- Mucha-Leszko, B., and Gawlikowska-Fyk, A. (2024). Major Energy Producers, Exporters and Importers—transition to Renewables Sources and Diversification of Suppliers in 2000–2019, *Sprawy Międzynarodowe*, Vol. 75, No. 3/4, 235–269. doi:10.35757/SM.2022.75.3-4.12.
- Murshed, M., and Tanha, M. M. (2021). Oil Price Shocks and Renewable Energy Transition: Empirical Evidence from Net Oil-Importing South Asian Economies, *Energy, Ecology and Environment*, Vol. 6, No. 3, 183–203. doi:10.1007/s40974-020-00168-0.
- Sahu, A. K., and Mahalik, M. K. (2024). Unveiling the Nexus between Energy Import Dependency and Macroeconomic Instability: Panel Evidence from Emerging Market Economies, *The Journal of International Trade & Economic Development*, 1–20. doi:10.1080/09638199.2024.2443401.
- Mingya, Z. (2025). The Role of the Oil and Gas Sector in Shaping Trinidad and Tobago's Economic Trajectory, *SSRN Electronic Journal*. doi:10.2139/ssrn.5402928.
- Lebrand, M., Vasishtha, G., and Yilmazkuday, H. (2024). Energy Price Shocks and Current Account Balances: Evidence from Emerging Market and Developing Economies, *Energy Economics*, Vol. 129, 107201. doi:10.1016/j.eneco.2023.107201.
- Umeaduma, C. M.-G., and Dugbartey, A. N. (2023). Effect of Exchange Rate Volatility on Export Competitiveness and National Trade Balances in Emerging Markets, *International Journal Computation Applied Technology Research*, Vol. 12, No. 11, 57–71. doi:10.7753/IJCATR1211.1008.
- Rafiq, S., Sgro, P., and Apergis, N. (2016). Asymmetric Oil Shocks and External Balances of Major Oil Exporting and Importing Countries, *Energy Economics*, Vol. 56, 42–50. doi:10.1016/j.eneco.2016.02.019.
- Rudenko, D., and Tanasov, G. (2022). The Determinants of Energy Intensity in Indonesia, *International Journal of Emerging Markets*, Vol. 17, No. 3, 832–857. doi:10.1108/IJOEM-01-2020-0048.

17. Dutu, R. (2016). Challenges and Policies in Indonesia's Energy Sector, *Energy Policy*, Vol. 98, 513–519. doi:10.1016/j.enpol.2016.09.009.
18. Abdul Latif, S. N., Chiong, M. S., Rajoo, S., Takada, A., Chun, Y.-Y., Tahara, K., and Ikegami, Y. (2021). The Trend and Status of Energy Resources and Greenhouse Gas Emissions in the Malaysia Power Generation Mix, *Energies*, Vol. 14, No. 8, 2200. doi:10.3390/en14082200.
19. Idroes, G. M., Hafizah, I., Hartono, D., Dharma, D. B., Hardi, I., Noviandy, T. R., and Idroes, R. (2025). Investigating Hydropower Energy Consumption's Effect on Southeast Asia's Path to Achieving Environmental Sustainability and Carbon Neutrality, *Carbon Research*, Vol. 4, No. 1, 57. doi:10.1007/s44246-025-00218-4.
20. Thorbecke, W. (2019). How Oil Prices Affect East and Southeast Asian Economies: Evidence from Financial Markets and Implications for Energy Security, *Energy Policy*, Vol. 128, 628–638. doi:10.1016/j.enpol.2019.01.044.
21. La Viña, A. G. M., Dulce, J. C., and Saño, N. (2011). National and Global Energy Governance: Issues, Linkages and Challenges in the Philippines, *Global Policy*, Vol. 2, No. s1, 80–93. doi:10.1111/j.1758-5899.2011.00134.x.
22. Nguyen, D. B., Nong, D., Simshauser, P., and Pham, H. (2024). Economic and Supply Chain Impacts from Energy Price Shocks in Southeast Asia, *Economic Analysis and Policy*, Vol. 84, 929–940. doi:10.1016/j.eap.2024.09.025.
23. Nong, D., Nguyen, D. B., Nguyen, T. H., Wang, C., and Siriwardana, M. (2020). A Stronger Energy Strategy for a New Era of Economic Development in Vietnam: A Quantitative Assessment, *Energy Policy*, Vol. 144, 111645. doi:10.1016/j.enpol.2020.111645.
24. Abdul Bahri, E. N., and Wye, C.-K. (2024). Nonlinearity in Energy–Employment Nexus: The Role of FDI, Trade and Growth in ASEAN-5, *Journal of Social and Economic Development*, Vol. 26, No. 3, 963–991. doi:10.1007/s40847-023-00288-3.
25. Rahman, M. M. (2021). The Dynamic Nexus of Energy Consumption, International Trade and Economic Growth in BRICS and ASEAN Countries: A Panel Causality Test, *Energy*, Vol. 229, 120679. doi:10.1016/j.energy.2021.120679.
26. Asian Development Bank. (2023). ADB SEADS 2023: Imagining a Net-Zero ASEAN, from <https://www.adb.org/news/features/adb-seads-2023-imagining-net-zero-asean>.
27. Niu, X., Dong, W., Niu, X., and Wasif Zafar, M. (2024). The Transition to Clean Energy and the External Balance of Goods and Services As Determinants of Energy and Environmental Sustainability, *Gondwana Research*, Vol. 127, 77–87. doi:10.1016/j.gr.2023.03.003.
