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Is Impact of Government Size on Growth in ASEAN Linear or Non-linear? Monte-Carlo Hierarchical Insights under Keynesian, Neoclassical, and Barro Perspectives

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Abstract

Many prior studies on the government-growth nexus have focused on Keynesian (Keynes, 1936) or neoclassical (Lucas, 1990) traditions, while a recent research strand has paid widespread attention to Barro (1990)'s non-linear perspective. Although modern complexity sciences suggest an overall non-linear trend in a complicated, interconnected, globalized world, non-monotonicity is poorly addressed in the applied literature. This work explores both the linear and non-linear effects of government size on economic growth. By employing a hybrid Metropolis-Hastings algorithm within a hierarchical Bayesian approach to a panel of ASEAN countries over 1950-2019, which aids in handling statistical complexities, the results show a negative growth impact of government size. This finding aligns with the neoclassical viewpoint on bureaucratic inefficiencies and the distortionary effects of government intervention in a market economy. Substantial measures are needed to increase public spending efficiency and accountability, focus on productive investments, encourage private sector activities, and implement structural reforms in ASEAN.

Keywords

Monte-Carlo algorithm, Bayesian hierarchical approach, Multicollineartity, Government-growth, Negative linear effect, ASEAN

JEL Classification

E62, O40

Introduction

Macroeconomists have been continuously debating the role and intervention level of government in a market-based economy. Macroeconomic theories present three distinct perspectives. Keynesian theorists (Keynes, 1936; Minsky, 1986; Krugman, 2012; Stiglitz, 2012; Summers, 2016) argue that substantial government intervention is necessary during economic crises, advocating for increased public expenditures, tax cuts, and expansionary monetary policies to stabilize the economy and promote growth. Conversely, neoclassical scholars (Hayek, 1960; Friedman, 1962; Friedman & Schwartz, 1963; Lucas, 1990) emphasize the self-regulating nature of markets, supporting minimal government intervention. They believe that markets naturally reach full employment and that government actions often lead to market distortions. The third perspective, endogenous growth theory, predicts a hump-shaped linkage between government size (or spending) and economic growth (Barro, 1990; Barro & Sala-i-Martin, 1995), commonly referred to as the Armey curve (Armey, 1995) or an inverted U-shape. This theory suggests achieving the optimal government size when the negative impact of marginal taxation on economic growth is balanced by the increase in the social marginal productivity of private capital.

In addition to theoretical insights, a substantial body of empirical literature examines the growth effects of government size, often measured by government expenditure. However, the findings are mixed and, therefore, inconclusive: some studies suggest that government expenditures hinder growth (Landau, 1983; Guseh, 1997; Fölster & Henrekson, 2001; Dar & AmirKhalkhali, 2002; Churchill et al., 2017; Buthelezi, 2023), others find that such expenditures enhance economic growth (Kormendi & Meguire, 1986; Ram, 1986; Vedder & Gallaway, 1998; Günalp & Gür, 2002; Loizides & Vamvoukas, 2005; Schaltegger & Torgler, 2006; Bose et al., 2007; Esen & Bayrak, 2015; Jordà & Taylor, 2016; Fatàs & Summers, 2018; Gechert et al., 2019; Poku et al., 2022; Okulola et al., 2024, and Colombier, 2024), and some recognize threshold effects of government size on output (Grossman, 1988; Chen

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& Lee, 2005; Tabassum, 2015; Asimakopoulos & Karavias, 2016; Aydin & Esen, 2018; Arawatari et al., 2023).

It is important to note that earlier studies predominantly utilized conventional frequentist techniques, which are susceptible to biases arising from omitted variables, reverse causality, and multicollinearity. In such cases, the Bayesian framework offers a more robust approach (Block et al., 2011; Winship & Western, 2016; Pesaran, 2018; Thach, 2019; Thach, 2023). Moreover, studies focusing on ASEAN data samples are relatively scarce, with no research specifically examining the negative relationship between government size and growth. Considering strong government intervention in the economy, low institutional quality, ineffective governance, and an underdeveloped economic structure as salient characteristics of most ASEAN nations, which lag behind developed countries, it is posited that government size negatively impacts economic growth in this region. This notion aligns with the neoclassical perspective on the minimal role and intervention level of the state. Meanwhile, Barro (1990) and other scholars suggest a possible non-linear government-growth correlation. Therefore, two key questions emerge: first, which pattern, linear or non-linear, does the government-growth causality follow in ASEAN? Second, which advanced econometric techniques can be adopted to obtain convincing results when statistical complexities pose challenges?

Stemming from the above argumentation, this study aims to explore the linear and non-linear relationships between government size and economic growth using an ASEAN panel dataset from 1950 to 2019. While the findings indicate a linear, monotonic effect where government size tends to constrain growth, the primary contributions include applying a Bayesian hierarchical approach to address statistical uncertainties in government-growth models and identifying a true linear, monotonic relationship using advanced econometric techniques on a larger sample. The results of the analysis serve as a robust and reliable empirical basis for designing efficient fiscal policies aimed at sustainable economic growth in ASEAN.

The study is structured as follows: Section II reviews the theoretical and empirical literature, identifying research gaps. Section III introduces the Bayesian hierarchical method, specifies baseline regression models, and describes the data sample. Section IV presents and analyzes the Bayesian results, followed by concluding remarks in Section V.

Literature Review

Theoretical background

Regarding the government-growth linkage, there are three prevailing perspectives: Keynesian, neoclassical, and endogenous growth theory.

The Keynesian view on the government-growth nexus revolves around the belief that government intervention in the economy is essential to stabilize economic cycles, promote growth, and mitigate the adverse impacts of economic downturns (Keynes, 1936; Minsky, 1975; 1986; Krugman, 2008; 2012; Stiglitz, 2002; 2012; Summers, 2016, Bofinger, 2020). Specifically, Keynesians believe that government spending on infrastructure, education, healthcare, and other public goods can boost economic growth. Such investments can increase productivity by improving the quality of the labor force and reducing costs for businesses. Infrastructure projects, in particular, can create jobs and stimulate demand in the short term while enhancing long-term economic capacity. As Keynesians argue, government spending has a multiplier effect on the economy. This means that an initial increase in government spending leads to a larger overall increase in economic activity. For example, when the government builds a new road, it not only creates construction jobs but also increases demand for materials and services, which in turn stimulates further economic activity. Contrary to the neoclassical "crowding out" argument, Keynesians posit that in times of underutilized resources (e.g., during a recession), government spending can "crowd in" private investment. By increasing demand and reducing uncertainty, government spending can encourage businesses to invest more, further stimulating economic growth.

