Natural resources and the underground economy: A cross-country study in ASEAN using Bayesian approach

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Abstract: *The development of the underground economy can significantly affect a country's economic indicators. Although there have been different studies on this phenomenon, many aspects of underground activities remain incompletely defined. Therefore, the current research aims to supplement the existing literature by analyzing the link between abundant natural resources and the scope of the underground economy. To accomplish this objective, we collected panel data from ten Association of Southeast Asian Nations (ASEAN) countries during the period 1991–2018. We then employed the Bayesian regression estimator to look into the influence of natural resources wealth on the scope of the underground sector. We found that the former can negatively and strongly affect the latter in ASEAN countries. That is, natural resources might be a blessing rather than a curse for economic growth and development in these countries. Other variables were found to have a strong positive relationship with the underground economy, like trade openness, tax burden, size of government, corruption, and the global financial crisis. Meanwhile, GDP growth, urbanization, and political stability had a strong negative effect on the size of the underground economy. These findings provide some implications for the governments of ASEAN countries to perform appropriate measures to control the underground economy.*

Keywords: *Natural resources, underground economy, Bayesian approach, ASEAN.*

JEL Classification: *C11, E26, O13.*

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Introduction

The underground economy is a section of the economy that is not subject to tax declaration, and usually involves the trade of goods and services paid in cash. The rise of the underground economy can distort investments, increase income inequality, create unfair competition for formal enterprises, reduce the quality of life, and ultimately hinder economic growth (Arezzo, 2014; Baklouti & Boujelbene, 2020; Kireenko & Nevzorova, 2015; Nguyen & Duong, 2021). Due to the prevalence and impact of the underground economy, various economists have tried to measure the size

and identify the determinants of this economy sector. Unfortunately, many aspects of the underground economy remain incompletely defined. Capasso and Jappelli (2013) argue that it is difficult to provide complete and rational explanations for why enterprises and individuals evade taxes or engage in illegal economic activities. One potential reason is mentioned in Alm et al. (2006). Notably, the authors state that taxpayers choose not to comply with if they believe they could benefit from tax evasion. The obtained benefits depend on the fine amount they are subject to pay if discovered and the probability of being discovered. The lower the expected penalty (measured in fines) and the probability of being discovered are, the higher the tax shunning is.

Nevertheless, tax rates may not be the only source of underground activities in ASEAN countries. There are ample reasons to expect that the underground economy sector and natural resources dependence are related. For instance, Le Billon (2011, p. 1) suggests that "Countries highly dependent on natural resources are among the most severely affected by the problem of illicit financial flows." Indeed, Blanton and Peksen (2023) discover that resource windfalls can enhance underground economy activities. Blanton and Peksen's (2023) result could rekindle the long-standing debate about whether abundant natural resources are a curse or a blessing for a nation's economic growth and development. Interestingly, Sovacool (2010) claims that Southeast Asia can avoid the resource curse thanks to certain characteristics, while other economists believe that natural resources are one of the most important economic assets and their presence will help countries achieve a sustainable growth trajectory (Barbier, 2019). If natural resources positively influence sustainable economic growth, or if the efficient exploitation of these resources helps promote employment in the formal sector, they might motivate individuals to participate in the official economy, thereby reducing the scope of the underground economy.

Despite the important role of this economic sector and natural resources, there is very little literature on the effect of the wealth of natural resources on the informal economy. Blanton and Peksen (2023) explore the impact of natural resources on the underground economy in numerous countries, but they do not specifically address the case of ASEAN, which represents an important economic region in the world. In that context, we aim to supplement the existing research by investigating the link between the wealth of natural resources and the scope of the underground economy in ASEAN countries over the 1991–2018 period.

Our paper attempts to improve the underground economy literature in three ways. First, to the best of our knowledge, our paper is among the first studies to empirically investigate the impact of natural resources on the underground economy in ASEAN countries. According to Elgin et al. (2021), the underground economy scope of 10 selected Southeast Asian countries between 1991–2018 varies widely, ranging from less than 13% of gross domestic product (GDP) in Singapore up to more than 50% in Thailand and Myanmar. Here comes a question that needs to be resolved: What makes countries in the same geographical region have such marked differences in the underground economy scope? Second, this paper applies new estimates of the informal economy produced by Elgin et al. (2021), given until 2018, in contrast to previous studies. Many anterior studies use data on the underground sector developed by Medina and Schneider (2019). In the analysis, we employ both estimates types of Elgin et al. (2021), namely the dynamic general equilibrium (DGE) and the multiple indicators multiple causes (MIMIC) models, to test whether the results are robust. Third, this is the first paper using the Bayesian approach, which has many advantages over the frequency approach, to explore the link between abundant natural resources and the informal economy. The findings of the study can contribute to the design of more effective policies to control underground economic activities.