28. Hardi, I., Afjal, M., Khan, M., Idroes, G. M., Noviandy, T. R., and Utami, R. T. (2024). Economic Freedom and Growth Dynamics in Indonesia: An Empirical Analysis of Indicators Driving Sustainable Development, *Cogent Economics & Finance*, Vol. 12, No. 1. doi:10.1080/23322039.2024.2433023.
29. Huntington, H. G. (2015). Crude Oil Trade and Current Account Deficits, *Energy Economics*, Vol. 50, 70–79. doi:10.1016/j.eneco.2015.03.030.
30. Insel, A., and Kayıkçı, F. (2013). Determinants of the Current Account Balance in Turkey: An ARDL Approach, *Economic Research-Ekonomska Istraživanja*, Vol. 26, No. 1, 1–16. doi:10.1080/1331677X.2013.11517587.
31. Sahu, A. K., and Mahalik, M. K. (2024). Unwrapping the Intricate Interplay between Energy Dependency and Macroeconomic Volatility in OECD Countries, *Economic Papers: A Journal of Applied Economics and Policy*, Vol. 43, No. 4, 389–410. doi:10.1111/1759-3441.12429.
32. Demir, F., and Razmi, A. (2022). The Real Exchange Rate and Development Theory, Evidence, Issues and Challenges, *Journal of Economic Surveys*, Vol. 36, No. 2, 386–428. doi:10.1111/joes.12418.
33. Yildirim, Z., and Ivrendi, M. (2016). Exchange Rate Fluctuations and Macroeconomic Performance, *Journal of Economic Studies*, Vol. 43, No. 5, 678–698. doi:10.1108/JES-01-2015-0010.
34. Hardi, I., Idroes, G. M., Márquez-Ramos, L., Noviandy, T. R., and Idroes, R. (2025). Inclusive Innovation and Green Growth in Advanced Economies, *Sustainable Futures*, Vol. 9, 100540. doi:10.1016/j.sfr.2025.100540.
35. Ullah, S., and Nobanee, H. (2025). Decoding Exchange Rate in Emerging Economy: Financial and Energy Dynamics, *Heliyon*, Vol. 11, No. 2, e41995. doi:10.1016/j.heliyon.2025.e41995.
36. Saqib, A., Chan, T.-H., Mikheylov, A., and Lean, H. H. (2021). Are the Responses of Sectoral Energy Imports Asymmetric to Exchange Rate Volatilities in Pakistan? Evidence From Recent Foreign Exchange Regime, *Frontiers in Energy Research*, Vol. 9. doi:10.3389/fenrg.2021.614463.
37. Pesaran, M. H., and Smith, R. (1995). Estimating Long-Run Relationships from Dynamic Heterogeneous Panels, *Journal of Econometrics*, Vol. 68, No. 1, 79–113. doi:10.1016/0304-4076(94)01644-F.
38. Pesaran, M. H., Shin, Y., and Smith, R. P. (1999). Pooled Mean Group Estimation of Dynamic Heterogeneous Panels, *Journal of the American Statistical Association*, Vol. 94, No. 446, 621–634. doi:10.1080/01621459.1999.10474156.
39. Kripfganz, S., and Schneider, D. C. (2023). Ardl: Estimating Autoregressive Distributed Lag and Equilibrium Correction Models, *The Stata Journal: Promoting Communications on Statistics and Stata*, Vol. 23, No. 4, 983–1019. doi:10.1177/1536867X231212434.
40. Idroes, G. M., Hardi, I., Hilal, I. S., Utami, R. T., Noviandy, T. R., and Idroes, R. (2024). Economic Growth and Environmental Impact: Assessing the Role of Geothermal Energy in Developing and Developed Countries, *Innovation and Green Development*, Vol. 3, No. 3, 100144. doi:10.1016/j.igd.2024.100144.
41. Malik, M. A., and Masood, T. (2022). Dynamics of Output Growth and Convergence in the Middle East and North African Countries: Heterogeneous Panel ARDL Approach, *Journal of the Knowledge Economy*, Vol. 13, No. 2, 1444–1469. doi:10.1007/s13132-021-00780-3.
42. Joo, B. A., and Shawl, S. (2023). Understanding the Relationship Between Foreign Direct Investment and Economic Growth in BRICS: Panel ARDL Approach, *Vikalpa: The Journal for Decision Makers*, Vol. 48, No. 2, 100–113. doi:10.1177/02560909231180078.
43. Pesaran, M. H. (2007). A Simple Panel Unit Root Test in the Presence of Cross-Section Dependence, *Journal of Applied Econometrics*, Vol. 22, No. 2, 265–312. doi:10.1002/jae.951.
44. Pedroni, P. (n.d.). Fully Modified OLS for Heterogeneous Cointegrated Panels, 93–130. doi:10.1016/S0731-9053(00)15004-2.
45. Kao, C. (1999). Spurious Regression and Residual-Based Tests for Cointegration in Panel Data, *Journal of Econometrics*, Vol. 90, No. 1, 1–44. doi:10.1016/S0304-4076(98)00023-2.
46. Phillips, P. C. B., and Hansen, B. E. (1990). Statistical Inference in Instrumental Variables Regression with I(1) Processes, *The Review of Economic Studies*, Vol. 57, No. 1, 99. doi:10.2307/2297545.