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Article

The impacts of economic growth, investment, and environmental degradation on public debt: New evidence from the ASEAN-5 countries

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Abstract: This study explores the impact of environmental degradation on public debt in the largest Southeast Asian (ASEAN-5) countries. Prior research has not examined environmental degradation as a possible determinant of public debt in the ASEAN region. As such, the primary objective is to examine key determinants of public debt, notably economic growth, trade openness, investment, and environmental degradation. Utilizing the Fully Modified Ordinary Least Squares (FMOLS) method and data from 1996 to 2021, the study reveals a negative correlation between investment and public debt. Conversely, a positive relationship exists between economic growth, environmental degradation, and public debt levels. These findings hold significant implications for policymakers seeking to craft effective economic and environmental strategies to ensure sustainable development in the ASEAN-5 region. Stronger economic growth can drive up public debt. Importantly, the study highlights the importance of tailored approaches, considering each country's unique fiscal and developmental characteristics. Applying the Two-Gap Model enhances the understanding of these complex dynamics in shaping public debt and its relationship with environmental factors.

Keywords: economic growth; investment; environmental degradation; public debt; sustainable energy; energy consumption

1. Introduction

Escalating global debt, reaching 256% of GDP in 2020, has raised concerns about economic stability and fiscal burdens (Olaoye et al., 2022). The impact of public debt on economies has been recognized worldwide (Lau et al., 2022; Hajian et al., 2022), with the Association of Southeast Asian (ASEAN) region actively engaged in economic and political discussions. Understanding the drivers of public debt is crucial for sustaining economic growth and fiscal equilibrium (Sundus et al., 2022). While prior research has explored factors influencing public debt, such as economic growth (Demikha et al., 2021; Shaari et al., 2024; Waheed, 2017), government spending (Dirir, 2022), foreign direct investment (FDI) (Swamy, 2015), and social variables such as corruption (Briceño and Perote, 2020), it has overlooked the role of environmental degradation in shaping public debt. The costs associated with environmental degradation, including expenses related to environmental cleanup, public health management, and infrastructure maintenance, can significantly exacerbate public debt burdens (Abbass et al., 2022). Therefore, this study is motivated by the need to address this gap in the existing literature. We aim to investigate the significance of environmental degradation as a determinant of public debt in the ASEAN region from 1996 to 2021, utilizing the Fully Modified Ordinary Least Squares (FMOLS) method.

The impact of environmental degradation on economies is palpable, incurring expenses for cleanup, healthcare, and infrastructure repair (Collatto et al., 2021). These expenses contribute to heightened public debt levels (Boly et al., 2022). The global commitment to address environmental concerns is evidenced by the USD 30 billion spent on renewable energy R&D. However, such efforts have led to budget deficits and increased public debt due to the costs of environmental protection programs (Catalano et al., 2020). In developing countries, increasing debt levels may impede the implementation of environmental recovery programs and the transition to a green economy (Dimnwobi et al., 2023; Onuoha et al., 2023). Additionally, environmental deterioration elevates healthcare costs due to pollution-induced health issues (Shang et al., 2022), straining government finances and contributing to public debt. Notably, the ASEAN-5 region's renewable energy goals necessitate substantial funds (Azhgaliyeva et al., 2020). Despite these targets, budget constraints hinder progress, potentially influencing national budgets. Furthermore, tax incentives designed to preserve the environment may further impact fiscal plans (Gazzani, 2021).

This study makes a significant contribution by examining the nexus between environmental degradation and public debt within the ASEAN-5 context. While previous studies have offered evidence of the impact of public debt on environmental degradation and identified a complementary role (Boly et al., 2022), no further evidence has been provided on environmental degradation's impact on public debt. This examination sheds light on whether countries like those in ASEAN, which experience substantial environmental impacts due to rapid economic growth, global trade, urbanization, and extensive fossil fuel use (Shaari et al., 2023), might also be facing a public deficit problem that could potentially worsen environmental quality in the long run. ASEAN economies have been driving economic growth by promoting investment and the expansion of various projects, including infrastructure development, natural resource extraction, and industrial activities, often leading to fiscal deficits.

By spotlighting this interrelation, our research profoundly enriches the ongoing policy debates around the objectives of environmental preservation, fiscal stability, and economic growth (Kirikkaleli and Sofuoğlu, 2023; Shah et al., 2023). The imperative lies in recognizing and including environmental considerations as pivotal determinants of sustainable fiscal management (Boly et al., 2022; Lin and Zhu, 2019). The symbiotic relationship uncovered by our study underscores that overlooking environmental degradation's role in public finances could yield far-reaching repercussions for both ecological well-being and the fiscal health of countries (Abbass et al., 2022). Beyond ecological imperatives, this urgency arises from its pivotal role in nurturing fiscal resilience within the ASEAN-5 nations and ensuring that they can provide sufficient fiscal support to drive the energy transition of the region. In the face of mounting public debt concerns, our study underscores that ecological and fiscal resilience are inextricably intertwined, demanding a concerted and holistic approach from policymakers.

This study utilizes the two-gap model to gain insights into the determinants of public debt, diverging from theories such as debt overhang and crowding out, which primarily explore how public debt impacts other variables. Notably, the versatility of the two-gap model allows for the introduction of other variables such as GDP, Foreign

Direct Investment (FDI), Government Expenditure (GE), and interest service (IS) to enrich the analysis, as demonstrated in Demikha et al. (2021). As an extension of this approach, our study incorporates economic growth and environmental degradation as additional factors within the two-gap framework, aiming to provide further evidence on whether environmental issues can be determinant factors influencing public debt dynamics in the ASEAN region. The evidence linking external debt and environmental quality (Akam et al., 2021, 2022; Katircioglu and Celebi, 2018) implies a possible nexus between public debt and the environment, warranting the need for new corroborating evidence.

In this research paper, our primary goal is to investigate the connection between public debt and various factors such as GDP, trade openness, investment, gross domestic savings, corruption, and CO_2 emissions. To analyze this relationship within the context of the largest Southeast Asian (ASEAN-5) economies from 1996 to 2021, we utilize the Fully Modified Ordinary Least Squares (FMOLS) method as our chosen methodology. We examine the ASEAN-5 collectively (panel) and individually. We begin by presenting the literature review, followed by the methodology, results, a concise discussion, and conclusions. Additionally, we include policy implications and avenues for future research.

2. Literature review

2.1. Theoretical review

Economic theory provides a rich landscape for understanding the relationship between public debt and a nation's developmental trajectory. Within this realm, three models are particularly relevant to our study. The two-gap model by Chenery and Strout (1966) highlights two critical gaps hindering the development of less developed nations. The first gap underscores the disparity between a country's savings (S) and necessary investments (I). In contrast, the second gap pertains to the imbalance between a nation's export (X) earnings and import (M) expenditures, known as the trade gap. This can lead to borrowing as countries lack funds for essential imports. The model considers internal factors like savings and investment and external factors like trade openness, collectively shaping a nation's debt accumulation and developmental trajectory.

The debt overhang theory explains that excessive borrowing can hinder a country's economy by impeding investments in vital sectors like education, healthcare, and infrastructure, which are crucial for growth (Diamond and He, 2014). When a nation's debt becomes burdensome, allocating funds to repay old debts limits resources for new projects, thereby slowing economic advancement (Manasseh et al., 2022). Additionally, concerns about repayment may lead to higher interest rates, exacerbating the debt challenge. Essentially, the theory emphasizes that while borrowing can be beneficial, excessive debt can restrain a country's progress, akin to carrying a heavy load on the path to economic development. The crowding-out theory explains that excessive government borrowing and high public debt can impact an economy. When the government borrows extensively for its projects, it reduces the available funds for individuals and businesses to borrow, a phenomenon known as "crowding out". As government borrowing increases, it competes for funds, driving

interest rates and discouraging business investments (Chen et al., 2022) and consumer spending (Dumitrescu et al., 2023). The theory suggests that substantial government borrowing can restrict others' borrowing, resulting in elevated interest rates and sluggish economic growth.

This study employs the two-gap model to delve into the factors influencing public debt dynamics, taking a distinct path from theories like debt overhang and crowding out, which primarily focus on the repercussions of public debt on other variables. We expand the two-gap model by introducing control variables such as GDP, Foreign Direct Investment (FDI), Government Expenditure (GE), interest service (IS), and environmental degradation as additional elements within the two-gap framework, striving for a comprehensive understanding of the factors shaping public debt dynamics. The increase in public debt by countries has stimulated economic growth through infrastructure expansion, industrial development, trade promotion, and new investments, all of which carry environmental consequences (Akam et al., 2021; Farooq et al., 2023). Addressing these effects requires heightened investments in green energy, climate change mitigation, ecological restoration, and sustainable development initiatives. This leads to the hypothesis that environmental pressures contribute to the rise in public debt.

2.2. Previous studies

Numerous researchers have expressed interest in researching how economic growth affects public debt. Briceño and Perote (2020), Dawood et al. (2021), Knapková et al. (2019), Sadik-Zada and Gatto (2019), Swamy (2015) and Waheed (2017), are some of the researchers. These researchers use different methodologies to investigate the topic, but they all agree that economic growth affects public debt in most nations. Ozturk et al. (2012) look into the factors that led to the onset of the European Union's debt crisis in 2009. The study focused on economic growth and inflation from 2000 to 2012, utilizing the Vector Auto-Regressive (VAR). The results highlighted a negative link between GDP-measured economic growth and total public debt, revealing a connection between inflation and public debt.