Contract to the Keynesian point of view, neoclassical economists generally mention that smaller government and minimal intervention are more conducive to economic growth. They believe in the efficiency of markets and that government involvement often leads to inefficiencies and distortions (Friedman, 1962; Friedman & Schwatz, 1963; Hayek, 1944; 1960; Lucas, 1972; 1976; 1990; Feldstein, 1995). Neoclassical economists stress that markets are efficient in allocating resources, where individuals and firms, driven by profit motives and competition, make decisions that lead to optimal resource use (Coase, 1937; Jensen & Meckling, 1976). Government intervention, they argue, often disrupts these market processes and leads to suboptimal outcomes (Lambsdorff, 2003). Besides, one key argument is the crowding-out effect. When the government increases its spending, it often finances this through borrowing. This can lead to higher interest rates, which may crowd out private investment (Atukeren, 2005). Reduced private investment is seen as detrimental to long-term economic growth, as the private sector is considered more efficient in investing resources. Neoclassical scholars contend that higher government spending requires higher taxes, which can distort economic incentives. Taxes on income, capital gains, and corporate profits can discourage work, saving, and investment, thereby reducing economic growth (Canto et al., 1981; Gwartney & Wagner, 1988; Henderson, 1989; Lucas, 1990; Lindsey, 1987; Feldstein, 1995). Government agencies are often viewed as less efficient than private firms due to lack of competition and profit incentives (Benz & Frey, 2005).

Bureaucratic inefficiencies and political motivations can lead to wasteful spending and misallocation of resources (Barnard, 1938; Herbert, 1947; Tullock, 1965; Niskanen, 1971; Wilson, 1989; Mauro, 1995; Wei, 1999; Cote, 2012). Neoclassical economists highlight the negative impact of policy uncertainty. Frequent changes in government policy can create an unpredictable business environment, which can deter investment and innovation.

Endogenous growth theory predicts an inverse U-shaped relationship between government size and economic growth (Barro, 1990; Barro & Sala-i-Martin, 1995; Armey, 1995). This theory postulates that the optimal government size is reached when the negative impact of marginal taxation, which is used to finance government activities, on economic growth is balanced by the increase in the social marginal productivity of private capital through a higher public-input-to-GDP ratio. At this steady-state equilibrium, the negative impact of marginal taxation on economic growth equals the marginal productivity of public input. Beyond this point, government activities hinder growth because the negative impact of taxation becomes dominant. As the public-input-to-GDP ratio increases, the marginal productivity of capital approaches zero. The model assumes that productive public inputs, such as education, infrastructure, and government-funded research and development, enhance private capital productivity because they are non-rival at the factor level (Barro & Sala-i-Martin 1995; Colombier & Pickhardt 2002). These inputs are factor-augmenting. Larger government implies higher tax rates, leading to the dampening effects of distortionary taxation on private households' savings-investment and labor-leisure decisions, outweighing the beneficial impact of public inputs. In the endogenous growth model, the marginal social costs of taxation exceed the marginal social productivity of factor-augmenting public inputs. Additionally, new political economists like Buchanan & Wagner (1977) document that democratic governments are incentivized to inefficiently oversize the government due to factors such as political business cycles or rent-seeking activities. Democratic governments often exhibit a deficit bias, as politicians might engage in pro-cyclical fiscal policies during economic booms, over-expand fiscal stabilization programs to appease their constituencies, or enact oversized social transfers to boost their re-election prospects, thereby increasing the risk of crowding-out effects.

Empirical studies

Empirical results on the government-growth nexus are mixed. Within the Keynesian approach, empirical evidence on fiscal policy following the Global Financial Crisis (GFC) contradicts new political economy arguments. Studies by Kormendi & Meguire (1986), Loizides & Vamvoukas, 2005; Aghion & Marinescu (2007), Jordà & Taylor (2016), Fatàs & Summers (2018), Gechert et al. (2019), and Colombier (2024) indicate that expansionary fiscal policy can positively impact economic growth. By using the pooled mean group, mean group, and dynamic fixed effect model, their empirical results demonstrate a positively significant influence of government expenditure on economic growth in the long run. Recently, Poku et al. (2022) and Okulola et al. (2024) provide similar findings for a single country, such as Ghana, from 1970 to 2016, and for a sample of 15 ECOWAS countries between 1999 and 2021, respectively. Several reasons explain the long-term effects of fiscal policy. Firstly, recessions tend to have persistent effects (Cerra & Saxena, 2008). Secondly, fiscal policy reduces uncertainty during recessions by smoothing business cycles (Aghion & Marinescu, 2007). Thirdly, market failures in capital and labor markets, caused by behavioral biases and information asymmetries like credit constraints and hysteresis, are common (Blanchard & Summers, 1987; Greenwald & Stiglitz, 1993; Akerlof, 2007). Fourthly, fairness concerns of employees are significant (Bhaskar 1990). Finally, long-run fiscal multipliers increase when monetary policy is constrained by the zero-lower bound of nominal interest rates (De Long & Summers, 2012; Gechert, 2015; Fatàs & Summers, 2018).

Recent surveys on the impact of government size show mixed results regarding its effect on economic growth. Gemmell & Au (2013) suggest that the positive impact of productive public inputs is offset by the distortionary effects of taxation, while Bergh & Henrekson (2011) and a meta-analysis by Churchill et al. (2017) find a systematic negative correlation between government size and economic growth in developed countries. A recent study by Chen et al. (2020) uncovers that government expenditure negatively influences long-run economic growth when financed by tax revenues, but positively influences long-run economic growth when financed by other sources such as non-tax revenues and budget surplus/deficit. Bergh & Henrekson (2011) argue for a consensus based on a small sample of seven studies, five of which support this thesis. The meta-analysis by Churchill et al. (2017) covers 29 studies on developed countries, including those referenced by Bergh & Henrekson. Six out of 23 studies reviewed by Gemmell & Au overlap with Churchill et al.'s meta-analysis. While Gemmell & Au focus on the tax side of the public budget, Churchill et al. analyze the growth effects of general government expenditure and government consumption as a ratio of GDP. Brändle (2020) provides a recent review. Thus, adopting the neoclassical framework, researchers like Landau (1983), Guseh (1997), Folster & Henrekson (2001), Dar & AmirKhalkhali (2002), Churchill et al. (2017), and Buthelezi (2023) argue that government consumption expenditures impede economic growth.