The results reveal that natural resources are one of the important factors of the underground economy in ASEAN. Interestingly, we find that abundant natural resources reduce the scope of the informal economy. Such a finding suggests that natural resources might be a blessing rather than a curse for ASEAN countries.

The rest of this paper is given as follows. Section 1 presents a quick literature review. Consequently, in section 2, the dataset, models, and estimation strategies are presented. Section 3 depicts and analyzes the results. Finally, section 4 concludes and suggests some policy recommendations.

1. Theoretical background

1.1 Natural resources and the underground economy

Besides the underground economy, multiple of its synonyms terms are frequently used in the related documents, consisting of "dark", "hidden", "unofficial", "black", "informal", or "shadow" economy/area. The subsistence of many terms hints that it is indeed a vague concept. In our study, the terms are substitutable and defined as an economic activity concealed from public authorities for monetary, legal, or institutional motives (Schneider et al., 2010). Monetary motives consist of avoiding taxes and social security contributions, legal motives consist of dodging government bureaucracy or regulatory burdens, and institutional motives consist of high corruption, which is often related to poor quality of institutions (Schneider et al., 2010).

Studies on the underground economy forked into three fundamental groups. The first group focuses on calculating the scope of the underground economy (Elgin et al., 2021; Medina & Schneider, 2019). The second group analyzes the impact of the underground economy on economic indicators such as economic development and sustainable development (Gharleghi & Jahanshahi, 2020; Nguyen & Duong, 2021). The third group explores the factors that affect the scope of the underground economy (Lyulyov et al., 2021; My et al., 2022).

Natural resources involve natural products that people acquire from nature to satisfy their needs and the outcomes of human activities impacting them (Wang et al., 2021). Although there is much research on the affinity between abundant natural resources and economic growth or development, the linkage between the abundant natural resources and the scope of the underground economy is rarely mentioned.

Blanton and Peksen (2023) use natural resources rents as a substitute for natural resources revenue and find that the more abundant the natural resources of a country are, the larger the scope of the underground economy is. This is because revenues from natural resources allocate skewed production capital across sectors of the economy (Ebeke et al., 2015). Simultaneously, increased investment in natural resources will cause damage to the poor, and countries that invest less in human resources or labor-intensive industries are more inclined to employ common labor (Gylfason, 2001). Moreover, the absence of transparency regarding resource rents and the poor accountability in the way these resources are managed (Vadlamannati & De Soysa, 2016) can facilitate the creation of illegal rent-seeking. Increased revenues from resources tend to raise the scope of the informal economy because they have the effect of "pushing" labor out of the office area and creating more rent-seeking apart from the official sector. With these arguments, we suggest a positive effect of natural resources on the scope of the underground economy in ASEAN countries. Therefore, we construct the hypothesis below:

H1: The abundant natural resources positively affect the scope of the underground economy in ASEAN.

1.2 Other variables and the underground economy

Focusing on the influence of the rule of law and economic growth on the shadow economy, Luong et al. (2020) explore the impact of economic growth on the size of the shadow economy in 18 transition countries using the generalized method of moments (GMM) technique. The authors establish that economic growth decreases the activities of shadow economies. In Southeast Asia, My et al. (2024) assess the nexus between the inclusion of LGBT people and the shadow economy through the lens of Bayesian estimation techniques. The conclusion from the study suggests that economic growth reduces the size of the shadow economy. Furthermore, Blanton and Peksen (2023) establish a negative relationship between GDP per capita and the shadow economy, thus suggesting that economic growth lessens the activities of the shadow economy. Similarly, Blanton and Peksen (2021) conclude that an increase in GDP will stop the expansion of the shadow economy in 120 countries for the period 1985–2012. Many studies also confirm the negative relationship between economic growth and the size of the dark economy (Lyulyov et al., 2021; My et al., 2022; Sahnoun & Abdennadher, 2019; Siddik et al., 2022; Thach et al., 2022).