Swamy (2015) used the Panel Granger causality test over 252 nations between 1980 and 2009. The results showed that macroeconomic parameters, such as economic growth, FDI, government spending, inflation, and population, negatively impact public debt. The researcher did discover a beneficial impact of final consumer spending and trade openness on governmental debt. High economic growth is related to lower public debt. Accordingly, increased investment raises a nation's public debt. The impact of eight variables on the level of public debt in gas-exporting and importing countries was then studied by Waheed (2017). The study examined panel data from 12 nations that export oil and gas and 12 countries that import oil and gas. The results from 2004 to 2013 showed that public debt is negatively impacted by four factors: economic growth, current account balance, oil prices, and foreign exchange reserves. The general government budget, general government spending, inflation, and investment all have a positive impact on governments' debt. Knapková et al. (2019) used a variety of tests to examine how macroeconomic factors affect public debt in the Slovak Republic, including comparisons, content-causal analysis, and simple linear

regression. The study used time-series data spanning 22 years, from 1995 to 2017. The study discovered that economic expansion has a detrimental effect on public debt. The analysis also supported the positive effects of unemployment, trade openness, and public sector size on public debt.

In an investigation into the factors affecting public debt in 184 countries, Sadik-Zada and Gatto (2019) revealed that a 1% rise in economic growth will result in a 3.32 % decrease in public debt. Briceño and Perote (2020) used 14 factors to explore the causes of governmental debt in the Eurozone, including macroeconomic and social variables. The study's use of the Generalized Method of Moment (GMM) led to the discovery of a negative correlation between ten variables related to public debt. Economic development is one of the factors that affect public debt negatively. In contrast to Dirir's (2022) study on public debt in Djibouti using the Auto Regressive Distributed Lag (ARDL) method, public debt will rise in tandem with an increase of 1% in economic growth. Studies on China's national debt using data from 1994 to 2013 by Dirir (2022) and Yinguo and Tingting (2016) indicated that economic growth, as measured by GDP, positively impacts the country's public debt.

In the past, scholars such as Asghar et al. (2022), Dawood et al. (2021), Gokmenoglu and Rafik (2018), Hilton (2021), and Swamy (2015) examined the effects of investment and economic growth on public debt. Asghar et al.'s (2022) descriptive analysis of Pakistan's primary debt drivers discovered a negative association between public debt and investment. The researchers concluded that investing in human resource sectors would boost output, improve country profitability, and reduce reliance on public debt marginally. In their study of 32 developing and transitioning nations using the GMM method to evaluate 24 years of data, Dawood et al. (2021) concluded that investment reduces public debt. In contrast, trade openness and government spending positively affect public debt. Hilton (2021) tested the effects of population, trade openness, inflation rate, and investment on public debt and found a consistent short-run negative relationship between investment and trade openness. This result is consistent with Swamy's (2015) research on the factors influencing government debt. Fatás et al. (2019) agreed with Gokmenoglu and Rafik (2018), who concluded a positive correlation between investment and public debt.

Most past studies on the impacts of economic growth and investment on public debt were conducted in countries other than ASEAN-5. For example, Ouhibi et al. (2017) studied the determinants of public debt in Southern Mediterranean countries and Eastern Europe, Semik and Zimmermann (2022) (Central and Eastern Europe countries), Forslund et al. (2011) (developing and emerging countries, except for the ASEAN-5 countries). However, only a few studies focused on the ASEAN countries, such as Hajian et al. (2022). Although several research studies have employed panel and time-series data to study the causes of public debt, they mainly concentrated on the effects of macroeconomic, socioeconomic, and governance issues. Still, they did not address the problem of environmental degradation, which might also reduce public debt. Whereas other scholars such as Li et al. (2021), Wang et al. (2023) and Wang et al. (2022) generally agreed that economic growth affects environmental degradation. Since previous studies found a correlation between economic growth and public debt, it is essential to simultaneously measure the effect of environmental degradation on public debt with many other variables.

Meanwhile, several studies, such as Mao and Failler (2022) and Qi et al. (2022), studied the effect of governmental debt on environmental degradation instead. Wei et al. (2022) suggested that government health spending increased due to environmental degradation, consistent with Ahmed Hussein's 2007 analysis determining that the cost of environmental degradation in the Middle East and North Africa region is high annually. Health spending as a contributor to higher public debt was established by Briceño and Perote (2020) as environmental degradation may affect government spending, and including it as a study variable is essential. **Figure 1** shows a million tonnes of carbon dioxide (CO_2) emissions in the ASEAN-5 between 1996 and 2021. The graph implied that all nations were dealing with increased CO_2 emissions. Over the years, Indonesia's CO_2 emissions measured in metric tons have been the highest (Esquivias et al., 2022). This might be due to the fact that Indonesia has a larger population than the other ASEAN-5 countries. As a result of Singapore's small population than the other ASEAN-5 nations, the country has the lowest CO_2 emissions. However, the ASEAN-5 nations saw continuous CO_2 growth (Shaari et al., 2023), albeit not significantly.

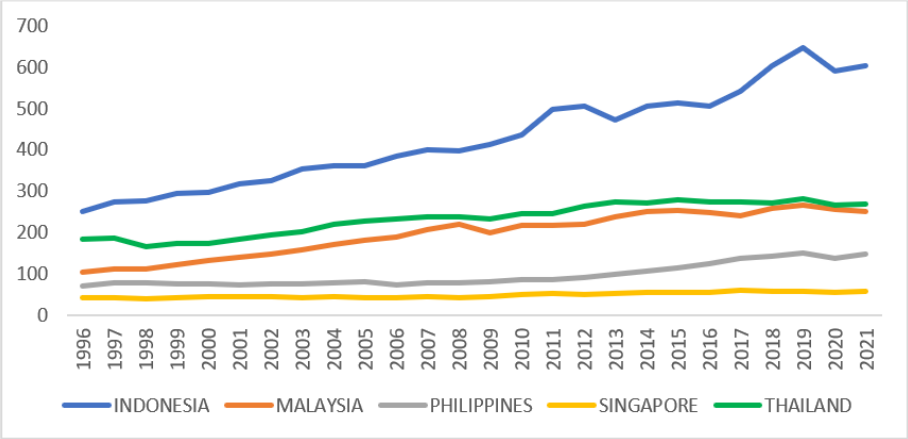

Figure 1. Carbon Dioxide (CO_2) emissions in metric tons in the ASEAN-5 countries.
Source: Countryeconomy (2023).

3. Methodology

3.1. Model specification

This study aims to investigate the determinants of public debt in the ASEAN-5 countries. According to the two-gap model introduced by Chenery and Strout (1966), public debt is influenced by savings and investment gaps and foreign exchange gaps measured by export and import gaps, also known as trade openness. Therefore, independent variables used in this study consist of trade openness, investment, gross domestic savings, gross domestic product (GDP), corruption, and CO_2 emission. Additionally, the variables used in the study are derived from the model applied and previous literature. Meanwhile, CO_2 emissions are included in the model as a novel element. Public debt is treated as a dependent variable. **Table 1** shows the variables' descriptions. This method was genuinely adopted by Erdal and Erdal (2020) and modified to examine the determinants of public debt in the ASEAN-5 countries. The model specification is as follows:

$$PD_{it} = \alpha + \beta_{1i}TO_{it} + \beta_{2i}INV_{it} + \beta_{3i}GDS_{it} + \beta_{4i}GDP_{it} + \beta_{5i}COR_{it} + \beta_{6i}CDE_{it} + \varepsilon_t \quad (1)$$

where i denotes the individual ASEAN-5 country (Indonesia, Malaysia, the Philippines, Singapore, and Thailand), t represents the time (year), and α is the intercept or constant term. β's are the coefficients associated with the independent variables. PD represents the public debt of country i in time t, TO represents trade openness, INV represents investment, GDS represents gross domestic savings, COR represents corruption, and CDE represents Carbon Dioxide emissions. ε_t represents the error term.

3.2. Data source

All data used in the study are subject to the availability provided by the responsible authorities (See **Table 1**) and the adoption by previous studies. Most of the data was acquired from the World Bank Development Indicators and Countryeconomy.com, spanning 1996 to 2021.

Table 1. Variables description.

Variable	Proxy	Unit of Measurement	Source	Previous studies
Gross Domestic Product (GDP)	Gross Domestic Product (Current US$)	US Dollar	The World Bank Development Indicators	Atinafu (2020); Bese et al. (2021); Dirir (2022)
Gross Domestic Savings (GDS)	Gross Domestic Savings (Current US$)	US Dollar	The World Bank Development Indicators	Abdullahi et al. (2015); Waheed (2017)
Corruption Perception Index (COR)	Corruption Perception Index	Index	Countryeconomy.com	Briceño and Perote (2020); Gründler and Potrafke (2019); Iloie (2015)
Investment (INV)	Gross fixed capital formation (formerly gross domestic fixed investment) (% of GDP)	% of GDP	The World Bank Development Indicators	Dawood et al. (2021); M. Ekouala (2022); Waheed (2017)
Trade openness (TO)	Net trade in goods and services (BoP, current US$)	US Dollar	The World Bank Development Indicators	Abbas et al. (2020); Danish et al. (2022); Dawood et al. (2021); Manalo et al. (2022)
Carbon Dioxide emission (CO_2)	CO_2 tons emissions per capita	Tons per capita	countryeconomy.com	Bese et al. (2021); Sarfaz et al. (2022); Saidi and Hammami (2014)
Public Debt (PD)	General government gross debt (current US$)	US Dollar	countryeconomy.com	Bese et al. (2021); Dirir (2022); Manalo et al. (2022); Hlongwane and Daw (2022); Swamy (2015)

3.3. Estimation procedures

The main objective of this study is to explore the long-run relationship between public debt and several factors, including GDP, trade openness, investment, gross domestic savings, corruption, and CO_2 emissions. We employ the Fully Modified Ordinary Least Squares (FMOLS) method to test this relationship. The data analysis is divided into four parts: a Cross-sectional dependence test, unit root tests, Pedroni co-integration analysis, and Fully Modified Ordinary Least Squares (FMOLS) regression. When assuming independence, unit root tests can be unreliable in the presence of cross-sectional dependence. The study utilizes three tests to identify cross-sectional dependence: the Breusch-Pagan LM test, the Pesaran scaled LM test, and the Pesaran CD test.