Notably, most studies focus on linear effects and fail to test for non-linear impacts. This indicates a lack of evidence supporting the non-linearity hypothesis, as recently noted by some authors (Christie, 2014; Hajamini & Falahi, 2018). The few studies examining non-linear effects of government expenditure on GDP in developed economies find evidence for an optimal government size, suggesting a tipping point of government activity as predicted by endogenous growth theory. However, comparability among these studies is limited due to varying measures of government size. For instance, Vedder & Gallaway (1998) and Christie (2014) utilized general government expenditure, while Asimakopoulos & Karavias (2016) and Hajamini & Falahi (2018) used government consumption. Additionally, Vedder & Gallaway (1998) supplement their analysis with central government expenditure, and Hajamini & Falahi (2018) include expenditures other than government consumption and public investments. This literature also employs different methods to test the non-linearity hypothesis. Recent empirical studies exploring the link between government size and economic growth consistently identify a historical pattern aligning with the inverted U-shaped curve, known as the Armey or BARS curve. Up to a certain point, there is a positive correlation between government expenditures and economic growth, with the peak indicating the "optimal" government size that maximizes GDP growth. Beyond this peak, the correlation turns negative, suggesting that further expansion of government size diminishes economic growth. Foundational research by Grossman (1988), Sheehey (1993), Karras (1996, 1997), Chen & Lee (2005), Abounoori & Nademi (2010), De Witte & Moesen (2010), Altunc & Aydın (2013), Tabassum (2015), Asimakopoulos & Karavias (2016), and Aydin & Esen (2018) identifies a non-monotonic relationship between government size and economic growth. Their findings affirm the robustness of the inverted U-shaped pattern, highlighting the complexity of the government's role in economic growth. Grossman (1988) pioneered this approach by introducing a simultaneous equations model that captures non-monotonic effects, showing it provides a better fit than linear models using U.S. time-series data. Further studies by Chen & Lee (2005) on Taiwan, Abounoori & Nademi (2010) on Iran, Asimakopoulos & Karavias (2016) on 129 countries, Ono (2014) on Japan, and others, reveal that government expenditures have a threshold effect on economic growth, forming a non-linear relationship characterized by Armey and BARS curves. Aydin & Esen (2018) extend this analysis to 26 transition economies, finding that government spending above a certain threshold negatively impacts growth, while spending below it has a positive effect. The results suggest that government expenditures exhibit a threshold effect on economic growth, following a non-monotonic pattern. Specifically, Thanh & Mai (2014) employed a smooth transition regression model for a panel of ASEAN countries over 1980–2011 and revealed the threshold effect of government size on growth. Utilizing a panel of ASEAN countries between 2000 and 2020, Hoa (2022) found a threshold level for government spending that reduces economic growth if government expenditure exceeds 26.82 percent of GDP. Recently, Arawatari et al. (2023) revealed the causality between the government expenditure/GDP ratio and the economic growth rate is depicted by an inverted U-shaped curve with a flat top.

The study identifies the following gaps:

First, methodologically, many studies suffer from endogeneity bias as they fail to account for reverse causality (Churchill et al. 2017). Wagner’s law, Baumol’s cost disease, or the long-term effects of fiscal policy contribute to the endogeneity of government expenditure (Wu et al. 2010). Wu et al. (2010), conducting a Granger causality analysis for a panel of 182 countries from 1950 to 2004, showed evidence of statistically significant bi-directional causation. Furthermore, cross-country studies that report a statistically negative correlation often suffer from omitted variable bias (Churchill et al. 2017). These studies usually do not account for country fixed effects that control for unobservable or immeasurable factors. Consequently, panel-data methods have become the standard approach over cross-country studies. Lastly, frequentist analyses encounter multicollinearity when certain covariates are highly correlated.

Second, there are few similar investigations in the ASEAN context. Some studies reveal threshold effects of government size on total output, while others find a positive impact. To the best of our knowledge, no studies have gained insights into the negative connections. We believe that a negative relationship between government size and growth is more realistic when accounting for the socio-economic, political, and institutional structures specific to the ASEAN countries, where the role and intervention of the government remain relatively significant compared to advanced nations. This study aims to use a longer time frame to capture potential non-linear, non-monotonic effects.

Methods

When faced with statistical uncertainties due to reverse causality, omitted variable bias, and multicollinearity in growth models, researchers have advocated for the adoption of Bayesian statistics, which offer a more sophisticated approach to econometric modeling (Block et al., 2011; Winship & Western, 2016; Pesaran, 2018; Briggs, 2023; Thach, 2023; Thach, 2024). The study applies Bayesian hierarchical method, which has substantially contributed to the growth literature, producing more consistent findings compared to conventional frequentist approaches. In a hierarchical (mixed effects) regression, data is organized into multiple levels or groups, and relationships between variables are modeled at each level (Nezlez, 2008). By incorporating both available data and prior information, Bayesian hierarchical regression demonstrates greater resilience in handling reverse causality, omitted variable bias, and multicollinearity.

First, Bayesian hierarchical regression can mitigate multicollinearity through a shrinkage effect, which reduces the impact of multicollinearity by shrinking estimates towards each other. This allows for differentiating the impacts of variables on economic growth while acknowledging their varying magnitudes of influence.

Second, the Bayesian approach proves valuable in addressing reverse causation by carefully selecting specific priors. Bayesian inference integrates prior beliefs or existing knowledge about variable relationships, dampening the potential impact of reverse causation. For instance, by assuming specific normal distributions for regression coefficients, we aim to affirm a unidirectional linkage where government spending either hinders or stimulates economic growth, thereby avoiding misleading bidirectional causality.

Finally, adding relevant covariates and country-specific effects to address omitted variable bias often leads to multicollinearity. The Bayesian approach handles multicollinearity better than the frequentist paradigm, making it advantageous for this type of analysis.

Our research deals with complex models and high-dimensional parameter spaces, such as hierarchical models. Hybrid Markov Chain Monte Carlo (MCMC) sampling algorithms, which combine the Metropolis-Hastings (MH) algorithm and Gibbs sampler, are crucial tools for performing Bayesian inference. These MCMC algorithms are used to generate samples from the posterior distribution of the parameters in a Bayesian hierarchical model. Once samples from the posterior are obtained using MCMC, these samples can be used to estimate posterior means, variances, and credible intervals, which are essential for Bayesian inference. Conducting the MCMC samplers with specific priors for the focus parameters, which capture variations across countries in a longitudinal dataset, produces more accurate predictions. We specify Bayesian hierarchical regression models as follows:

$$lnQ_{jt} = \beta_0 + \beta_1 lnG_{jt} + \beta_2 lnX_{jt} + u_j + \vartheta_j + \varepsilon_{jt}. \quad (1)$$

To account for potential non-linear and non-monotonic relationships, the quadratic term for government size (*lnG2*) is incorporated in the linear model (1).

$$lnQ_{jt} = \alpha_0 + \alpha_1 lnG_{jt} + \alpha_2 lnG2_{jt} + \alpha_3 lnX_{jt} + u_j + \vartheta_j + \varepsilon_{jt}. \quad (2)$$

where Q represents real GDP, G denotes government consumption spending as a ratio of real GDP, and X is a vector of control variables that includes physical capital (K), labor (L), human capital (H), and technology (TFP). The term ε accounts for random error, while u and ϑ signify random effects and random coefficients, representing general and government spending-specific country attributes. The subscripts t and j refer to year and country, respectively, and α and β are structural parameters. To control for the effect of physical capital, the variable K is a proxy for the physical capital stock. Human capital is represented by the variable H, which is derived from the average years of schooling and the returns to education based on the Mincer equation. The labor variable L reflects the number of people engaged in the economy. Total output Q and physical capital K are measured at constant 2017 national prices, while labor L is measured in millions. In the literature, various measures of government size have been utilized (Vedder & Gallaway, 1998; Nijkamp & Poot, 2004; Gemmell & Au, 2013; Colombier, 2015; Churchill et al., 2017; Hajamini & Falahi, 2018). These measures include the ratios of general, central, and subnational government expenditures, tax revenues, government consumption, government consumption plus transfers, and public investments to GDP. For data consistency, we have chosen to utilize government consumption expenditure as a share of real GDP. Although this measure excludes transfer payments and public investments, it aligns with the study's focus. All data for the MCMC simulations were collected from the latest Penn World Table version 10.01, covering the period from 1950 to 2019 (Table 1).

