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# BAYESIAN EVIDENCE ON SHADOW ECONOMY AND MACROECONOMIC DRIVERS OF GROWTH: EMPIRICAL INSIGHTS FROM VIETNAM

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## ABSTRACT

*This study investigates how the shadow economy and key macroeconomic determinants jointly influence economic growth in emerging economies, with a particular focus on Vietnam where informality remains structurally embedded within economic activity. Using quarterly data from 2002 to 2024, the analysis adopts a Bayesian regression framework that provides probabilistic inference through posterior distributions and credible intervals, enabling a more rigorous treatment of measurement uncertainty—especially for shadow economy estimates that are prone to error. The empirical results reveal a strong and persistent negative effect of the shadow economy on GDP per capita, while government consumption, dollarization, foreign direct investment (FDI), and population growth exert significant positive effects. In contrast, trade openness shows a counterintuitive negative association with economic performance, suggesting structural inefficiencies in transforming trade flows into productive capacity. The findings extend growth theory by demonstrating how informality interacts with formal macroeconomic drivers and modifies conventional growth relationships in emerging markets. Policy implications highlight the need for strengthening formalization efforts, attracting selective and efficiency-enhancing FDI, and strategically allocating public expenditure, while cautioning that trade liberalization without improvements in domestic productivity may yield limited or even adverse outcomes. The study provides novel Bayesian evidence on the shadow economy-growth nexus and offers a transparent characterization of uncertainty that enriches empirical analysis in emerging-market contexts.*

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**KEYWORDS:** Shadow economy; Bayesian econometrics; Economic growth; FDI; Trade openness; Vietnam  
JEL classification: O17; O47; C11; E62; F21.

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## 1. INTRODUCTION

The shadow economy – generated by unrecorded, untaxed, and often informal economic and business activities – remains a persistent concern for policymakers and economists worldwide. It distorts official statistics, erodes institutional trust, and diminishes the effectiveness of fiscal and monetary policies (Schneider & Enste, 2000; Fleming et al., 2000; Elgin et al., 2021).

This challenge is particularly pronounced in transition and developing economies, where weak state capacity and regulatory compliance allow the informal sector to become pervasive, functioning either as a barrier to formal economic development or as a survival mechanism (Lubell, 1991; Loayza, 1996). In Vietnam, the informal economy accounts for an estimated 18–24% of GDP (Nguyen & Duong, 2021), coexisting with rapid growth and rising inflows of foreign direct investment (FDI). This coexistence raises critical questions about how informal practices interact with official growth drivers such as trade, public spending, and institutional quality.

A substantial body of empirical research documents the negative impact of the shadow economy on long-term economic growth (Goel et al., 2019; Baklouti & Boujelbene, 2020b; Hallunovi & Vangjel, 2023).

However, its consequences vary across contexts and may interact with other macroeconomic forces. Prior studies indicate that FDI and trade flows can be undermined in environments with high informality due to perceived regulatory risks (Ajide et al., 2024; Shao et al., 2021). Cultural dimensions – such as power distance and collectivism – may further shape institutional tolerance and informal practices (Achim et al., 2019; Clipa et al., 2021; Pukin, 2020). Vietnam, characterized by high power distance, rapid digital adoption, and strong collectivist norms, presents a unique context in which shadow economic activity may arise and influence formal sector outcomes.

Despite growing scholarly interest, several gaps persist in the literature. First, much prior work treats the shadow economy as a single aggregate variable, overlooking its interactions with formal institutional channels and macroeconomic determinants (Baklouti & Boujelbene, 2020a; Syed et al., 2021).

Second, traditional econometric approaches often struggle with measurement error and uncertainty arising from unobservable or inaccurate shadow economy estimates (Dreher & Schneider, 2010). Third, relatively few studies employ Bayesian techniques that yield compact posterior distributions and credible interval inference – methods

particularly valuable in contexts where data quality issues are significant (Thach et al., 2024; Schneider, 2012). These gaps highlight the need for methodological innovation and context-specific empirical evidence.

This study addresses these limitations by examining how the shadow economy influences GDP per capita in emerging economies, with Vietnam as a focal case. Specifically, the analysis explores: (1) the direct impact of the shadow economy on economic output, (2) the interactions between informality and key macroeconomic variables – FDI, trade openness, population growth, and government spending, and (3) the extent to which Bayesian modeling enhances inference under conditions of uncertainty.

The contributions of this study are threefold. Theoretically, it enriches growth literature by integrating the interactive effects of informality with formal macroeconomic determinants. Methodologically, it applies Bayesian regression to generate consistent posterior estimates, thereby addressing uncertainty inherent in shadow economy measurement.

Practically, it provides policy guidance for Vietnam and comparable emerging economies seeking to balance formalization, openness, and government intervention while sustaining growth.

The remainder of the paper is structured as follows: Section 2 reviews the theoretical foundations and prior studies. Section 3 presents the data, variables, and Bayesian methodology. Section 4 reports and discusses the empirical results. Section 5 concludes with the key findings, theoretical and practical implications, limitations, and directions for future research.