Moreover, we opted for a panel unit root test instead of conducting a unit root test for each country. This choice allows us to account for cross-sectional dependence and heterogeneity among the countries in our sample. By pooling the data across countries, we can obtain more efficient estimates of the unit root process and better control for common factors affecting all countries in the panel. Furthermore, a panel unit root test enables us to distinguish between the presence of a unit root at the individual country level and a common stochastic trend across all countries. Therefore, the panel unit root test provides more robust and reliable results than conducting separate unit root tests for each country.

A unit root test is employed to confirm the stationarity of time series data $[y_t] = T_{t=1}$, and the equation is as follows:

$$y_t = D_t + z_t + \varepsilon_t \tag{2}$$

where,

y_t is the determinant of the dependent variable at time *t*. D_t denotes the deterministic component in the equation, z_t represents the stochastic component, and ε_t is the error term used to check the stationarity of the data. This study applies three widely- used unit root tests to confirm the stationarity of the time-series data, namely Levin-Lin-Chu (LLC), Im, Pesaran, and Shin (IPS), and Augmented Dickey-Fuller (ADF).

After the stationarity of the data has been confirmed, a co-integration test must be performed to examine the co-integrating relationship among the variables, particularly (INV, GDP, TO, PD, CDE, COR and GDS). The Pedroni co-integration is employed in this study to detect any heterogeneous intercept and trend coefficient. Pedroni (1999) developed seven statistics to test a panel co-integrating relationship within the dimension and between the dimensions. The equation based on the Pedroni co-integration is as follows:

$$y_{it} = \alpha_i + \delta_i t + \gamma_t + X_{it}\beta_i + e_{it} \tag{3}$$

where,

y_{it} is the dependent variable of country *i* at time *t*, α_i symbolizes the intercept or constant term in our regression equation, while δ_i represents the coefficient associated with the lagged dependent variable. The variable *t* signifies the time period under examination, γ_t encompasses a vector of dependent variables that are modeled as linear combinations of two or more non-stationary time series variables across multiple entities (i.e., individuals or countries) over time. X_{it} portrays a vector of non-stationary independent variable(s), and β_i is the vector of coefficients that captures the long-run equilibrium relationship between the dependent variable(s) *Y* and the non-stationary independent variable(s) *X* across multiple entities. e_{it} represents the vector of residuals that captures the short-run dynamics and the idiosyncratic shocks in the relationship between the dependent variable(s) *Y* and the independent variable(s) *X* across multiple entities over time. e_{it} is assumed to be white noise, meaning it is uncorrelated with the non-stationary variables and the lagged values of the dependent variable(s) *Y* and the independent variable(s) *X*.

3.4. Fully modified least square

FMOLS stands for Fully Modified Ordinary Least Squares. It is an econometric

technique used for estimating co-integrating relationships and conducting long-run analysis in the presence of endogeneity and serial correlation. FMOLS is particularly useful when dealing with non-stationary variables and dynamic economic relationships (Heriqbaldi et al., 2022). FMOLS addresses some limitations of other econometric approaches, such as GMM (Generalised Method of Moments) and ARDL (Autoregressive Distributed Lag) models. Some limitations are the endogeneity handling, simultaneous equation bias, efficiency improvement, inclusion of lagged dependent variables, and asymptotic distribution. All of the issues are absent by using FMOLS.

The FMOLS estimator model is:

$$B_{Fm}^{\wedge} = \left[\sum_{i=1}^{N}\sum_{t=1}^{T}(x_{it}-x_i)'\right]^{-1}\left[\sum_{i=1}^{N}\left(\sum_{t-1}^{T}(x_{it}-x_i)'\right)\hat{y}_{it}^{\ *} + T\,\triangle_{it}^{\wedge}\,\varepsilon\mu^{*}\right] \quad (4)$$

where, $\hat{y}_{it}$* is the transformed form of the endogenous variables and $\triangle_{it}^{\wedge}\,\varepsilon\mu^{*}$ is the parameter of autocorrelation adjustment.

4. Results

4.1. Descriptive test results

The results of descriptive statistics for each variable used in this analysis are shown in **Table 2**. The table displays the mean, standard deviation, maximum, and minimum values for PD, TO, INV, GDS, GDP, COR, and CDE. Based on the table, each variable's variation differs significantly. The mean for GDP is 11.3728, whereas the mean for CDE is 0.5276.

Table 2. Descriptive statistic results.

	PD	TO	INV	GDS	GDP	COR	CDE
Mean	11.0904	5.414047	1.393596	10.87079	11.3728	1.612734	0.527624
Median	11.11597	10.53988	1.384549	10.84331	11.40811	1.556303	0.553883
Maximum	11.81333	24.76416	1.634622	11.62078	12.07412	1.973128	1.074816
Minimum	10.42243	−24.4023	1.25963	10.05039	10.85834	1.230449	−0.08092
Std.Dev.	0.301069	18.34003	0.083207	0.357092	0.308419	0.203978	0.37424
Skewness	−0.04089	−0.7072	0.704288	−0.0417	0.269496	0.406759	–0.11368
Kurtosis	2.471783	1.884031	3.2219	2.577456	2.389214	2.292306	1.58812
Jarque-Bera	1.54755	17.582	11.01386	1.004793	3.594347	6.297641	11.0776
Probability	0.461268	0.000152	0.004059	0.605079	0.165767	0.042903	0.003931
Sum	1441.753	703.8261	181.1674	1413.202	1478.464	209.6554	68.59116
Sum Sq. Dev.	11.6929	43390.02	0.89311	16.44941	12.27075	5.367307	18.06719
Observations	130	130	130	130	130	130	130

Note: Gross Domestic Product (GDP), Gross Domestic Savings (GDS), Corruption Perception Index (COR), Investment (INV), Trade Openness (TO), Carbon Dioxide Emission (CDE), and Public Debt (PD).

4.2. Covariance analysis

The statistical analysis in **Table 3** reveals several notable correlations among the variables under consideration. The correlation coefficient between PD and TO is 0.216,

implying a relatively weak yet positive linear relationship between these two variables. Meanwhile, the correlation between PD and GDP is substantially stronger, with a coefficient of 0.705. This signifies a moderately robust positive linear relationship between PD and GDP. The association between INV and COR demonstrates a correlation coefficient of 0.344. This finding indicates a moderate positive linear relationship between INV and COR. The correlation coefficient of 0.055 between CDE and GDS implies a very mild positive linear relationship between CDE and GDS. Conversely, a correlation coefficient of −0.328 is observed between GDS and COR, suggesting a moderate negative linear relationship between GDS and COR. These outcomes provide quantitative insights into the interplay of these variables, thereby enriching our understanding of their potential connections.

Table 3. Covariance analysis.

Covariance Correlation	PD	TO	INV	GDS	GDP	COR	CO_2
LNPD	0.089945						
	1						
LNTO	1.183662	333.7693					
	0.216031	1					
LNINV	0.002335	0.245008	0.00687				
	0.09393	0.161799	1				
LNGDS	0.010998	1.86116	0.0066	0.03022			
	0.210941	0.586021	0.458078	1			
LNGDP	0.049085	0.900851	0.004009	−0.0026	0.053789		
	0.70568	0.212609	0.208546	−0.06438	1		
LNCOR	0.014868	0.625627	0.005801	0.025037	−0.01547	0.041287	
	0.243983	0.168533	0.344464	0.708804	−0.32817	1	
$LNCO_2$	0.025759	3.320168	0.010307	0.055162	−0.01992	0.065115	0.138978
	0.230393	0.487487	0.333566	0.851182	−0.23044	0.859611	1

4.3. Variance Inflation Factor test (VIF) results

We apply VIF as a sensitivity test for multicollinearity's impact on regression reliability. Specifically, we assess the potential impact of multicollinearity among predictors by looking at the VIF values. High VIF (usually ≥ 10) signals a strong correlation, leading to less reliable coefficients. **Table 4** indicated that when the Variance Inflation Factor (VIF) for each variable is lower than 10, it generally suggests that multicollinearity associated with that variable is not a significant concern. VIF values below 10 indicate that the coefficient variance for a particular predictor variable is not greatly inflated due to multicollinearity with other predictor variables in the model.

Table 4. Variance inflation factor.

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
TO	7.63×10^{-7}	2.657879	2.443306
INV	0.022447	419.6797	1.479355
GDS	0.017245	376.2181	4.999353
GDP	0.002744	3458.723	1.415987
COR	0.014838	376.0890	5.876765
CO_2	0.006599	26.42025	8.797663
C	0.366654	3517.309	NA

4.4. Cross-sectional dependence test results

The study uses three tests to identify cross-sectional dependence, particularly Breusch-Pagan LM, Pesaran scaled LM, and Pesaran CD tests. The result of the cross-sectional dependence analysis is presented in **Table 5**, which indicates no existence of cross-sectional dependence. Hence, all three analysis methods failed to reject the null hypothesis as all the probabilities exceed 0.05. Therefore, it is further validated to implement the unit root test.