Table 1. Definition of variables.

Variables		Proxies	Period	Not.	Data source
Dependent	Economic growth	Natural logarithm of real GDP	1950-2019	lnQ	PWT 10.01
Independent	Government size	Natural logarithm of share of government consumption in real GDP	1950-2019	lnG	PWT 10.01
	Physical capital stock	Natural logarithm of physical capital	1950-2019	lnK	PWT 10.01
	Labor	Natural logarithm of the number of people engaged in an economy	1950-2019	lnL	PWT 10.01
	Human capital	Natural logarithm of the index derived from the average years of schooling and the returns to education based on the Mincer equation	1950-2019	lnH	PWT 10.01
	Technology level	Natural logarithm of total factor productivity	1950-2019	lnTFP	PWT 10.01

Source: Authors.

Due to data unavailability, Timor-Leste is excluded from the analysis. Consequently, our dataset comprises 10 ASEAN countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam.

Logarithmic transformations are applied to all variables to normalize skewed data, minimize the impact of outliers, and stabilize variance. The prefix "ln" is used before variable notations to indicate that the logarithm has been taken. As a result, the histograms of all the variables look better after log transformation. For illustration purposes, we present histogram plots for the dependent and focus variables, G and Q (see Figs. 1 and 2).

(a) (b)

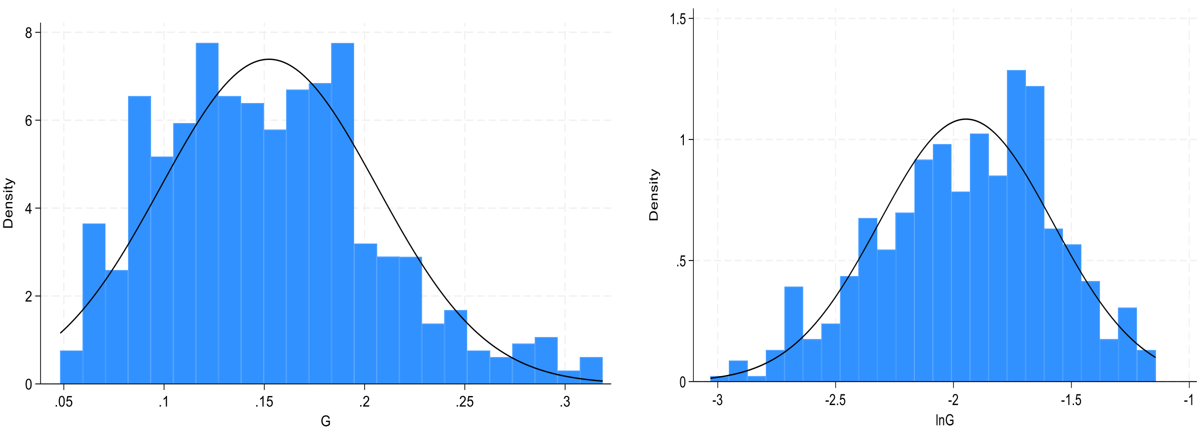

Fig. 1. Histogram plots: (a) G and (b) lnG.
Source: Authors.

(a) (b)

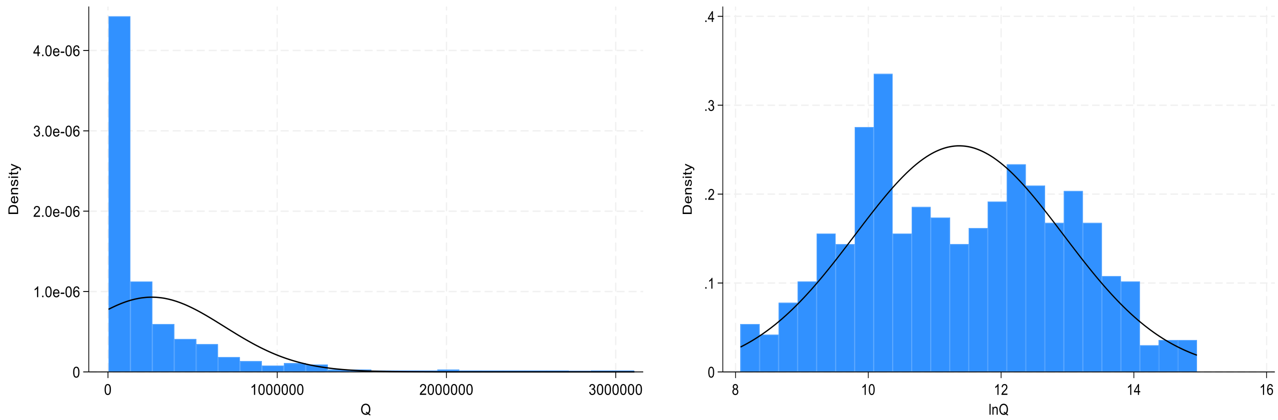

Fig. 2. Histogram plots: (a) Q and (b) lnQ.
Source: Authors.

The Bayesian hierarchical models are simulated using the hybrid Metropolis-Hastings sampler, a Monte Carlo algorithm, which requires priors for all model parameters. Since the parameters can take either negative or positive values, a N(0,1) prior is assigned to all structural parameters (Block et al., 2011). Additionally, when lacking knowledge about model parameters, Darnieder (2011), Thach (2023), and Thach (2024) suggest selecting data-driven (or empirical) priors. Research by Lee & Song (2004), McNeish (2016), and van Erp et al. (2018) indicates that Bayesian results based on data-driven priors are superior to those from frequentist and naïve (non-informative) Bayesian estimations. Even research incorporating empirical or naïve priors can be considered within a thoughtful framework if justified under specific conditions (Smid et al., 2019). The data-driven priors for the parameters of the focus variables in the linear and quadratic (non-linear) equations (1) and (2), *lnG* and *lnG2*, are derived from the frequentist mixed-effects estimates, as shown in Tables A and B (see Appendix). Specifically, the parameters for *lnG* in equation (1) are -0.04, and for *lnG* and its quadratic term *lnG2* in equation (2) are 0.02 and 0.02, respectively. These numbers are assigned as the prior means of normal distributions for the parameters *lnG* and *lnG2* in Bayesian hierarchical regressions. A prior variance of 1 for these parameters is recommended by Block et al. (2011). However, if greater uncertainty regarding parameter estimates is desired, a variance greater than 1 can be set. To avoid an excessively narrow prior variance, we assign a value of 10 to the prior variances of the focus parameters. Meanwhile, the parameters for the control variables *K, L, H*, and *TFP* are set with a default N(0, 10000) prior. Additionally, a non-informative Ig(0.01, 0.01) prior is specified for all variance components (van de Schoot et al., 2015). Prior distributions for the model parameters are summarized as follows:

(i) N(0,1) prior in the linear equation: $\beta \sim N(0,1)$,

N(0,1) prior in the quadratic equation: $\alpha \sim N(0,1)$, Ig(0.01, 0.01) prior for all the variances: $\sigma^2 \sim Ig(0.01, 0.01)$

And

(ii) Data-driven priors for the focus parameter in the linear equation:

$\beta_1 \sim N(-0.04,1),$

Data-dependent priors for the focus parameters in the quadratic equation:

$\alpha_1 \sim N(0.02,1),$

$\alpha_2 \sim N(0.02,1),$

Default priors for the remaining structural parameters:

$\beta \sim N(0,10000)$

$\alpha \sim N(0,10000),$

Ig(0.01, 0.01) prior for all the variances: $\sigma^2 \sim Ig(0.01, 0.01)$

where β_1 represents slope parameter for *G* (in the linear equation), α_1, α_2 represent slope parameters for *lnG* and *lnG2* (in the quadratic equation), α, β are vectors of the remaining structural parameters (intercept and controls variables), and σ^2 $({\sigma_0}^2, {\sigma_1}^2, {\sigma_2}^2)$ are the variances for random effects, random coefficients, and the overall variance, respectively.

Results

Explanatory analysis

Before delving into the formal econometric analysis, we perform an exploratory examination of the data.

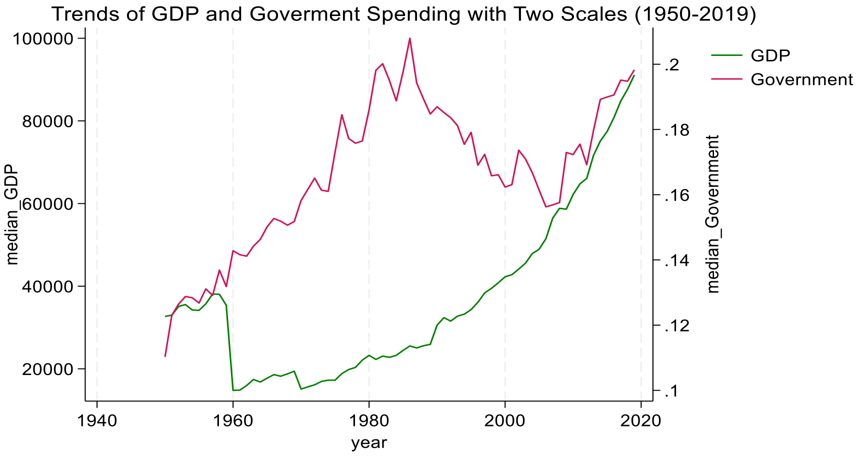

Fig. 3. Dynamics of real GDP and government spending in ASEAN.
Source: PWT. 10.01.

First, our unbalanced panel data sample comprises 10 ASEAN countries spanning from 1950 to 2019. To illustrate overarching trends in government spending and real GDP over this period, we utilize median values instead of means. By focusing on the median, which is the middle value in a dataset, we avoid the influence of extreme values, making it a more accurate measure of central tendency for skewed distributions or datasets with outliers. This approach provides a clearer picture of the trends in government spending as a percentage of GDP and total output. Fig. 3 demonstrates a positive correspondence between government spending and GDP until the late 1980s. After that period, divergent trends for these two variables persisted until the global recession of 2008-2009. A positive correlation re-emerged during the 2010s following the end of the global crisis. Thus, while the trend of GDP is generally upward, the dynamics of government spending can vary significantly depending on changes in fiscal policy.

Second, we provide the results of descriptive statistics (Table 2). Except for *lnTFP*, all the remaining variables have 583 observations. *lnQ* (Log of real GDP) has the average log value of real GDP of 11.37 across all observations. Standard deviation of 1.57 indicates moderate variation in the log of real GDP. The lowest and the highest log value of real GDP in the dataset is 8.08 and 14.95, respectively. *lnG* (Log of government consumption as a ratio of real GDP) has a mean -1.95, Standard deviation of 0.37 indicating relatively low variation. Minimum and maximum are -3.03 and -1.14, respectively. *lnK* (Log of physical capital) has a mean of 12.21 and standard deviation of 1.93, a considerable variation in physical capital. The lowest and highest log value of physical capital is 8.02 and 16.67, respectively. *lnL* (Log of labor) has the average log value of 2.07 and standard deviation of 1.66, a moderate variation. Minimum and maximum are -2.72 and 4.88 respectively. Mean and standard deviation of *lnH* (Log of human capital) are 0.61 and 0.27, respectively. Minimum and maximum are 0.14 and 1.47, respectively. Due to missing data, there are 345 observations for *lnTFP* (Log of total factor productivity). This variable has a mean of -0.05, while standard deviation of 0.25 indicates relatively low variation in total factor productivity. Minimum and maximum are -1.12 and 0.46, respectively.

Table 2. Descriptive statistics.

Variable	Obs	Mean	Std. dev.	Min	Max
lnQ	583	11.37	1.57	8.08	14.95
lnG	583	-1.95	0.37	-3.03	-1.14
lnK	583	12.21	1.93	8.02	16.67
lnL	563	2.07	1.66	-2.72	4.88
lnH	583	0.61	0.27	0.14	1.47
lnTFP	345	-0.05	0.25	-1.12	0.46

Source: Authors.

Third, we examine pairwise correlations in Table 3, noting that *lnH* and *lnK* exhibit a strong correlation with a coefficient over 0.7, indicating a multicollinearity issue in our dataset. Multicollinearity poses challenges for frequentist estimation; however, the Bayesian framework, which encodes interactions among variables using well-specified priors, can effectively address this issue (Thach, 2023; Thach, 2024).

Table 3. Matrix of correlations.

	*ln*Q	*ln*G	*ln*K	*ln*L	*ln*H	*ln*TFP
*ln*Q	1.00					
*ln*G	0.07	1.00				
*ln*K	0.96	0.18	1.00			
*ln*L	0.68	-0.28	0.52	1.00		
*ln*H	0.63	0.33	0.71	-0.04	1.00	
*ln*TFP	-0.07	0.07	-0.10	-0.34	0.09	1.00

Source: Authors.

Sensitivity analyses

In Bayesian estimation, sensitivity analysis aims to determine which model best fits the data patterns using a variety of popular Bayesian information criteria, such as:

Deviance Information Criterion (DIC):

$$DIC = D(mean\ deviance) + pD, \tag{3}$$

where D(mean deviance) is the average deviance over the posterior samples, pD is the effective number of parameters, which is a measure of model complexity.

Log of marginal likelihood (log(ML)):

$$logp(y|M) = \log(\int p(y|\theta, M)p(\theta|M)d\theta), \tag{4}$$

where $p(y|\theta, M)$ is the likelihood of the data given the parameters θ and the model M, $p(\theta|M)$ is the prior distribution of the parameters θ under the model M.