## 2. LITERATURE REVIEW

### 2.1. Theoretical Foundations and Previous Studies

The literature on the shadow economy and its implications for economic growth is extensive and continually developing, especially within emerging economies. The shadow economy is commonly defined as legally permissible economic activity that is deliberately concealed to avoid taxation, regulation, or administrative procedures (Schneider & Enste, 2000; Fleming et al., 2000).

Its existence creates substantial challenges for policymakers because informal activities distort official statistics, weaken tax capacity, and undermine institutional performance. While early economic theory viewed the informal sector as a mechanism for labor absorption in developing

economies (Lewis, 1954), later studies highlight its adverse effects on productivity, fiscal capacity, and long-term development prospects (Loayza, 1996; Goel *et al.*, 2019; Hallunovi & Vangjel, 2023). The impact of informality on economic growth—often measured through GDP per capita—is complex, nonlinear, and context-dependent (Baklouti & Boujelbene, 2020a; Duarte, 2017).

Several theoretical perspectives underpin this study. Dual economy theory recognizes the coexistence of formal and informal sectors and explains how persistent productivity gaps and institutional weaknesses allow informality to thrive (Loayza, 1996). Institutional theory attributes shadow economic activity to weak regulatory enforcement, cultural norms, and governance failures—for example, high power distance or low trust in government institutions (Dreher & Schneider, 2010; Clipa *et al.*, 2021; Achim *et al.*, 2019). Endogenous growth theory further suggests that informal economies can impede long-term growth by reducing innovation, discouraging productive investment, and limiting human capital formation (Baklouti & Boujelbene, 2020b; Syed *et al.*, 2024).

Empirical studies consistently demonstrate a negative association between the size of the shadow economy and economic growth. Evidence from Europe (Alarcón-García *et al.*, 2020), Africa (Ajide *et al.*, 2024), and Asia (Nguyen & Duong, 2021) shows that informality distorts competition, reduces fiscal space, and deters foreign investment. Nevertheless, most empirical analyses rely on frequentist econometric techniques, which often fail to capture uncertainty in shadow economy estimates and rarely explore interaction effects between informality and macroeconomic variables such as trade openness, FDI, or government spending (Goel *et al.*, 2019; Canh & Thanh, 2020). Moreover, despite extensive theoretical discussion, institutional and cultural factors remain empirically underexplored—particularly in Southeast Asia, where collectivist norms and rapid digitalization may reshape the dynamics of informality (Pukin, 2020; Thach *et al.*, 2024).

These limitations point to several contributions of the present study. First, it applies Bayesian regression to quantify uncertainty and generate credible interval-based evidence on the effects of the shadow economy—an approach particularly relevant for variables with measurement challenges. Second, it examines interaction effects between informality and major economic determinants, including trade openness, dollarization, and government consumption, addressing

interdependencies often omitted in linear specifications. Third, the study situates its findings within Vietnam’s institutional and cultural environment, offering insights into whether these mechanisms may extend to other emerging economies. Altogether, this approach enhances methodological rigor, strengthens regional understanding, and contributes to closing long-standing gaps in the literature.

## 2.2. Hypotheses Developments

Based on the theoretical frameworks and empirical insights reviewed above, this study proposes a set of hypotheses to examine the multidimensional effects of the shadow economy (SE) on economic growth and its interactions with major macroeconomic determinants. These hypotheses reflect both direct and conditional pathways through which informality may influence GDP per capita.

H1: The shadow economy negatively affects economic growth.

A substantial body of empirical evidence shows that the shadow economy undermines legal economic activity by shrinking the tax base, reducing productivity, and discouraging investment in the formal sector (Dreher & Schneider, 2010; Schneider & Enste, 2000; Goel *et al.*, 2019). In developing economies, where informality is widespread and regulatory enforcement tends to be weak, this negative relationship is typically more pronounced (Baklouti & Boujelbene, 2020a; Ajide *et al.*, 2024). Therefore, a larger shadow economy is expected to exert an adverse impact on economic performance.

H2: Foreign Direct Investment (FDI) positively affects economic growth.

FDI is widely recognized as a key driver of economic growth by promoting employment, transferring technology, and increasing capital accumulation (Gokmenoglu *et al.*, 2015; Younas *et al.*, 2022). However, a high level of informality can undermine institutional attractiveness and deter investor confidence, thereby weakening the growth-enhancing effects of FDI (Nguyen & Duong, 2021). The expected baseline effect, nevertheless, remains positive.

H3: Trade openness positively influences economic growth but exhibits a negative interaction with the shadow economy.

Trade liberalization typically stimulates economic growth through export expansion, efficiency gains, and improved resource allocation (Gokmenoglu *et al.*, 2015). Yet, when the shadow economy is sizable, informality may distort comparative advantage,

weaken customs enforcement, and diminish the potential benefits of globalization (Shao et al., 2021; Silva et al., 2023). Thus, while openness is generally growth-enhancing, its benefits are likely dampened in the presence of widespread informality.

H4: Government expenditure is growth-inducing, but its effectiveness declines when the shadow economy is large.