Table 5. Cross-sectional dependence result.

Test	Statistic	d.f.	Prob.
Breusch-Pagan LM	14.3319	10	0.1584
Pesaran scaled LM	0.968642		0.3327
Pesaran CD	0.361944		0.7174

4.5. Panel unit root test results

The unit root test results are shown in **Table 6**. In level, none of the variables are stationary. The findings also show that all the variables are stationary at the 1% significance level at the first difference. Except for TO, which is stationary at the 10% significance level according to the LLC approach, the five variables are stationary at the 1% significance level. All the variables are stationary at the 1% significance level for the various unit root methods (LLC, IPS and ADF). Every variable is integrated of order I(1). In order to assess the co-integrating relationship between TO, INV, GDS, GDP, COR, and CDE, a panel co-integration test can be carried out.

Table 6. Unit root test results.

Variables	LLC		IPS		ADF	
	Level	1st difference	Level	1st difference	Level	1st difference
TO	1.40983	−3.11822***	−0.63904	−5.79417***	13.5097	50.2890***
	(0.9207)	(0.0009)	(0.2614)	(0.0000)	(0.1966)	(0.0000)
INV	0.50374	−4.43666***	−1.21186	−4.38629***	13.4453	38.3823***
	(0.6928)	(0.0000)	(0.1128)	(0.0000)	(0.1998)	(0.0000)

Table 6. (*Continued*).

Variables	LLC		IPS		ADF	
	Level	**1st difference**	**Level**	**1st difference**	**Level**	**1st difference**
GDS	0.14468	−8.50211***	1.9907	−7.31615***	2.00749	64.9669***
	(0.5575)	(0.0000)	(0.9767)	(0.0000)	(0.9963)	(0.0000)
GDP	0.39791	−10.2941***	2.69319	−8.86443***	1.21215	79.5786***
	(0.6547)	(0.0000)	(0.9965)	(0.0000)	(0.9996)	(0.0000)
COR	0.27598	−5.81591***	0.0364	−7.24128***	9.14868	64.1698***
	(0.6087)	(0.0000)	(0.5145)	(0.0000)	(0.5181)	(0.0000)
CDE	–1.02035	–4.37857***	0.72831	–5.12709***	6.98546	45.1493***
	(0.1538)	(0.0000)	(0.7668)	(0.0000)	(0.7268)	(0.0000)
PD	1.49719	–4.50952***	4.12955	–8.18147***	0.75793	73.1204***
	(0.9328)	(0.0000)	(1.0000)	(0.0000)	(1.0000)	(0.0000)

Note: Gross Domestic Product (GDP), Gross Domestic Savings (GDS), Corruption Perception Index (COR), Investment (INV), Trade Openness (TO), Carbon Dioxide Emission (CDE), and Public Debt (PD).
Note: * is significant at 10%, ** at 5%, and *** at 1%.

4.6. Panel co-integration test results

The results of the panel co-integration tests with and without any trend are displayed in **Table 7**. The findings indicate that three out of seven statistics are significant, suggesting that the variables have a co-integrating connection.

Table 7. Panel co-integration test results.

Within Dimension		
	Without Trend	**With Trends**
Panel *v*-Statistic	−0.236418	−0.959748
	(0.5934)	(0.8314)
Panel rho-Statistic	−0.107848	0.022684
	(0.4571)	(0.5090)
Panel PP-Statistic	−4.042887***	−5.630458***
	(0.0000)	(0.0000)
Panel ADF-Statistic	−1.671107**	−2.698345***
	(0.0474)	(0.0035)
Between Dimension		
	Without Trend	**With Trends**
Group rho-Statistic	1.530959	1.896241
	(0.9371)	(0.9710)
Group PP-Statistic	−1.520776**	−1.709592**
	(0.0642)	(0.0437)
Group ADF-Statistic	−0.617548	−0.919215
	(0.2684)	(0.1790)

Note: * is significant at 10%, ** at 5%, and *** at 1%.

4.7. Estimates at country group level

Panel FMOLS results

Table 8 shows the results of the FMOLS test. The test is conducted to examine the long-term elasticity. The FMOLS approach expands upon the ordinary least squares (OLS) method to account for issues related to serial correlation and endogeneity in independent variables resulting from co-integration (Raihan et al., 2023). A co-integrating equation model is also addressed in this study. At the 1% significance level, a significant negative coefficient between investment (INV) and public debt has been found, indicating a negative correlation between the two variables. Thus, a 1% increase in investment would result in a 1.2452% reduction in public debt. At the 1% significance level, GDP and CO_2 emissions positively correlate with public debt, with coefficient values of 1.0179 and 0.4449, respectively. Additionally, a 1% increase in GDP would increase public debt by 1.0179%, but a 1% increase in CO_2 emissions would increase public debt by 0.4449%.

Table 8. Grouped panel Fully Modified Ordinary Least Square (FMOLS) results.

Variables	Coefficient	Std. Error	*t*-statistic	Prob.
TO	0.0073	0.019470	0.37561	0.7079
INV	−1.2452***	0.12091	−10.2982	0.0000
GDS	−0.1687	0.14099	−1.19665	0.2339
GDP	1.0179***	0.1514	6.7244	0.0000
COR	0.0107	0.2461	0.0434	0.9654
CDE	0.4449**	0.1918	2.3201	0.0221

Note: Gross Domestic Product (GDP), Gross Domestic Savings (GDS), Corruption Perception Index (COR), Investment (INV), Trade Openness (TO), Carbon Dioxide Emission (CDE), and Public Debt (PD).
Note: * is significant at 10%, ** at 5%, and *** at 1%.

Panel FMOLS can account for differences in the relationship between variables across countries (Heriqbaldi et al., 2022). This is especially relevant in the context of this study, as the ASEAN-5 countries have different economic, social, and environmental characteristics that could influence the relationship between economic growth, investment, environmental degradation, and public debt (Hajian et al., 2022; Shaari et al., 2023). Accounting for differences in the level of development is crucial as the relationship between the proposed variables can be diverse, as noted in earlier studies (e.g., Wang et al., 2023 examining the EKC across countries with different levels of development). This approach is a powerful technique that can provide valuable insights into the long-run relationships between key variables and public debt in the ASEAN-5 region while also accounting for cross-sectional dependence and heterogeneity among the countries in the panel.

The positive nexus between public debt, GDP growth, and CO_2 emissions has important implications for the ASEAN-5 region. Earlier studies have pointed out the rapid economic growth and the rise of carbon dioxide emissions in the ASEAN (Esquivias et al., 2022; Shaari et al., 2023), suggesting that public debt may also be jeopardized.

4.8. Estimates at individual country level

The individual FMOLS test results are displayed in **Table 9**. The coefficients at specific country levels are generally in line with the group-level results, although some differences arise. For the case of Malaysia, at the 1% significance level, it is discovered that GDS has a negative and significant impact on public debt. Public debt can be decreased by 0.8338% with a 1% increase in GDS. GDP's significant and positive impact on Malaysia's public debt has also been observed. Public debt in Malaysia rises by 1.9387% due to a 1% increase in GDP; meanwhile, trade openness, investment, corruption, and environmental degradation are insignificant for Malaysia.

Table 9. Individual Fully Modified Least Square (FMOLS) results.

Countries	Variables	TO	INV	GDS	GDP	COR	CDE
Malaysia	Coeff.	0.0821	−0.0151	−0.8338***	1.9387***	−0.3022	−0.2445
	Std. Error	0.0518	0.2133	0.224	0.1447	0.3132	0.3274
	Prob.	0.1308	0.9443	0.0016	0	0.3474	0.4648
Indonesia	Coeff.	0.0019**	−2.4302***	1.2261***	−0.8617**	1.2993***	0.9144
	Std. Error	0.0007	0.4088	0.3079	0.3832	0.314	0.6455
	Prob.	0.0204	0	0.0009	0.0373	0.0006	0.1737
Philippines	Coeff.	−0.0022	−1.5106***	−0.2629**	1.0467***	−0.3074***	0.9876**
	Std. Error	0.0208	0.3133	0.124	0.1165	0.0998	0.3642
	Prob.	0.9152	0.0001	0.0481	0	0.0064	0.0143
Singapore	Coeff.	0.0088	−0.7169*	−0.0652	1.1693	−0.7929	0.3607
	Std. Error	0.2546	0.3965	0.6646	0.7077	1.3361	0.6573
	Prob.	0.9727	0.0873	0.923	0.1158	0.5603	0.59
Thailand	Coeff.	−0.0026***	−1.5531***	−0.9078***	1.7968***	0.1566	0.2064
	Std. Error	0.0006	0.1992	0.297	0.3369	0.3323	0.4339
	Prob.	0.0004	0	0.0068	0	0.6431	0.64

Note: Gross Domestic Product (GDP), Gross Domestic Savings (GDS), Corruption Perception Index (COR), Investment (INV), Trade openness (TO), Carbon Dioxide emission (CDE), Public Debt (PD), natural logarithm (ln).
Note: * is significant at 10%, ** is significant at 5% and *** is significant at 1%.