Bayes factor (BF):

$$BF_{12} = \frac{p(y|M_1)}{p(y|M_2)}, \tag{5}$$

where BF_{12} is a ratio of the marginal likelihoods of two competing models, $p(y|M_1)$ and $p(y|M_2)$ are the marginal likelihood of model 1 and 2, respectively. In terms of the log marginal likelihoods, the log Bayes factor is:

$$logBF_{12} = logp(y|M_1) - p(y|M_2), \tag{6}$$

A smaller DIC indicates a better model fit, while greater values of log(ML) or log(BF) (or BF) suggest better goodness-of-fit. In our research, sensitivity analyses are employed for three main objectives. First, to decide which prior, standard normal or data-driven, performs better. Second, to capture potential linear or non-linear relationships in the data. Third, to check how the posterior results of a chosen model react to various prior specifications. For model selection purposes, we undertake the first two analyses in this subsection.

Table 4. Comparing Bayesian linear and non-linear models.

Model specification	DIC	log(ML)	log(BF)
Non-linear model using N(0,1)	-1031.89	439.11	.
Linear model using N(0,1)	-1030.69	446.03	6.92
Non-linear model using data-driven priors	3826.36	-1439.05	-1878.15
Linear model using data-driven priors	-1023.73	444.27	5.16

Source: Authors.

According to Table 4, the linear models outperform the non-linear ones. Additionally, the N(0,1) priors perform better than the data-driven priors in the corresponding models. Hence, the linear model using N(0,1) priors is selected for further analysis.

Discussion

The estimation results for the Bayesian linear model using the standard normal prior with controls incorporated are reported in Table 5. The Bayesian hierarchical regressions provide variances for random effects and coefficient effects for the focus parameter, *lnG*, along with the overall variance. A sufficiently small value of standard deviation and Monte Carlo SE indicates precise estimates of structural and variance parameters. A probability of more than 0.7 suggests strong effects of the covariates. Notably, the regression coefficient of lnG is significantly negative, whereas the coefficients for the remaining variables (*lnK, lnL, lnH*, and *lnTFP*) are significantly positive. This indicates that government size is strongly and negatively correlated with economic growth, consistent with some past analyses (Landau, 1983; Guseh, 1997; Fölster & Henrekson, 2001; Dar & AmirKhalkhali, 2002; Churchill et al., 2017), but contradictory to analyses in the ASEAN context (Thanh & Mai, 2014; Hoa, 2022). Conversely, physical capital, labor, human capital, and technology are strongly and positively associated with economic growth in ASEAN countries. Physical capital, labor, human capital, and technology are recognized as fundamental factors of economic growth by growth theories, from neoclassical exogenous models (Solow, 1956; Swan, 1956) to endogenous frameworks (Arrow, 1962; Uzawa, 1965; Lucas, 1988; Romer, 1986, 1990; Grossman & Helpman, 1991; Aghion & Howitt, 1992; Farmer & Schelnast, 2021). Later, modern institutionalism considers these determinants as proximate factors, emphasizing institutions as the ultimate source of economic growth (North, 1990; Acemoglu et al., 2012). Remarkably, the results on the negative impact of government expenditures on growth warrant further discussion.

Table 5. Bayesian results using N(0,1).

Model	Without controls			With controls			
Parameter	Reg. coef.	MCSE	PPI	Reg. coef	MCSE	Probability of estimated effect	PPI
Dependent: lnQ							
Independent:							
lnG	-0.24	0.09	[-0.97, 0.46]	-0.09	0.02	0.97	[-0.14, -0.05]
lnK				0.62	0.00	1	[0.60, 0.65]
lnL				0.33	0.01	1	[0.24, 0.39]
lnH				0.45	0.01	1	[0.34, 0.57]
lnTFP				0.61	0.00	1	[0.57, 0.66]
Constant	10.28	0.225165	[8.81, 2.02]	2.72	0.01	1	[2.47, 2.97]
Variances:							
For random effects	23.05	0.50	[8.26, 8.10]	0.02	0.00	1	[0.00, 0.09]
For random coefficients	5.25	0.14	[1.90, 3.10]	0.01	0.00	1	[0.00, 0.05]
Overall	0.77	0.00	[0.67, 0.91]	0.00	0.00	1	[0.00, 0.01]

Note: A MCMC sampler is considered efficient when the Monte Carlo standard error (MCSE) is approximately close to one decimal place. The posterior probability interval (PPI) represents the range within which a parameter has a 95% probability of lying in the population.

Source: Authors.

Additionally, we perform a frequentist maximum likelihood (ML) hierarchical regression for the same linear model (1). The estimation results (see Table A) are similar to those of the Bayesian hierarchical linear regression reported in Table 5, where the estimated coefficient of *lnG* is negative and those of the remaining covariates are positive.

I. The finding shows that government spending harms GDP in the ASEAN sample. Here are some potential explanations for this result:

II. Inefficiency in government spending: Government consumption spending might be inefficiently allocated, resulting in waste or misallocation of resources. This could be due to bureaucratic inefficiencies, corruption, or lack of proper planning and oversight.

III. Crowding out effect: High levels of government consumption spending might crowd out private investment. When the government borrows heavily to finance its spending, it can lead to higher interest rates, making it more expensive for the private sector to borrow and invest.

IV. Focus on non-productive expenditures: Government consumption often includes expenditures on wages, salaries, and goods and services that do not directly contribute to productivity enhancements. If a significant portion of government spending is directed towards non-productive areas, it may not stimulate economic growth effectively.

V. (iv) Fiscal sustainability concerns: Persistent high levels of government consumption spending can lead to concerns about fiscal sustainability and rising public debt. This can undermine investor confidence, leading to reduced investment and slower economic growth.

VI. Low multiplier effect: The multiplier effect of government consumption spending may be lower in the ASEAN context compared to other regions. This means that each dollar of government spending generates less than a dollar increases in GDP, which can result from structural factors and economic conditions unique to these countries.

VII. Dependence on external factors: ASEAN economies are often highly dependent on external trade and investment. If government consumption spending does not support sectors that drive export growth or attract foreign investment, its impact on GDP may be limited.

VIII. Economic structure and development stage: The structure of the economy and its stage of development can influence the effectiveness of government spending. In many ASEAN countries, the private sector might be more efficient in driving growth, and excessive government consumption could distort markets and reduce overall economic efficiency.

Robustness checks

To test for estimation stability, the study conducts MCMC convergence diagnostics using trace, autocorrelation, histogram, and kernel density (smoothed histogram) plots for the focus variable, lnG. Convergence aims for a target distribution (the required posterior), not a single value as in maximum likelihood methods. Upon reaching convergence, samples should resemble a random scatter around a stable mean value. Fig. 4 shows no anomalies in the diagnostic plots, indicating that the chain has converged to a stationary distribution.