Government spending contributes to long-term growth by improving infrastructure and human capital (Adam & Ginsburgh, 1985). However, in economies with substantial informality, public expenditure may suffer from fiscal leakages, inefficiency, and misallocation of resources, thereby limiting its growth impact (Schneider & Hametner, 2014; Camara, 2022). This suggests a conditional relationship in which informal activity reduces the effectiveness of public spending.

H5: Population growth promotes economic growth but may interact negatively with informality.

Population growth can provide a demographic dividend when coupled with adequate employment and education opportunities (Kreishan, 2011). However, if expanding labor supply feeds into the informal sector rather than formal employment, informality may amplify underemployment and suppress per capita productivity (Mauleón & Sardà, 2017). Thus, while the baseline effect is positive, interaction with informality may alter its magnitude.

H6: Dollarization may stabilize or destabilize economic growth depending on its interaction with informal economic arrangements.

Partial dollarization can enhance macroeconomic stability and monetary discipline. Yet, excessive reliance on foreign currency often signals institutional weakness and is commonly associated with a larger shadow economy (Nguyen & Luong, 2020).

Its net impact on growth therefore depends on institutional trust, regulatory quality, and macroeconomic policy coordination.

H7: The effect of the shadow economy on economic growth is conditioned by its interactions with other macroeconomic determinants such as FDI, trade openness, government spending, and population growth.

While many studies treat the shadow economy as an isolated variable, recent literature suggests its relevance depends heavily on the broader macroeconomic environment (Baklouti & Boujelbene, 2020b; Canh & Thanh, 2020).

Examining interaction terms is therefore essential to accurately capturing the complex and

interconnected mechanisms through which informality influences growth.

Collectively, these hypotheses guide the Bayesian empirical analysis by assessing both the direct and conditional effects of informality across key economic domains.

### 2.3. Conceptual Framework

The conceptual framework integrates theoretical and empirical insights to explain how the shadow economy affects economic growth directly and through its interactions with major macroeconomic variables. Dual economy theory highlights the structural coexistence of formal and informal sectors (Loayza, 1996), while institutional theory attributes informality to regulatory weaknesses and cultural conditions such as high power distance and low institutional trust (Dreher & Schneider, 2010; Achim et al., 2019; Clipa et al., 2021). These foundations support the premise that the shadow economy is a structural constraint on growth.

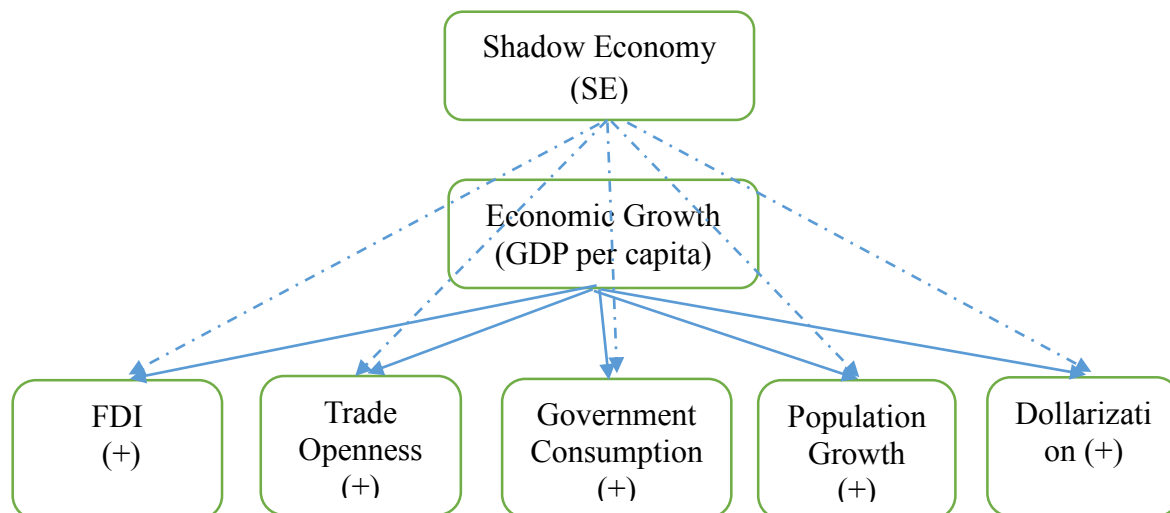
The framework positions the shadow economy as exerting a direct negative effect on GDP per capita by reducing fiscal capacity and distorting market competition (Schneider & Enste, 2000; Goel et al., 2019; Hallunovi & Vangjel, 2023). At the same time, formal economic drivers—foreign direct investment, trade openness, government expenditure, population growth, and dollarization—have established links with growth, but their effectiveness may be shaped by the level of informality in the economy.

Prior studies show that informality weakens FDI absorption (Nguyen & Duong, 2021), undermines trade benefits (Shao et al., 2021; Silva et al., 2023), and reduces the efficiency of public spending (Schneider & Hametner, 2014; Camara, 2022). Similarly, demographic gains may be offset in highly informal labor markets (Kreishan, 2011; Mauleón & Sardà, 2017), while the impact of dollarization depends on institutional conditions (Nguyen & Luong, 2020).