In the case of Indonesia, trade openness, GDS, and corruption are all positively and significantly correlated with public debt. As GDS and corruption increase by 1%, public debt increases by 1.2261% and 1.2993%, respectively. Results align with Handoyo et al. (2020), who pointed out that Indonesia faces a twin deficit problem caused by low public savings. Public debt rises by 0.0019% for every 1% increase in trade openness. Investment in Indonesia has been discovered to negatively and significantly impact public debt. Public debt is reduced by 2.4302% for every 1% increase in investment. Additionally, public debt might decrease by 0.8617% for every 1% increase in GDP. The results align with studies in Spain (Cifuentes-Faura et al., 2022), where boosting economic growth helps lower public debt, contrary to the case of Malaysia, Thailand, and the Philippines, where GDP is positively related to public debt. Earlier studies noted that Indonesia performs better than neighboring Asian partners in terms of government debt ratio (Nazamuddin et al., 2022). The GDP debt

ratio of Indonesia has decreased substantially from 2000 to 2015. Meanwhile, environmental degradation is insignificant in Indonesia.

Regarding the case of the Philippines, earlier studies pointed out that GDP and CO_2 have a positive and significant relationship with public debt. Public debt increases by 1.0467% in tandem with a 1% increase in GDP, in line with earlier studies in developing countries (Forslund et al., 2011). Additionally, any 1% rise in CO_2 emissions results in a 0.9876% increase in public debt. Public debt in the Philippines is negatively and significantly correlated with investment, GDS, and corruption. Any increase in investment and corruption can result in a 1.5106% and a 0.3074% fall in public debt, respectively. It has also been discovered that any rise in GDS significantly lowers public debt by 0.2629%. In the meantime, Trade openness is insignificant in the Philippines.

The only factor in Singapore that significantly impacts public debt is investment. A 1% increase in investment results in a 0.716% reduction in public debt. Trade openness, investment, and GDS can significantly and negatively impact public debt in Thailand. A 1% increase in these variables can reduce public debt by 0.0026%, 1.5531%, and 0.9078%, respectively. However, it has been discovered that GDP and public debt have a positive association. A 1% increase in the variable can cause a 1.7968% increase in public debt.

Overall, the findings presented in the study are different than the past studies as it is emphasized on several variables measured in past studies but tested on different samples. Besides, this study embedded the function of environmental degradation on public debt as the past studies do not consider it one of the impetuses to the swollen public debt in the ASEAN region.

5. Discussion

This study confirms the conclusions of prior studies by Dawood et al. (2021), Demikha et al. (2021), Dirir (2022), Forslund et al. (2011), and Waheed (2017) that stronger economic growth might lead to rising public debt. Public debt can rise due to increased government spending on infrastructure and social programs to support economic growth. This indicates that Malaysia, the Philippines, and Thailand have increased government expenditure to boost their economies. Additionally, economic growth, represented by GDP in the study, can increase the amount of public debt, as GDP determines the value of government debt instruments or bonds (Yinguo and Tingting, 2016). Thus, as GDP rises, nations can issue a larger amount of bonds or debt instruments in the financial market. This creates a positive relationship between GDP and public debt in this study. Indonesia is the only ASEAN country in which increasing GDP is linked to decreased public debt. Environmental deterioration has also been linked to increased public debt. The ASEAN-5 nations' efforts to reduce CO_2 emissions have involved significant expenditure in protecting the environment. This suggests that public debt will rise as environmental deterioration worsens. In the single-country analysis, the Philippines is the only nation in our analysis to observe a strong correlation between environmental deterioration and public debt. The result is positive but not statistically significant for the case of Indonesia, Singapore, and Thailand. Government spending may increase due to environmental protections,

increasing the nation's public debt in line with earlier studies (Catalano et al., 2020). Hence, as the environment deteriorates, the cost of cleanup increases (Abbass et al., 2022a). The government must bear the expenses of imposing environmental restrictions and developing renewable energy sources to reduce pollution, which can lead to higher spending (Collatto et al., 2021). The imbalance between income and expenditure caused by environmental degradation often forces the government to rely on debt to cover the shortfall.

Investment might be able to reduce public debt in the ASEAN-5 nations, in line with the findings of Afflatet (2018) and Hilton (2020), as well as Abbas et al. (2020). Except for Malaysia, all other ASEAN-5 countries exhibit statistically significant outcomes. The nexus between economic growth and fiscal health becomes evident, as it can translate into augmented tax revenues and a curtailed budget deficit (Boly et al., 2022). Furthermore, the government's strategic investments in income-generating ventures, such as asset sales and natural resource development, offer promising avenues for debt reduction. Equally noteworthy is the government's propensity to borrow funds for investment in high-yield projects like infrastructure and education. This collective evidence underscores that the ASEAN-5 nations possess ample leeway to expand their investment initiatives without imperiling their public debt situations. The allure of substantial returns from public investments implies that bolstering public financing may yield positive economic ripple effects, ultimately alleviating the debt burden. In other words, economic growth can lead to higher tax revenues and a reduction in the budget deficit. High returns from public investment suggest that expanding public funding might foster positive economic spillovers, reducing the debt burden.

The results of trade openness for the group panel FMOLS are not significant. However, at the country level, the results indicate that increasing trade openness is likely to increase public debt in Indonesia, in line with the evidence from Zafar et al. (2015). Trade openness may also necessitate government investment in programs or policies to support exporters and encourage foreign investment. These programs may include export promotion schemes, investment incentives, and trade negotiations (Heriqbaldi et al., 2022). As a result, public debt might increase. Conversely, in Thailand, a different dynamic unfolds, where trade openness has the potential to reduce public debt. This phenomenon can be attributed to its capacity to attract increased foreign investment and spur economic growth, thereby bolstering tax revenues and curtailing budget deficits, a trend corroborated by the findings of Gnangnon (2020). It's worth noting that previous studies have underlined the variable impact of trade openness on an economy, often contingent on the country's income level, as observed in Wang et al. (2023).

The results also show that corruption tends to amplify public debt levels in Indonesia, and this has been concurred by Azolibe (2020), Forslund et al. (2011), and Thuy Van et al. (2020). The misappropriation of government funds caused the deterioration of government revenues and increased the budget deficit. This unsettling correlation stems from the misappropriation of government funds, which can erode government revenues while concurrently inflating the budget deficit. Such fiscal mismanagement occurs when corrupt officials divert public funds for personal gain rather than directing them toward public expenditure, as elucidated by Shaari et al.

(2023). Conversely, a distinctive narrative unfolds in the Philippines, where corruption has an opposing effect on public debt. This result corroborates the findings of Jalles and Medas (2022) and can be attributed to the tarnished international image resulting from heightened corruption levels. Such a tarnished reputation can hinder the country's ability to secure borrowing, reducing its reliance on debt as a financial resource.

Gross Domestic Savings (GDS) emerges as a potential factor influencing public debt levels, with corroborating evidence from several prior studies, including the works of Omar and Ibrahim (2021) and Waheed (2017). Elevated savings rates can serve as a tool for reducing public debt burdens. This is supported by the idea that higher savings rates can reduce the government's need for external borrowing, thereby promoting reliance on domestic funding sources. Moreover, increased domestic savings can also reduce the trade deficit, lessening the need for borrowing to finance imports. This observed trend holds true in Indonesia, Malaysia, the Philippines, and Thailand. However, a contrasting perspective surfaces in the research of Ikiz (2020), which reveals a positive relationship between GDS and public debt, echoing the findings in Indonesia. This anomaly could be attributed to government policies imposing heavy taxes on domestic savings, inadvertently discouraging citizens from saving. Such a scenario could result in a lack of funds available for investment and impede overall economic growth. Further studies may consider non-linear relationships between public debt and the proposed variables as trade-offs likely vary across the ASEAN-5 region.

Future studies may benefit from exploring non-linear models, especially when accounting for variations in income levels and economic development across regions. As highlighted by earlier studies demonstrating the influence of economic growth (Wang et al., 2023), urbanization (Wang et al., 2023), and trade openness (Wang et al., 2023) on variables like environmental quality, it is plausible that analogous non-linear relationships exist between economic growth, trade openness, and public debt. This implies a pressing need to adopt alternative analytical methods in future research to capture the nuances and complexities inherent in these intricate associations.

6. Conclusions

This study employed the FMOLS approach to analyze the connection between public debt, investment, economic growth, and environmental degradation in the ASEAN-5 nations. The findings have significant implications for policymakers, offering potential strategies to manage and decrease regional public debt. The study's outcomes were assessed both at the collective group level and on a country-specific basis. At the group level, the research reveals that in the ASEAN-5 countries, public debt tends to rise due to robust economic growth and increased investment. Furthermore, the study suggests that heightened investment has the potential to boost tax revenues, which could then be channeled to fund developmental endeavors, ultimately leading to a reduction in public debt. Moreover, this research advocates for government investments that enhance productivity generate income, and boost tax revenues while reducing social spending. Notably, the collective results indicate an upsurge in carbon dioxide emissions corresponds to increased public debt. This

underscores the potential advantage of implementing carbon taxes, which could concurrently safeguard the environment and enhance revenue, ultimately contributing to a reduction in public debt (Gazzani, 2021).