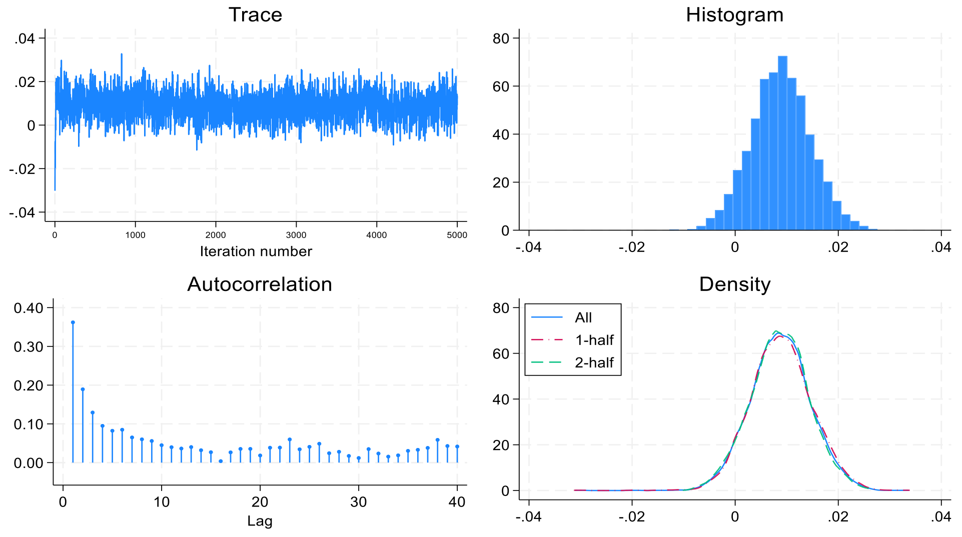

Fig. 4. Graphical diagnostics.
Source: Authors.

Furthermore, we vary the hyperparameters (mean and variance) of the normal distribution for the focus variable, *ln*G. First, we vary the prior variance within a range of 1 to 10,000, and then adjust the prior mean from -0.5 to 0.5 at intervals of 0.1. The results reported in Tables 6 and 7 show that the estimates of the regression coefficients change insignificantly across different prior specifications.

Table 6. Sensitivity of posterior results to various prior variances.

Parameter	N(0,10000)	N(0,1000)	N(0,100)	N(0,50)	N(0,30)	N(0,10)	N(0,5)	N(0,1)
Dependent: lnQ								
Independent:								
lnG	-0.07	-0.04	-0.09	-0.05	-0.03	-0.05	-0.03	-0.09
lnK	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
lnL	0.32	0.33	0.33	0.32	0.33	0.33	0.33	0.33
lnH	0.47	0.46	0.45	0.47	0.45	0.46	0.45	0.45
lnTFP	0.61	0.62	0.61	0.61	0.62	0.62	0.62	0.61
Constant	2.73	2.73	2.72	2.72	2.72	2.68	2.68	2.72
Variances:								
For random effects	0.03	0.02	0.03	0.02	0.03	0.03	0.02	0.02
For random coefficients	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.01
Overall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors.

Table 7. Sensitivity of posterior results to various prior means.

Para-meter	N(-0.5,1)	N(-0.4,1)	N(-0.3,1)	N(-0.2,1)	N(-0.1,1)	N(0,1)	N(0.1,1)	N(0.2,1)	N(0.3,1)	N(0.4,1)	N(0.5,1)
Dependent: lnQ											
Independent:											
lnG	-0.07	-0.08	-0.09	-0.06	-0.10	-0.09	-0.06	-0.08	-0.07	-0.07	-0.02
lnK	0.63	0.63	0.63	0.63	0.62	0.62	0.63	0.62	0.63	0.63	0.63
lnL	0.31	0.32	0.32	0.31	0.33	0.33	0.32	0.32	0.32	0.32	0.32
lnH	0.45	0.44	0.45	0.46	0.44	0.45	0.44	0.46	0.44	0.44	0.45
lnTFP	0.61	0.61	0.61	0.62	0.61	0.61	0.61	0.61	0.61	0.61	0.61
Constant	2.67	2.63	2.62	2.64	2.71	2.72	2.66	2.72	2.69	2.69	2.67
Variances:											
For random effects	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.02	0.02	0.02
For random coefficients	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.02
Overall	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Authors.

Finally, we test how the results of the selected Bayesian model using N(0,1) priors change with and without control variables. As exhibited in Table 5, the sign of the regression coefficient for lnG remains consistent, affirming the robustness of the estimation.

Additional analysis

Along with the estimation of an ASEAN panel, this subsection estimates the linear government-growth link for each of the 10 ASEAN countries to illustrate how this relationship varies across countries. To this end, we make use of equation (1) employing two priors for the focus parameter, lnG: N(−0.09,1) and N(0,1). The mean of the former is derived from the estimated coefficient of the variable lnG when modeling the panel sample (see Table 5) and assigns a prior variance of 1. In addition, the utilization of the N(0,1) prior is similar to the panel analysis above. In the meanwhile, the remaining structural parameters and variances are assigned non-informative default priors of N(0,10000) and Ig(0.01,0.01), respectively. The intermediate and final results are summarized in Tables 8 and 9.

Table 8. Comparison of N(-0.09,1) and N(0,1) priors for the *lnG* parameter using the log of marginal likelihood.

Prior	Brunei	Cambodia	Indonesia	Laos	Malaysia	Myanmar	Philippi-nes	Singapore	Thailand	Vietnam
N(-0.09,1)	24.05	27.67	57.00	50.66	65.52	34.52	58.92	67.32	65.31	77.99
N(0,1)	23.88	28.67	55.63	47.59	68.52	44.99	64.74	76.03	69.31	74.79

Source: Authors.

The higher the log of marginal likelihood, the more appropriate a prior distribution is for a certain parameter. As a result, the N(−0.09,1) prior is more suitable for Brunei, Indonesia, Laos, and Vietnam, while the N(0,1) prior is more appropriate for Cambodia, Malaysia, Myanmar, the Philippines, Singapore, and Thailand. (Table 8) Based on the selected priors, the results for the 10 ASEAN countries are reported in Table 9.

Table 9. Results for the key variable *lnG* in ASEAN countries.

Country	Mean	Prior	MCSE	PPI
(1)	-0.04	N(-0.09,1)	0.09	[-0.73, 0.70]
(2)	-0.53	N(0,1)	0.08	[-1.18, 0.05]
(3)	0.31	N(-0.09,1)	0.06	[-0.02, 0.78]
(4)	-0.06	N(-0.09,1)	0.04	[-0.36, 0.27]
(5)	0.11	N(0,1)	0.05	[-0.25, 0.46]
(6)	-0.27	N(0,1)	0.05	[-0.65, 0.29]
(7)	-0.39	N(0,1)	0.05	[-0.74, 0.01]
(8)	0.37	N(0,1)	0.04	[0.09, 0.69]
(9)	-0.10	N(0,1)	0.05	[-0.44, 0.27]
(10)	0.64	N(-0.09,1)	0.05	[0.37, 1.03]

Note: Indices from 1 to 10 denote Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam, respectively. **Source:** Authors.