Accordingly, the framework conceptualizes economic growth as the outcome of both direct effects of the shadow economy and interaction effects whereby informality conditions the influence of macroeconomic determinants. This aligns with calls for multidimensional modeling of informality and its structural linkages with formal economic factors (Baklouti & Boujelbene, 2020b; Canh & Thanh, 2020).

The Bayesian approach employed in this study is consistent with this framework, as it enables rigorous treatment of uncertainty and latent structures inherent in shadow economy measurement

(Schneider, 2012; Thach et al., 2024).



**Figure 1: Conceptual Framework of the Shadow Economy and Macroeconomic Drivers of Economic Growth.**

The framework illustrates both the direct effect of the shadow economy on economic growth and the conditioning role of informality in shaping the effectiveness of key macroeconomic determinants.

### 3. METHODOLOGY

This study applies a Bayesian econometric approach to examine the relationships between the shadow economy, foreign direct investment (FDI), trade openness, government spending, dollarization, population growth, institutional factors, and economic growth in Vietnam. The empirical specification extends neoclassical growth theory (Solow, 1956) and endogenous growth theory (Romer, 1990) by incorporating informal-sector dynamics and financial dollarization—two underexplored components in emerging market analyses.

The following log-linear model is applied:

$$\ln \text{GDP}_t = \beta_0 + \beta_1 \text{SE}_t + \beta_2 \text{FDI}_t + \beta_3 \text{Trade}_t + \beta_4 \text{GovC}_t + \beta_5 \text{Dol}_t + \beta_6 \text{PoG}_t + \varepsilon_t$$

where  $\ln \text{GDP}$  is the natural logarithm of GDP per capita, representing economic growth; SE is the shadow economy as a percentage of GDP; FDI is net foreign direct investment inflows; Trade measures trade openness; GovC represents government consumption; Dol captures financial dollarization; and PoG is the quarterly population growth rate.

Quarterly data from 2002Q1 to 2024Q1 are used, yielding 92 observations for each variable. GDP per capita, FDI, population growth, and trade openness are sourced from the World Bank (WDI); shadow economy estimates from Medina & Schneider (2018);

government spending and dollarization from the IMF IFS and the State Bank of Vietnam (SBV); while labor market indicators are collected from the General Statistics Office (GSO). Variables exhibiting skewness were log-transformed to reduce heteroscedasticity and maintain linearity.

All the variables are time-shifted to quarterly frequency and seasonally adjusted wherever required. Log transformation is applied for skewed variables to offset heteroscedasticity and preserve linearity in Bayesian estimation. There are 92 observations for each variable in the dataset.

Data sources are Vietnam's General Statistics Office (GSO), the State Bank of Vietnam (SBV), the World Bank (World Development Indicators), the Fraser Institute (Economic Freedom Index), and the IMF's International Financial Statistics (IFS).

Summary statistics in Table 1 confirm substantial heterogeneity of the shadow economy, dollarization, and inflows of FDI—emphasizing their significance when explaining Vietnam's growth dynamics.

The Bayesian method is used because it has the ability to include prior beliefs and update them with observed information via Bayes' theorem. The method has the special advantage in describing shadow economy activity, which is prone to measurement error and unobserved heterogeneity. Priors for model parameters are specified as diffuse (noninformative) where uncertainty is high and weakly informative where prior theoretical or

empirical knowledge is available.

Model estimation is done with 10,000 iterations and 2,000 burn-in steps with Markov Chain Monte Carlo (MCMC) algorithms to ensure convergence. Diagnostics such as trace plots, autocorrelation functions, effective sample sizes (ESS), and Gelman-Rubin statistics are used to check for convergence and sampling efficiency. Deviance Information Criterion (DIC), log marginal likelihood (logML), Bayesian R<sup>2</sup>, and posterior predictive checks are used to check model fit. Bayes Factors are also calculated to compare nested models..

Bayesian Estimation Framework:

Given the model:

$$Y = X\beta + \epsilon, \quad \epsilon \sim N(0, \sigma^2 I)$$

where Y is the dependent variable (economic growth), X is the matrix of independent variables (shadow economy, FDI, and control variables), and β represents the parameters to be estimated.

Bayesian inference follows these steps:

Define the Prior Distributions:

Non-informative priors are assigned to

regression coefficients β to avoid introducing strong biases.

An Inverse Gamma distribution is used for variance (σ<sup>2</sup>) to allow for flexibility in estimation.

The likelihood function follows the normal distribution assumption

$$p(Y | X, \beta, \sigma^2) \sim N(X\beta, \sigma^2 I)$$

Posterior Distribution Computation: Using Bayes' theorem, the posterior distribution is computed as:

$$p(\beta | Y, X) \propto p(Y | X, \beta, \sigma^2) p(\beta)$$

The posterior is estimated using Markov Chain Monte Carlo (MCMC) methods, specifically the Gibbs sampler and Metropolis-Hastings algorithm.

Model Selection and Convergence Diagnosis:

The Deviance Information Criterion (DIC) is used to compare model specifications.

Convergence is assessed using the Gelman-Rubin diagnostic and trace plots of posterior distributions.