However, when examining country-specific results, variations emerge, reflecting the heterogeneous fiscal landscape and economic development across the ASEAN-5 countries. Indonesia's case stands out, where increasing GDP appears to lower public debt, contrary to the trend observed in the rest of the ASEAN-5 nations. The relationship between savings and public debt also differs across countries, with higher savings being associated with reduced public debt in most ASEAN-5 countries, except Indonesia, where higher savings seem to elevate public debt. Similarly, the impact of corruption on public debt diverges between Indonesia and the Philippines, highlighting the complexity of country-specific dynamics. Moreover, the strategies to mitigate public debt differ among nations. While Thailand benefits from raising trade openness, investment, and savings, Singapore relies heavily on heightened investment to alleviate its public obligations. Malaysia's public debt reduction seems to hinge on higher savings, while in the Philippines, a combination of increased savings, investment, and lower corruption appears effective.

The two-gap model conventionally emphasizes the significance of savings-investment imbalances and foreign exchange gaps in influencing levels of public debt. In our study, including factors such as investment, economic growth, and various economic indicators closely aligns with the fundamental principles of the two-gap model. These elements play a direct or indirect role in contributing to the imbalances that the model seeks to address. Furthermore, the investigation into the effects of environmental degradation, while not a typical component of the traditional two-gap model, can be viewed as an extension of the model's framework to encompass contemporary challenges. Notably, our study's findings regarding the potential of investment to mitigate public debt align with the model's central premise, underscoring investment as a pivotal driver in achieving economic equilibrium.

Nevertheless, the study's spotlight on environmental degradation introduces a novel dimension not explicitly addressed in the traditional two-gap model. Despite this departure, our broader examination of economic and environmental factors in shaping public debt remains consistent with the model's overarching goal of comprehending economic imbalances. It is worth noting that while the specifics of the environmental aspect extend beyond the model's traditional scope, they contribute to a more holistic understanding of the intricate forces at play in the realm of public debt.

7. Policy implications

Policy implications derived from the discussion highlight the interconnectedness of various factors influencing public debt across ASEAN-5 countries. The findings underscore the need for targeted policy interventions tailored to each nation's unique economic landscape. The study's findings regarding the relationships among key variables—investment, GDP, CO_2 emissions, trade openness, corruption, GDS, and environmental degradation—and public debt in the ASEAN-5 countries necessitate the formulation of targeted policies. For nations such as Indonesia and the Philippines, where investment is noted to exert a significant and negative influence on public debt,

policymakers should concentrate on cultivating an environment conducive to heightened investment. Facilitating an atmosphere that encourages both domestic and foreign investments, coupled with directing resources toward infrastructure projects, holds the potential to alleviate public debt gradually. In contexts like Singapore and Thailand, where a favorable correlation between GDP growth and public debt is established, meticulous fiscal oversight becomes vital. Governments must manage their fiscal strategies, ensuring that economic growth remains sustainable and governmental expenditure remains within prudent boundaries to avert an unsustainable surge in public debt.

The positive correlation between CO_2 emissions and public debt in certain countries—such as the Philippines—calls for a proactive approach to environmental consciousness. Creating and implementing measures to curb carbon emissions, including endorsing clean energy sources, amplifying energy efficiency, and instituting carbon pricing mechanisms, can concurrently foster environmental sustainability and mitigate public debt. In jurisdictions where a marked link between trade openness and the reduction of public debt is established—exemplified by Thailand—sustaining an expansive and diversified trade environment can prove advantageous. Amplifying trade relations, diversifying export markets, and fostering industries with a competitive edge can collectively drive heightened economic growth and diminish public debt.

The significant and negative correlation between corruption and public debt in certain countries, notably the Philippines and Thailand, underscores the imperative of tackling corruption head-on. Bolstering anti-corruption endeavors, enhancing transparency in governmental operations, and reinforcing accountability mechanisms can collectively invigorate governance structures and optimize the use of public resources. Policymakers must meticulously strive for equilibrium between economic expansion and environmental preservation. While prioritizing GDP growth remains pivotal for progress, it is equally vital to implement policies that curtail the detrimental impact of economic undertakings on the environment. By seamlessly integrating environmental considerations into economic policies, countries can chart a course toward sustainable growth trajectories while enhancing their debt management strategies.

8. Limitations and future research

While this study strives to examine the association between environmental degradation and public debt in the ASEAN-5 region, several limitations must also be addressed. Notably, the analysis does not incorporate exchange rates as an independent variable. Exchange rate fluctuations can substantially influence a country's economic dynamics, affecting trade balances, external debt, and public debt levels. The absence of exchange rate considerations could potentially create a gap in assessing factors that drive trends in public debt.

The study's findings provide a foundation for future research to explore the nexus between environmental degradation and public debt more comprehensively. First, extending the analytical framework to incorporate exchange rate variables can provide further insights into their potential impact on public debt within the ASEAN-5 context.

Moreover, alternative econometric methods, such as Panel AutoRegressive Distributed Lag (ARDL) or Generalized Method of Moments (GMM), could enhance the study's rigor by addressing potential endogeneity concerns and unobserved heterogeneity.

Additionally, expanding the geographical scope beyond the ASEAN-5 nations to encompass developing Asian countries would provide a broader context for assessing common trends and divergent patterns in the relationship between environmental degradation and public debt. This comparative analysis could reveal how varying economic conditions shape these dynamics. Furthermore, a longitudinal analysis spanning an extended timeframe could shed light on temporal patterns, lagged effects, and cumulative impacts, contributing to a deeper understanding of this relationship over time. Moreover, future works should look into the potential non-linear relationships among the studied variables on public debt, offering deeper insights into their complex interplay and implications for economic policy.

Finally, future research could delve into the policy implications of mitigating public debt burdens through strategies to address environmental degradation. Examining how environmental sustainability aligns with fiscal stability would offer valuable guidance to policymakers seeking to balance economic growth and environmental preservation. By pursuing these research directions, scholars can advance our comprehension of the intricate dynamics between environmental factors, public debt, and sustainable economic development.

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References

Abbas, S., Wizarat, S., & Mansoor, S. (2020). External Debt Distress in South Asia: Evidence from Panel Data Analysis. South Asian Journal of Macroeconomics and Public Finance, 9(2), 221–236. https://doi.org/10.1177/2277978720966485

Abbass, K., Qasim, M. Z., Song, H., et al. (2022). A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environmental Science and Pollution Research, 29(28), 42539–42559. https://doi.org/10.1007/s11356-022-19718-6

Abbass, K., Song, H., Khan, F., et al. (2021). Fresh insight through the VAR approach to investigate the effects of fiscal policy on environmental pollution in Pakistan. Environmental Science and Pollution Research, 29(16), 23001–23014. https://doi.org/10.1007/s11356-021-17438-x

Abdullahi, M. M., Bakar, N. A. Bt. A., & Hassan, S. B. (2015). Determining the Macroeconomic Factors of External Debt Accumulation in Nigeria: An ARDL Bound Test Approach. Procedia - Social and Behavioral Sciences, 211, 745–752.

https://doi.org/10.1016/j.sbspro.2015.11.098

Afflatet, N. (2018). The Impact of Population Ageing on Public Debt: A Panel Data Analysis for 18 European countries. International Journal of Economics and Financial Issues, 8(4), 68–77.

Ahmed Hussein, M. (2008). Costs of environmental degradation. Management of Environmental Quality: An International Journal, 19(3), 305–317. https://doi.org/10.1108/14777830810866437

Akam, D., Nathaniel, S. P., Muili, H. A., et al. (2021). The relationship between external debt and ecological footprint in SANE countries: insights from Kónya panel causality approach. Environmental Science and Pollution Research, 29(13), 19496–19507. https://doi.org/10.1007/s11356-021-17194-y

Akam, D., Owolabi, O., & Nathaniel, S. P. (2021). Linking external debt and renewable energy to environmental sustainability in heavily indebted poor countries: new insights from advanced panel estimators. Environmental Science and Pollution Research, 28(46), 65300–65312. https://doi.org/10.1007/s11356-021-15191-9

Asghar, N., Amjad, M. A., & Rehman, H.-. (2022). Historical Perspective of External Debt in Pakistan: Identifying Key Determinants/Strategies. Review of Economics and Development Studies, 8(1), 13–24. https://doi.org/10.47067/reads.v8i1.427

Atinafu, W. (2020). External debt-growth nexus: Empirical evidence from Ethiopian economy. Economics, Management and Sustainability, 5(2), 6–27. https://doi.org/10.14254/jems.2020.5-2.1

Azhgaliyeva, D., Kapoor, A., & Liu, Y. (2019). Green bonds for financing renewable energy and energy efficiency in South-East Asia: a review of policies. Journal of Sustainable Finance & Investment, 10(2), 113–140. https://doi.org/10.1080/20430795.2019.1704160

Azolibe, C. B. (2020). Determinants of External Indebtedness in Heavily Indebted Poor Countries: What Macroeconomic and Socioeconomic Factors Matter? SAGE Journals, 6(2).

Belguith, S. O., & Omrane, H. (2017). Macroeconomic Determinants of Public Debt Growth: A case study for Tunisia. Theoretical and Applied Economics, 24(613), 161–168.

Bese, E., Friday, H. S., & Özden, C. (2020). The Effect of External Debt on Emissions: Evidence from China. International Journal of Energy Economics and Policy, 11(1), 440–447. https://doi.org/10.32479/ijeep.10605

Boly, M., Combes, J. L., Menuet, M., et al. (2022). Can public debt mitigate environmental debt? Theory and empirical evidence. Energy Economics, 111, 105895. https://doi.org/10.1016/j.eneco.2022.105895

Briceño, H. R., & Perote, J. (2020). Determinants of the Public Debt in the Eurozone and Its Sustainability Amid the Covid-19 Pandemic. Sustainability, 12(16), 6456. https://doi.org/10.3390/su12166456

Catalano, M., Forni, L., & Pezzolla, E. (2020). Climate-change adaptation: The role of fiscal policy. Resource and Energy Economics, 59, 101111. https://doi.org/10.1016/j.reseneeco.2019.07.005

Chen, W., Zhu, Y., He, Z., et al. (2022). The effect of local government debt on green innovation: Evidence from Chinese listed companies. Pacific-Basin Finance Journal, 73, 101760. https://doi.org/10.1016/j.pacfin.2022.101760

Chenery, H. B., & Strout, A. M. (1966). Foreign Assistance and Economic Development. The American Economic Review, 56(4), 679–733.