Table 9 exhibits the negative effects of government spending on total output for Brunei, Cambodia, Laos, Myanmar, the Philippines, and Thailand, while it indicates positive effects for Indonesia, Malaysia, Singapore, and Vietnam. The negative impacts of government spending in the former group can be explained as follows: government spending might be inefficiently allocated, leading to waste or misallocation of resources, which stems from bureaucratic inefficiencies, corruption, or a lack of proper planning and oversight. Moreover, government consumption predominantly includes expenditures on wages, salaries, and goods and services that do not directly contribute to productivity enhancements. If a significant portion of government spending is directed toward non-productive areas, it may not effectively stimulate economic growth. Consequently, the multiplier effect of government spending may be lower, meaning each dollar of government spending generates less than a dollar increases in GDP. Non-effective government spending can result from structural factors and economic conditions unique to these countries. In contrast, the positive effects of government consumption spending on GDP in the latter group including more advanced ASEAN countries like Indonesia, Malaysia, Singapore, and Vietnam, can be attributed to several factors. Government spending in these countries tends to be more efficiently and effectively managed. Better governance, reduced corruption, and stronger institutions contribute to the more productive usage of government resources. Additionally, government expenditures often include significant investments in infrastructure and public services, which can enhance productivity and stimulate economic growth. Improved infrastructure facilitates business operations and attracts foreign investment. These countries also incline towards education, healthcare, and other social services. These investments in human capital improve labor force productivity and contribute to long-term economic growth. Hence, the economic structure of these more advanced countries allows for a higher multiplier effect of government spending. Each dollar of government expenditure generates more than a dollar increase in GDP due to stronger linkages within the economy and more efficient exploitation of resources. As a result, government spending often complements rather than crowds out private sector activity. Public investments in R&D, technology, and innovation spur private sector growth and development.

Conclusion

The study aims to explore the linear and non-linear effects of government size on economic growth in a panel of 10

ASEAN countries from 1950 to 2019, utilizing the latest PWT version 10.01. A hybrid MH algorithm within the Bayesian hierarchical approach, with specific normal priors and data-driven priors, is adopted to address potential statistical complexities such as omitted variable bias, reverse causality, and multicollinearity, which previous frequentist research has struggled to handle, leading to mixed results. Standard normal priors perform better for the ASEAN panel sample, while either data-driven or standard normal priors are good for different countries. The results for the panel data set indicate that government size strongly and negatively impacts economic growth, whereas the positive elasticities of proximate determinants such as physical capital, labor, human capital, and technology align with the fundamentals of growth theory. The adverse effects of government spending are attributed to several factors, including the low efficiency of fiscal policy, the predominance of non-productive expenditures, crowding out effects, excessive reliance on foreign sources, serious problems with fiscal sustainability, and an outdated economic structure in several ASEAN countries. Our findings are consistent with neoclassical views on the minimal role and intervention level of government in a market economy. Additionally, the individual results for the government-growth causality for each ASEAN country vary, showcasing a negative effect for Brunei, Cambodia, Laos, Myanmar, the Philippines, and Thailand, and a positive effect for the rest of the countries. It is noteworthy that a negative correlation between government size and economic growth dominates in less developed ASEAN countries, where bureaucratic inefficiencies, corruption, lack of proper planning and oversight, predominant non-productive public expenditures, and a lower multiplier effect are more challenging.

Given these potential explanations, policymakers should consider the following recommendations to mitigate the negative impact of government consumption spending on GDP:

- Improve Efficiency and Accountability: Enhance the efficiency and accountability of government spending through better governance, transparency, and anti-corruption measures. Ensure that funds are directed towards high-impact and productive areas.
- Focus on Productive Investments: Shift the focus from consumption to productive investments in infrastructure, education, healthcare, and technology, which have higher potential to boost economic growth.
- Encourage Private Sector Participation: Create an enabling environment for private sector investment by reducing bureaucratic hurdles, ensuring stable macroeconomic policies, and providing incentives for private enterprises.
- Monitor Fiscal Sustainability: Maintain fiscal discipline and monitor public debt levels to ensure long-term fiscal sustainability. Implement policies that balance government spending with revenue generation.
- Structural Reforms: Implement structural reforms to improve the overall business environment, enhance competitiveness, and support sectors that have strong growth potential.
- Regional Cooperation and Learning: Engage in regional cooperation and learning from best practices within ASEAN and other regions to adopt successful strategies for economic growth and development.

By addressing these areas, ASEAN countries can better harness government spending to support sustainable economic growth and development.

The main limitation of this research is data availability. We attempt to capture both linear and non-linear global trends by using a large global sample. Such a dataset can be accessed from two widespread sources: World Development Indicators (WDI) and the Penn World Table (PWT). Data available for all the fundamental variables of a growth model (physical capital, human capital, labor, and TFP) is the latter's advantage. Additionally, though government spending data is provided in both WDI and PWT, WDI values are consistent with national accounts and are directly comparable to other GDP components within the same country, while PWT values are designed for cross-country comparisons and may show different trends due to price level adjustments, making them more appropriate for international comparisons. This adjustment accounts for differences in price levels across countries, resulting in values that may differ from those presented by WDI. Therefore, PWT global data are more relevant to our research purpose, but the latest PWT version 10.01 only updates data up to 2019. Furthermore, future research should incorporate country-specific variables such as institutional quality, structural factors, and economic conditions to provide more in-depth insights into the government-growth nexus. To achieve more precise predictions in updated models, we recommend implementing a comprehensive Bayesian approach to obtain more accurate results.

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Appendix

Table A. Frequentist hierarchical results for government-growth linear causality.

lnQ	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
					Lower	Upper
lnG	-0.041	0.03	-1.46	0.14	-0.10	0.01
lnK	0.62	0.01	56.28	0.00	0.60	0.65
lnL	0.32	0.02	15.96	0.00	0.28	0.36
lnH	0.46	0.05	9.85	0.00	0.37	0.55
lnTFP	0.61	0.02	29.75	0.00	0.57	0.65
Constant	2.72	0.11	25.75	0.00	2.51	2.92

Random-effects parameters	Estimate	Std. err.	[95% conf. interval]	
			Lower	Upper
country: Independent				
var(lnQ)	0.00	0.00	0.00	0.01
var(Constant)	0.00	0.00	3.82e-07	2.38
var(Residual)	0.00	0.00	0.00	0.00
LR test vs. linear model: chi2(2) = 376.71 Prob > chi2 = 0.0				

Source: Authors.

Table B. Frequentist hierarchical results for government-growth non-linear causality.

lnQ	Coefficient	Std. err.	z	P>z	[95% conf. interval]	
					Lower	Upper
lnG	0.02	0.16	0.13	0.90	-0.29	0.33
lnG2	0.02	0.04	0.41	0.68	-0.07	0.10
lnK	0.62	0.01	55.80	0.00	0.60	0.65
lnL	0.32	0.02	15.20	0.00	0.28	0.36
lnH	0.46	0.05	9.76	0.00	0.37	0.55
lnTFP	0.61	0.02	29.40	0.00	0.57	0.65
Constant	2.78	0.18	15.41	0.00	2.42	3.13

Random-effects parameters	Estimate	Std. err.	[95% conf. interval]	
			Lower	Upper
country: Independent				
var(lnG)	0.00	0.00	0.00	0.01
var(Constant)	0.00	0.00	0.00	0.30
var(Residual)	0.00	0.00	0.00	0.01
LR test vs. linear model: chi2(2) = 375.43 Prob > chi2 = 0.00				

Source: Authors.