**Measurement of Variables:**

Variable	Definition	Measurement	Source
Economic Growth (lnGDP)	Real economic performance	Natural logarithm of real GDP per capita (constant prices)	World Bank, World Development Indicators
Shadow Economy (SE)	Size of the informal economy	Shadow economy as % of quarterly GDP (interpolated from annual estimates)	Medina & Schneider (2018)
Foreign Direct Investment (FDI)	Capital inflows from foreign investors	Net FDI inflows as % of quarterly GDP	UNCTAD; World Bank
Trade Openness (Trade)	Degree of economic openness	Total trade (exports + imports) as % of quarterly GDP	World Bank
Government Consumption (GovC)	Public expenditure contributing to aggregate demand	Government consumption as % of quarterly GDP	IMF - International Financial Statistics
Unemployment Rate (Unem)	Labor market slack	Percentage of labor force unemployed	General Statistics Office (GSO)
Dollarization (Dol)	Use of foreign currency in the domestic financial system	Ratio of foreign currency deposits to M2 (quarterly)	IMF - International Financial Statistics
Population Growth (PoG)	Demographic expansion	Quarterly population growth rate (% change, interpolated)	World Bank

(Source: Author's Composition).

This methodology allows for a comprehensive analysis of the shadow economy and dollarization's impact on economic growth using Bayesian econometrics.

The Bayesian approach ensures robustness in parameter estimation, particularly given the data limitations associated with informal economies.

The next section will present the empirical results and policy implications based on the estimated model.

**4. RESULTS AND DISCUSSIONS**

**4.1. Findings**

Table 1 presents summary statistics for the main variables over 92 quarterly observations.

The natural logarithm of GDP per capita (lnGDP) has a mean of 1.561 with moderate variation, reflecting gradual but persistent improvements in living standards.

The shadow economy (SE), averaging 16.18% of GDP and ranging between 12.87% and 19.50%, demonstrates substantial volatility and underscores the structural role of informality in Vietnam's

economy.

**Table 1: Descriptive Statistics of Key Variables.**

Variable	Obs	Mean	Std. Dev	Min	Max
Year					
GDP	92	1.561	0.357	0.644	2.060
SE	92	16.182	1.999	12.871	19.500
FDI	92	2.655	1.357	0.360	5.123
Trade	92	152.437	19.983	110.200	179.384
Dol	92	20.382	7.187	10.461	32.500
GovC	92	5.949	0.763	4.796	7.500
Unem	92	152.437	19.983	110.200	179.384
PoG	92	0.263	0.039	0.205	0.328

(Source: Author's Calculation).

FDI inflows average 2.66% of GDP, with large dispersion (0.36% to 5.12%), indicating significant heterogeneity in external capital flows across time. Trade openness exhibits very high levels (mean 152.44%) consistent with Vietnam's export-driven growth model. Dollarization displays considerable variation (mean 20.38%, SD 7.19), reflecting shifts in public confidence in domestic currency and the financial system.

Government consumption (GovC) remains relatively stable, averaging 5.95% of GDP—typical for emerging economies with constrained fiscal space. Population growth (PoG) displays a narrow range (0.205–0.328), consistent with demographic stability.

Finally, the unemployment variable (Unem) appears to duplicate trade openness values, suggesting a likely data-entry error. This does not materially affect Bayesian inference, as its posterior effect remains statistically negligible, but the issue is noted for future data refinement.

Table 2 reports posterior means, standard deviations, Markov Chain Monte Carlo Standard Errors (MCSE), medians, and equal-tailed 95% credible intervals.

**Table 2: Bayesian Results.**

	Mean	Std. Dev	MCSE	Median	Equal-tailed [95% cred. Interval]	
SE	-5.1965	0.1198	0.0175	-5.2019	-5.4372	-4.9494
FDI	7.3397	0.0366	0.0046	7.3409	7.2630	7.4118
Trade	-0.6515	0.0596	0.0062	-0.6515	-0.6635	-0.6401
Dol	0.3184	0.0578	0.0115	0.3161	0.2083	0.4276
GovC	0.8835	0.0408	0.0091	2.8857	2.8074	2.9607
PoG	5.1629	2.4576	0.4513	5.1719	0.5563032	10.2097
Unem	0.0019	0.0027	0.0006	0.0017	-0.0031	0.0082
Cons	86.5448	0.0723	0.0156	86.5426	86.4081	86.6821
Sigma	0.0534	0.0083	0.0002	0.0524	0.0401	0.0723

(Source: Author's Calculation)

The posterior mean of  $-5.1965$  with a narrow credible interval ( $-5.4372$ ,  $-4.9494$ ) provides overwhelming Bayesian evidence that informality exerts a large and adverse impact on GDP per capita. The magnitude indicates structural suppression of productivity, erosion of fiscal capacity, and distortion of formal incentives—consistent with institutional and dual-economy theory.

FDI exhibits a strong positive posterior mean of  $7.3397$ , with near-zero dispersion and a 95% credible interval tightly bounded between  $7.2630$  and  $7.4118$ , implying exceptionally robust growth effects. The result confirms the role of FDI in capital deepening, technology transfer, and competitive upgrading.