Cifuentes-Faura, J., Simionescu, M., & Gavurova, B. (2022). Determinants of local government deficit: evidence from Spanish municipalities. Heliyon, 8(12), e12393. https://doi.org/10.1016/j.heliyon.2022.e12393

Collatto, D. C., Lacerda, D. P., Ott, E., et al. (2021). Method for measurement and evidencing of environmental debt (MEED) in productive systems. Journal of Cleaner Production, 282, 124453. https://doi.org/10.1016/j.jclepro.2020.124453

Coulibaly, B. S., Gandhi, D., & Senbet, L. W. (2019). Is sub-Saharan Africa facing another systemic sovereign debt crisis? Africa Growth Initiative.

Countryeconomy. (2023). Available online: https://countryeconomy.com (accessed on 26 June 2023).

Croitoru, L., & Sarraf, M. (2018). How Much Does Environmental Degradation Cost? The Case of Morocco. Journal of Environmental Protection, 09(03), 254–265. https://doi.org/10.4236/jep.2018.93017

Danish, M. H., Jamshaid, F., & Shahzadi, S. (2022). Macroeconomic Determinants of External Debt in Selected SAARC Countries: A Panel Data Analysis. International Journal of Contemporary Economics & Administrative Sciences. https://doi.org/10.5281/ZENODO.7087785

Dawood, M., Baidoo, S. T., & Shah, S. M. R. (2021). An empirical investigation into the determinants of external debt in Asian developing and transitioning economies. Development Studies Research, 8(1), 253–263. https://doi.org/10.1080/21665095.2021.1976658

Del Monte, A., & Pennacchio, L. (2020). Corruption, Government Expenditure and Public Debt in OECD Countries. Comparative Economic Studies, 62(4), 739–771. https://doi.org/10.1057/s41294-020-00118-z

Demikha, L., Shaharuddin, A. B., & Ridzuan, A. R. (2021). The effects of foreign direct investment, external debts and trade openness on economic growth: Evidence from the Ottoman Empire 1881–1913. International Journal of Economics and Business Research, 21(3), 387–410. https://doi.org/10.1504/IJEBR.2021.114382

Demikha, L., Shaharuddin, A., & Edris, M. M. A. M. (2021). The macroeconomic determinants of external debt in Ottoman Empire: A study of data from 1881–1913. The Journal of Muamalat and Islamic Finance Research, 120–136. https://doi.org/10.33102/jmifr.v18i1.336

Diamond, D. W., & He, Z. (2014). A Theory of Debt Maturity: The Long and Short of Debt Overhang. The Journal of Finance, 69(2), 719–762. Portico. https://doi.org/10.1111/jofi.12118

Dimnwobi, S. K., Ikechukwu Okere, K., Azolibe, C. B., et al. (2023). Towards a green future for Sub-Saharan Africa: do electricity access and public debt drive environmental progress? Environmental Science and Pollution Research, 30(41), 94960–94975. https://doi.org/10.1007/s11356-023-29058-8

Dirir, S. A. (2022). Macroeconomic Determinants of the National Debt in Djibouti: An ARDL Approach. International Journal of Economics, Finance and Management Sciences, 5(10), 250–257.

Diwan, R. K. (1968). A test of the two gap theory of economic development. Journal of Development Studies, 4(4), 529–537. https://doi.org/10.1080/00220386808421273

Dumitrescu, B. A., Enciu, A., Hândoreanu, C. A., et al. (2022). Macroeconomic Determinants of Household Debt in OECD Countries. Sustainability, 14(7), 3977. https://doi.org/10.3390/su14073977

Ekouala, U. M. (2022). The role of socio-political factors in public debt accumulation: Evidence from CEMAC countries. International Studies of Economics, 18(3), 306–325. Portico. https://doi.org/10.1002/ise3.17

Erdal, H., & Erdal, G. (2020). Panel FMOLS Model Analysis of the Effects of Livestock Support Policies on Sustainable Animal Presence in Turkey. Sustainability, 12(8), 3444. https://doi.org/10.3390/su12083444

Esquivias, M. A., Sethi, N., & Iswanti, H. (2021). Dynamics of Income Inequality, Investment, and Unemployment in Indonesia. Journal of Population and Social Studies, 29, 660–678. https://doi.org/10.25133/jpssv292021.040

Esquivias, M. A., Sugiharti, L., Rohmawati, H., et al. (2022). Nexus between Technological Innovation, Renewable Energy, and Human Capital on the Environmental Sustainability in Emerging Asian Economies: A Panel Quantile Regression Approach. Energies, 15(7), 2451. https://doi.org/10.3390/en15072451

Farooq, F., Aurang Zaib, Faheem, M., & Gardezi, M. A. (2023). Public debt and environment degradation in OIC countries: the moderating role of institutional quality. Environmental Science and Pollution Research, 30(19), 55354–55371. https://doi.org/10.1007/s11356-023-26061-x

Fatás, A., Ghosh, A. R., Panizza, U., et al. (2019). The Motive to Borrow. Sovereign Debt, 102–150. https://doi.org/10.1093/oso/9780198850823.003.0004

Fodha, M., & Seegmuller, T. (2013). Environmental Quality, Public Debt and Economic Development. Environmental and Resource Economics, 57(4), 487–504. https://doi.org/10.1007/s10640-013-9639-x

Forslund, K., Lima, L., & Panizza, U. (2011). The determinants of the composition of public debt in developing and emerging market countries. Review of Development Finance, 1(3–4), 207–222. https://doi.org/10.1016/j.rdf.2011.09.004

Gazzani, F. (2021). Transition to social-ecological sustainability using the environmental fiscal reform. International Journal of Social Economics, 48(5), 675–692. https://doi.org/10.1108/ijse-09-2020-0656

Gnangnon, S. K. (2021). Tax reform and public debt instability in developing countries: The trade openness and public revenue instability channels. Economic Analysis and Policy, 69, 54–67. https://doi.org/10.1016/j.eap.2020.11.005

Gokmenoglu, K., & Rafik, R. A. (2018). Determinants of External Debt: The Case of Malaysia. Springer International Publishing.

Gründler, K., & Potrafke, N. (2019). Corruption and economic growth: New empirical evidence. European Journal of Political Economy, 60, 101810. https://doi.org/10.1016/j.ejpoleco.2019.08.001

Hajian, H., Mohamed, A., & Ranjanee A/P Kaliappan, S. (2022). Government Debt-Economic Growth Nexus in ASEAN-4 Countries. Journal of Developing Economies, 7(1), 45–69. https://doi.org/10.20473/jde.v7i1.30122

Heriqbaldi, U., Esquivias, M. A., Handoyo, R. D., et al. (2022). Exchange rate volatility and trade flows in Indonesia and ten main trade partners: asymmetric effects. Studies in Economics and Finance, 40(4), 708–739. https://doi.org/10.1108/sef-10-2021-0451

Hilton, S. K. (2021). Public debt and economic growth: contemporary evidence from a developing economy. Asian Journal of

Economics and Banking, 5(2), 173–193. https://doi.org/10.1108/ajeb-11-2020-0096

Hlongwane, N. W., & Daw, O. D. (2022). Determinants of public debt in South Africa: A regime-switching approach. Munich Personal RePEc Archive.

IEA. (2020). World Energy Investment Report. Available online: http://www.iea.org/ (accessed on 9 March 2024).

İkiz, A. S. (2020). Testing the Ricardian Equivalence Theorem: Time Series Evidence from Turkey. Economies, 8(3), 69. https://doi.org/10.3390/economies8030069

Iloie, R. E. (2015). Connections between FDI, Corruption Index and Country Risk. Procedia Economics and Finance, 32, 626–633. https://doi.org/10.1016/S2212-5671(15)01442-2

Imran, M. (2016). The Determinants of Public Debt in Pakistan: An ARDL Approach [Master's thesis]. KDI School of Public Policy and Management.