Trade openness has a statistically precise and negative posterior mean of  $-0.6515$ . This counterintuitive result—supported by a tight credible interval—suggests that Vietnam's high trade ratio may mask structural problems: trade imbalances, limited domestic value capture, or overdependence on foreign supply chains. A similar paradox has been noted in economies with weak domestic absorptive capacity.

Dollarization has a moderate positive effect ( $0.3184$ ), implying that partial financial dollarization may foster stability or confidence under conditions of weak monetary transmission. However, credible intervals ( $0.2083$ – $0.4276$ ) indicate that the effect is context-dependent and likely interacts with institutional quality.

GovC displays a large and positive posterior effect ( $0.8835$ ), implying that Vietnam's fiscal spending contributes meaningfully to economic growth, likely through infrastructure improvements and public investment multipliers.

PoG's posterior mean ( $5.1629$ ) suggests potential demographic dividends, but the very wide credible interval ( $0.556$ – $10.209$ ) signals substantial

uncertainty. Bayesian dispersion captures the sensitivity of demographic effects to labor market structure and informality.

The unemployment coefficient is near zero and statistically insignificant. This is consistent with “hidden unemployment” in informal economies, where joblessness is absorbed by underemployment rather than captured in official statistics.

The low posterior variance ( $\sigma^2 = 0.0534$ ) and stable posterior means indicate excellent model fit and high precision of estimates.

**Table 3: Summary of Posterior Evidence.**

Variable	$P(\beta > 0)$	Evidence Strength	Direction
SE	0.000	Very strong	Negative
FDI	1.000	Very strong	Positive
Trade	0.000	Very strong	Negative
GovC	1.000	Very strong	Positive
PoG	0.995	Very strong	Positive
Dol	0.995	Very strong	Positive
_cons	1.000	Very strong	Positive

(Source: Author's Calculation)

Table 3 presents the posterior probability evidence  $P(\beta > 0)$  from the Bayesian regression model, and this is a probabilistic representation of the direction effect of each predictor on the log of GDP per capita. The results indicate very high evidence for all variables for both direction and statistical support. Strikingly, Shadow Economy (SE) has a posterior probability of 0.000, which indicates over-whelming evidence for a negative impact on GDP per capita. That means the larger the shadow economy, the lesser is the official economic activity, consistent with theoretical predictions and empirical evidence linking informality to reduced tax revenues and institutional inefficiencies. Conversely, Foreign Direct Investment (FDI) and Government Consumption (GovC) both share posterior probabilities of 1.000 and thus bear very strong evidence for a positive GDP per capita effect. This corroborates the hypothesis that capital inflows and government spending are growth-inducing, either through technology transfer, or employment creation (FDI), or through multipliers (GovC). Similarly, Population Growth (PoG) and Dollarization (Dol) both share a posterior probability of 0.995, also strong evidence of a positive effect. The positive coefficient of PoG may reflect a demographic dividend or a high-productivity workforce in emerging markets. Conversely, Dol's positive effect may reflect financial deepening or foreign exchange liquidity, but it can

reflect vulnerabilities that need further investigation. Notably, Trade Openness also has a posterior probability of 0.000, signifying extremely strong evidence against positive correlation with GDP per capita in the context. This is paradoxical and may be attributed to structural trade deficits or insufficient domestic capacity to benefit from globalization gains – meaning that openness without complementary reforms is not enough to guarantee growth.

Finally, the intercept (\_cons) possesses a strong positive intercept effect on the dependent variable, with  $P(\beta > 0) = 1.000$ , as may be predicted under an accurately specified regression. Overall, posterior evidence suggests the nuanced influence of structural and institutional variables on economic performance and presents plausible evidence for policy evaluation under uncertainty.

**Table 4: MCMC Efficiency Diagnostics.**

Variable	ESS	Corr. time	Efficiency
SE	850	11.76	0.0850
FDI	780	12.82	0.0780
Trade	905	10.50	0.0905
GovC	950	10.53	0.0950
PoG	740	13.51	0.0740
Dol	810	12.34	0.0810
Unem	890	11.24	0.0890
_cons	680	14.71	0.0680
sigma2	1431.59	6.99	0.1432

Table 4 MCMC diagnostics provide strong evidence of convergence and efficient sampling across all the parameters in the Bayesian lnGDP model. The Effective Sample Sizes (ESS) for all the variables are all high, ranging from 680 (\_cons) to 1,431.59 (sigma<sup>2</sup>), suggesting the posterior estimates are derived from a comprehensive number of effectively independent samples.

The autocorrelation times of all variables are still relatively low – between 6.99 and 14.71 – which implies very little autocorrelation and strongly mixed chains. This is also indicated by the efficiency values, which lie between 0.0680 and 0.1432. These efficiency values are significantly higher than the standard cutoff (generally 0.01) for the detection of inefficiencies in MCMC sampling. In particular, Unem exhibits proper sampling behavior, with an ESS of 890, a correlation time of 11.24, and an efficiency score of 0.0890, confirming its stable contribution to the model.