Karazijienė, Ž. (2015). Critical Analysis of Public Debt and Tendencies of its Management. Public Policy and Administration, 14(2), 194. https://doi.org/10.13165/vpa-15-14-2-03

Katircioglu, S., & Celebi, A. (2018). Testing the role of external debt in environmental degradation: empirical evidence from Turkey. Environmental Science and Pollution Research, 25(9), 8843–8852. https://doi.org/10.1007/s11356-018-1194-0

Kirikkaleli, D., & Sofuoğlu, E. (2023). Does financial stability matter for environmental degradation? Geological Journal, 58(9), 3268–3277. Portico. https://doi.org/10.1002/gj.4707

Knapková, M., Kiaba, M., & Hudec, S. (2019). Impact Of Macroeconomic Indicators On Public Debt Of Slovak Republic. Journal of Business Economics and Management, 20(4), 734–753. https://doi.org/10.3846/jbem.2019.10184

Lau, E., Moll de Alba, J., & Liew, K.-H. (2022). Debt and economic growth in Asian developing countries. Economic Analysis and Policy, 76, 599–612. https://doi.org/10.1016/j.eap.2022.09.011

Li, R., Wang, Q., Liu, Y., et al. (2021). Per-capita carbon emissions in 147 countries: The effect of economic, energy, social, and trade structural changes. Sustainable Production and Consumption, 27, 1149–1164. https://doi.org/10.1016/j.spc.2021.02.031

Lin, B., & Zhu, J. (2019). Fiscal spending and green economic growth: Evidence from China. Energy Economics, 83, 264–271. https://doi.org/10.1016/j.eneco.2019.07.010

Manasseh, C. O., Abada, F. C., Okiche, E. L., et al. (2022). External debt and economic growth in Sub-Saharan Africa: Does governance matter? PLOS ONE, 17(3), e0264082. https://doi.org/10.1371/journal.pone.0264082

Mao, K., & Failler, P. (2022). Local Government Debt and Green Total Factor Productivity—Empirical Evidence from Chinese Cities. International Journal of Environmental Research and Public Health, 19(19), 12425. https://doi.org/10.3390/ijerph191912425

Medas, P., & Jalles, J. T. (2022). Economic Growth After Debt Surges. IMF Working Papers, 2022(159), 1. https://doi.org/10.5089/9798400217227.001

Misra, S., Gupta, K., & Trivedi, P. (2021). Sub-national government debt sustainability in India: an empirical analysis. Macroeconomics and Finance in Emerging Market Economies, 16(1), 57–79. https://doi.org/10.1080/17520843.2021.1948171

Nagou, M., Bayale, N., & Kouassi, B. K. (2021). On the robust drivers of public debt in Africa: Fresh evidence from Bayesian model averaging approach. Cogent Economics & Finance, 9(1). https://doi.org/10.1080/23322039.2020.1860282

Nazamuddin, B. S., Wahyuni, S. S., Fakhruddin, F., et al. (2022). The nexus between foreign exchange and external debt in Indonesia: evidence from linear and nonlinear ARDL approaches. Journal of the Asia Pacific Economy, 29(2), 810–836. https://doi.org/10.1080/13547860.2022.2054153

Olaoye, O. O., Tabash, M. I., Omokanmi, O. J., et al. (2022). Macroeconomic implications of escalating stock of public debt: Evidence from sub-Saharan African economies. African Development Review, 34(4), 527–540. https://doi.org/10.1111/1467-8268.12677

Omar, Z. M., & Ibrahim, M. I. (2021). Determinants Of External Debt: The Case of Somalia. Asian Development Policy Review, 9(1), 33–43.

Onuoha, F. C., Dimnwobi, S. K., Okere, K. I., & Ekesiobi, C. (2023). Funding the green transition: Governance quality, public debt, and renewable energy consumption in Sub-Saharan Africa. Utilities Policy, 82, 101574. https://doi.org/10.1016/j.jup.2023.101574

Ostry, J. D., Ghosh, A. R., & Espinoza, R. (2015). When Should Public Debt Be Reduced? Available online: https://www.imf.org/external/pubs/ft/sdn/2015/sdn1510.pdf (accessed on 9 March 2024).

Ouhibi, S., Zouidi, N., & Hammami, S. (2017). The Nexus Between Foreign Direct Investment, Economic Growth and Public

Debt in the Southern Mediterranean Countries: Evidence from Dynamic Simultaneous-Equation models. Journal of Economics and Economic Education Research, 18(1), 1–13.

Ozturk, M., Aras, O. N., & Kadi, F. S. (2012). Determinants of Debt Crisis in EU and The Recovery Efforts. International Journal of Social Sciences and Humanity Studies, 4(2), 343–354.

Pedroni, P. (1999). Critical values for co-integration tests in heterogenous panels with multiple regressors. Oxford Bulletin of Economics and Statistics.

Peng-Lee, S., & Ng, Y. L. (2015). Public Debt and Economic Growth in Malaysia. Asian Economic and Financial Review, 5(1), 119–126. https://doi.org/10.18488/journal.aefr/2015.5.1/102.1.119.126

Pincus, S. C., & Robinson, J. A. (2011). What Really Happened During the Glorious Revolution? Available online: https://www.nber.org/papers/w17206 (accessed on 8 March 2024).

Qi, Z., Yang, S., D. F., & Wang, W. (2022). The impact of local government debt on urban environmental pollution and its mechanism: evidence from China. Plos One, 17(3). https://doi.org/10.1371/journal.pone.0263796

Rahman, M. M., Saidi, K., & Mbarek, M. B. (2020). Economic growth in South Asia: the role of CO2 emissions, population density and trade openness. Heliyon, 6(5). https://doi.org/10.1016/j.heliyon.2020.e03903

Raihan, A., Ibrahim, S., & Muhtasim, D. A. (2023). Dynamic impacts of economic growth, energy use, tourism, and agricultural productivity on carbon dioxide emissions in Egypt. World Development Sustainability, 2, 100059. https://doi.org/10.1016/j.wds.2023.100059

Sadik-Zada, E. R., & Gatto, A. (2019). Determinants of the Public and the Role of the Natural Resources: A Cross-country analysis. Fondazione Eni Enrico Mattei Working Paper Series.

Saidi, K., & Hammami, S. (2014). The impact of CO_2 emissions and economic growth on energy consumption in 58 countries. Energy Reports, 1, 62–70. https://doi.org/10.1016/j.egyr.2015.01.003

Sarfaz, M., Naseem, S., & Mohsin, M. (2022). Adoption of renewable energy, natural resources with conversion information communication technologies and environmental mitigation: Evidence from G-7 countries. Energy Reports, 8, 11101–11111. https://doi.org/10.1016/j.egyr.2022.08.248

Semik, S., & Zimmermann, L. (2022). Determinants of substantial public debt reductions in Central and Eastern European Countries. Empirica, 49, 53–70. https://doi.org/10.1007/s10663-021-09529-2

Shaari, M. S., Abidin, N. Z., & Rahim, H. A. (2022). Macroeconomic determinants of child abuse in Malaysia: an ARDL approach. International Journal of Economic Policy in Emerging Economies, 15, 139–152.

Shaari, M. S., Masnan, F., Rani, M. J., et al. (2023). The Grim Cost of Economic Growth and Environmental Degradation: A Comprehensive Panel ARDL study of Public Debt in the ASEAN-5 countries. Sustainability, 15. https://doi.org/10.3390/su151410756

Shaari, M. S., Sulong, A., Ridzuan, A. R., Esquivias, M. A., & Lau, E. (2024). The Carbon Conundrum: Exploring CO_2 Emissions, Public Debt, and Environmental Policy. Emerging Science Journal, 8(3), 933–947. http://dx.doi.org/10.28991/ESJ-2024-08-03-08

Shah, M. I., Shuaibu, M. S., AbdulKareem, H. K., et al. (2023). Inequality consequences of natural resources, environmental vulnerability, and monetary-fiscal stability: A global evidence. Environmental Science and Pollution Research, 30(4), 10329–10345.

Shah, M., Khan, M. M., & Kamal, A. (2022). The Impact of Trade Openness and Public Debt Level on Fiscal Spending in Pakistan. International Journal of Business and Management Sciences, 3(2), 1–18.

Shang, Y., Razzaq, A., Chupradit, S., et al. (2022). The role of renewable energy consumption and health expenditures in improving load capacity factor in ASEAN countries: Exploring new paradigm using advance panel models. Renewable Energy, 191, 715–722. https://doi.org/10.1016/j.renene.2022.04.013

Sundus, Naveed, S., & Islam, T. U. (2022). An empirical investigation of determinants & sustainability of public debt in Pakistan. PLOS One, 17(9), e0275266. https://doi.org/10.1371/journal.pone.0275266

Swamy, V. (2015). Government Debt and its Macroeconomic Determinants an Empirical Investigation. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.2601875

Thuy Van, V. T., Thai Ha, N. T., Quyen, P. G., et al. (2020). The Relationship Between Public Debt, Budget Deficit, and Sustainable Economic Development in Developing Countries: The Role of Corruption Control. Jurnal Ekonomi & Studi Pembangunan, 21(1). https://doi.org/10.18196/jesp.21.1.5033

Waheed, A. (2017). Determinants of External Debt: A Panel Data Analysis for Oil and Gas Exporting and Importing countries.

International Journal of Economics and Financial Issues, 7(1), 234–240.

Wang, Q., Wang, X., & Li, R. (2022). Does urbanisation redefine the environmental Kuznets curve? An empirical analysis of 134 Countries. Sustainable Cities and Society, 76, 103382. https://doi.org/10.1016/j.scs.2021.103382

Wang, Q., Zhang, F., & Li, R. (2023). Revisiting the environmental kuznets curve hypothesis in 208 counties: The roles of trade openness, human capital, renewable energy and natural resource rent. Environmental Research, 216. https://doi.org/10.1016/j.envres.2022.114637

Wei, J., Rahim, S., & Wang, S. (2022). Role of environmental degradation, Institutional quality and government health expenditure for human health: evidence from emerging seven countries. Frontier in Public Health.

Yinguo, L., & Tingting, L. (2016). Analysis of Affecting Factors of China's National Debt. In: International Conference on Education, Management, Computer and Society. Atlantis Press.

Zafar, M., Sabri, P. S., Ilyas, M., & Kousar, S. (2015). The Impact of Trade Openness and External Debt on Economic Growth: New Evidence from South Asia, East Asia. Science International, 27(1), 509–516.