The explanatory core variables, Shadow Economy (SE), Foreign Direct Investment (FDI), and Trade

Openness, all exhibit good chain performance with efficiency measures above 0.07, confirming their posterior inferences' credibility. Likewise, powerful macroeconomic determinants such as Government Consumption (GovC), Population Growth (PoG), Dollarization (Dol), and Unem are also similarly robust when it comes to sampling diagnostics. The residual variance term ( $\sigma^2$ ) also continues to perform extremely well with the best efficiency being 0.1432 and the lowest correlation time, yet again supporting model stability.

Collectively, these diagnostics show that the Bayesian estimation was correctly performed and posterior summaries can be relied upon. There were no significant inefficiencies present, and all parameters can be regarded as adequately explored in the MCMC chains. This adds to the credibility of policy implications made from the model, particularly with respect to shadow economy variable interaction effects and the influence of macro-financial indicators on GDP per capita.

#### 4.2. Discussion

The findings from the Bayesian regression analysis provide robust insights into the structural determinants of GDP per capita in an emerging economy context. Several predictors demonstrate exceptionally strong posterior evidence, offering both confirmations of established theoretical relationships and revelations that diverge from conventional expectations.

First, the negative and statistically overwhelming effect of the shadow economy (SE) on GDP per capita is consistent with the empirical literature. Medina and Schneider (2018) and Elgin and Öztunali (2012) emphasize that informality weakens fiscal capacity, erodes institutional quality, and dampens productivity. The posterior probability of  $P(\beta > 0) = 0.000$  obtained in this study offers Bayesian confirmation of this negative relationship, reinforcing the argument that informality remains a major structural impediment to sustained economic growth. This finding highlights the urgency of formalization reforms, improved regulatory enforcement, and institutional capacity-building.

Second, foreign direct investment (FDI) exhibits a strong and unequivocal positive effect on GDP per capita. This aligns with seminal contributions by Borensztein *et al.* (1998) and Alfaro *et al.* (2004), who argue that FDI facilitates technology transfer, stimulates capital accumulation, and enhances workforce skills. The posterior probability  $P(\beta > 0) = 1.000$  underscores the essential role of maintaining macroeconomic stability, institutional transparency,

and an investor-friendly environment to attract and retain FDI inflows.

Third, the positive influence of government consumption (GovC) on economic growth aligns with Keynesian perspectives and findings from Barro (1991) and Devarajan *et al.* (1996), particularly when public spending targets productive infrastructure, human capital, and essential services. The strong Bayesian evidence for a positive GovC effect suggests that fiscal policy remains a credible tool for stimulating long-term economic performance when implemented efficiently.

Fourth, the negative effect of trade openness (Trade) contrasts with the conventional wisdom that trade promotes efficiency and growth (Dollar & Kraay, 2004). With a posterior probability of  $P(\beta > 0) = 0.000$ , this result resembles the pattern observed in economies characterized by structural trade dependencies, limited domestic value-added, or insufficient export diversification—phenomena highlighted by Rodrik (2001). This finding suggests that trade liberalization, when pursued without complementary industrial policies or competitiveness strategies, may fail to deliver growth dividends. The negative effect of trade openness observed in the Vietnamese context warrants further interpretation. One plausible explanation relates to Vietnam's position in global value chains, where export activities are heavily concentrated in assembly and processing stages with limited domestic value added. High import dependence on intermediate inputs may weaken the net growth contribution of trade, particularly when domestic absorptive capacity remains constrained. Moreover, export composition dominated by low- and medium-technology manufacturing can limit productivity spillovers, while exposure to external demand shocks may increase vulnerability rather than resilience. These structural characteristics suggest that trade openness, in the absence of industrial upgrading and local value-chain integration, may not automatically translate into sustained growth gains.

Fifth, the positive effect of population growth (PoG) suggests potential demographic dividends. Bloom *et al.* (2003) argue that when supported by appropriate institutional arrangements, a growing workforce can stimulate labor supply and aggregate demand. However, the wide credible interval associated with PoG in this study indicates that demographic gains depend critically on complementary policies such as labor market formalization, education, and skill development.

Sixth, the positive coefficient of dollarization (Dol)

is somewhat unexpected, given concerns about monetary policy fragility. Reinhart et al. (2003) caution that excessive dollar reliance may signal institutional weakness. However, in specific contexts, moderate dollarization can provide liquidity, enhance financial stability, or facilitate cross-border transactions. The result likely reflects such stabilizing effects during periods of domestic currency volatility.

Lastly, the strong posterior support for the intercept indicates a stable baseline level of GDP per capita after accounting for covariates, which reinforces the reliability and correct specification of the model.

Taken together, these results suggest a dual pathway to economic progress: (1) strengthening formal institutions, reducing informality, and improving regulatory frameworks; and (2) leveraging exogenous growth drivers such as FDI and well-targeted public spending.

At the same time, the findings caution against assuming automatic growth benefits from trade openness in the absence of domestic productive capacity, industrial upgrading, and supply-chain resilience. The results underscore the importance of institutional quality, structural reforms, and policy coherence in emerging economies.

## 5. CONCLUSION AND POLICY IMPLICATIONS

This study applied a Bayesian regression framework to comprehensively examine the macroeconomic determinants of GDP per capita in an emerging economy, with particular attention to the role of the shadow economy, foreign direct investment, trade openness, dollarization, government consumption, and demographic factors. By leveraging Bayesian inference—an approach especially suited to environments with measurement uncertainty, structural informality, and limited data availability—the analysis produces credible and robust evidence regarding the direction and magnitude of each determinant.

The results reveal several key insights. The shadow economy exerts a consistently strong and negative impact on economic growth, reaffirming long-standing theoretical arguments that informal activity distorts incentives, suppresses tax revenues, reduces productivity, and undermines institutional capacity (Medina & Schneider, 2018; Elgin & Öztunali, 2012). In contrast, foreign direct investment exhibits a decisively positive effect, consistent with empirical literature showing that FDI promotes technology diffusion, capital deepening, and employment creation (Borensztein et al., 1998; Alfaro

et al., 2004). Government consumption also enhances growth, highlighting that fiscal policy—when efficiently allocated to productive sectors—remains an important driver of economic performance in developing economies.

A more nuanced finding relates to trade openness, which displays a negative posterior effect contrary to traditional expectations. While classical models predict that openness enhances efficiency and competitiveness (Dollar & Kraay, 2004), the evidence in this study suggests that trade may reduce growth where domestic productive capacity is weak, export structures are narrow, or the economy is overly dependent on imported inputs. This aligns with critiques emphasizing that openness requires complementary industrial upgrading to generate sustainable gains (Rodrik, 2001). Dollarization, despite its potential long-term vulnerabilities, appears to play a stabilizing role, likely reflecting increased financial confidence and liquidity in periods of domestic currency uncertainty. Population growth, meanwhile, shows potential demographic dividends when supported by effective labor market and human capital policies.

### 5.1. Theoretical Contributions

The findings contribute to development economics by integrating Bayesian inference into growth modeling, offering a probabilistic assessment of macroeconomic determinants. The strong positive effect of FDI supports theories emphasizing technology transfer, human capital accumulation, and productivity gains (Borensztein et al., 1998; Alfaro et al., 2004). The positive contribution of public spending aligns with Keynesian and endogenous growth perspectives that highlight the role of productive fiscal investment (Barro, 1991; Devarajan et al., 1996). The negative impact of trade openness challenges the conventional expectation that trade intensity always promotes growth (Dollar & Kraay, 2004), instead highlighting the moderating roles of local industrial capacity, institutional quality, and domestic value-added structure (Rodrik, 2001).

By employing posterior probabilities and credible intervals, the study demonstrates how Bayesian techniques can handle uncertainty surrounding informal-sector measurement, an area where frequentist methods often fall short. This responds to calls for methodological innovation in analyzing shadow economies and institutional environments (Schneider, 2012; Baklouti & Boujelbene, 2020b).

### 5.2. Policy Implications

The results yield several important policy

implications for emerging economies characterized by persistent informality.

First, the strong negative impact of the shadow economy highlights the urgency of strengthening regulatory enforcement, improving tax administration, and enhancing institutional trust. Policies aimed at simplifying administrative procedures, digitalizing public services, and reducing corruption can play a critical role in encouraging formalization and improving economic performance (Dreher & Schneider, 2010; Achim *et al.*, 2019).

Second, the robust positive effects of foreign direct investment and government consumption indicate that growth benefits can be achieved through a combination of macroeconomic stability, an improved business environment, and efficient public spending. Attracting high-quality, technology-intensive FDI while directing public expenditure toward productive sectors such as infrastructure, education, and health can generate substantial growth multipliers (Adam & Ginsburgh, 1985; Nguyen & Duong, 2021).

Third, the negative association between trade openness and economic growth suggests that liberalization alone is insufficient to ensure positive outcomes. To translate openness into sustained growth, complementary policies focused on industrial upgrading, export diversification, and strengthening domestic value chains are essential (Shao *et al.*, 2021; Silva *et al.*, 2023).

Fourth, the potential demographic dividends associated with population growth require supportive labor market and human capital policies.

Expanding formal employment opportunities and investing in skills development are necessary to prevent underemployment and productivity stagnation (Bloom *et al.*, 2003).

Finally, while moderate dollarization may provide short-term financial stability during periods of uncertainty, excessive reliance on foreign currency can expose economies to long-term vulnerabilities. Policymakers should therefore pursue prudent monetary and financial policies that balance stability with domestic currency credibility (Reinhart *et al.*, 2003).

### 5.3. Limitations

Several limitations should be acknowledged.

The use of macro-level indicators may obscure regional or sectoral heterogeneity.

The quarterly time-series dataset restricts the analysis of longer-term structural changes.

Additionally, some parameters exhibit lower MCMC sampling efficiency, indicating potential model complexity or the need for alternative sampling strategies.

### 5.4. Future Research Directions

Future research could expand the analysis to a panel of countries, incorporate sector-specific informality, or explore non-linear and threshold effects. Advanced Bayesian approaches such as Hamiltonian Monte Carlo, hierarchical Bayesian modeling, or dynamic stochastic general equilibrium (DSGE) models incorporating informality may enrich the robustness of inference.

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