Lyulyov et al. (2021) examine the drivers of shadow economies within transition economies. Findings from the study show that an increase in tax level by 10% increases the shadow economy by 1%. Duong et al. (2021) also submit that the tax burden contributed to increasing the scale of underground economic activities in BRICS countries during

1995 and 2014. Using Bayesian regression, My et al. (2022) investigate the influence of tourism and other variables on the shadow economy in ASEAN countries. The study's outcome suggests that tourism and tax burden variables increase the shadow economy. Similarly, Arsić et al. (2015) and Sahnoun and Abdennadher (2019) conclude that the size of the tax burden is one of the fundamental factors determining tax evasion as well as participation in the underground economy.

Focusing on 18 Central Eastern European and former Soviet Union countries, Ghosh and Paul (2008) document that urbanization increases the scale of the underground economy. Meanwhile, Acosta-González et al. (2014) establish a negative relationship between the urban population and the underground economy, thus suggesting that urbanization lessens activities in the underground economy.

Sahnoun and Abdennadher (2019) examine the link between political stability and the underground economy in 38 developing and 40 developed countries over the 2000–2015 period. Findings from the study show that a negative relationship exists between political stability and the underground economy. Siddik et al. (2022) submit that political stability contributed to reducing the size of the shadow economy in the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation Countries (BIMSTEC) during 1998 and 2015. Similarly, Razmi and Jamalmanesh (2014) conclude that the more politically stable countries will have a smaller shadow economy.

For government size, Ghosh and Paul (2008) document that government size, measured by general government final consumption expenditure, increases the shadow economy in 18 Central and Eastern European and former Soviet Union countries. My et al. (2022) conclude that government size and shadow economy were complementary in ASEAN countries from 1999 to 2017. Sahnoun and Abdennadher (2019) found a positive effect of the size of government spending on the underground economy in developed countries. However, Siddik et al. (2022), using fixed-effect or random-effect investigations for a sample period of 1998–2015, suggest that government spending has significant negative effects on the shadow economy. Similarly, My et al. (2024) found that government spending weakens activities in the underground economy.

In ASEAN nations, My et al. (2022) assess the nexus between international trade and the shadow economy using Bayesian estimation techniques. The conclusion from the study suggests that trade openness decreases the scale of the underground economy. Similarly, Blanton and Peksen (2021), Duong et al. (2021), and Siddik et al. (2022) establish a negative relationship between international trade and the underground economy, thus suggesting that international trade lessens the size of the shadow economy. Contrary to the conclusion above, Ghosh and Paul (2008) conclude that international trade by measure of percent of trade over GDP strengthens the shadow economy in 18 Central Eastern European and former Soviet Union countries. Similarly, Blanton and Peksen (2023) conclude that trade openness has a positive relationship with shadow economic activities.

Razmi and Jamalmanesh (2014) consider the influence of political indicators on the underground economies of 34 countries using data for 8 years from 2000–2007. The two authors' submission reveals that better government control of corruption decreases the size of the underground economy. Similarly, My et al. (2022) conclude that high corruption will encourage individuals and businesses to engage in illegal activities in ASEAN countries. Focusing on BRICS countries, Duong et al. (2021) document that control of corruption abates the underground economy. Numerous studies (Acosta-González et al., 2014; Blanton & Peksen, 2021, 2023; Luong et al., 2020; Sahnoun & Abdennadher, 2019; Thach et al., 2022) have confirmed the negative relationship between corruption control and the underground economy.

Finally, we examine the impact of the global financial crisis (GFC) on the size of the shadow economy. Using random effects, fixed effects, and GMM for a sample period of 1970–2011, Blanton and Peksen (2021) suggest that crises strengthen the size of the shadow economy in 143 countries. Similarly, Siddik et al. (2022) found that GFC strengthens the shadow economy in BIMSTEC countries.

2. Research methodology

2.1 Dataset

In this study, we explore the effect of natural resources on the underground economy. Using a secondary dataset available from 1991 to 2018,

we cover ten Southeast Asian countries, including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam, to attain the study objectives.

The dependent variable is the scope of the underground economy. The variable is expressed as a percentage of gross domestic product (GDP), showing the expansion of the underground economy compared to the formal economy. It is derived from the work of Elgin et al. (2021), in which they used an estimation method based on a DGE model as well as an estimate based on a MIMIC model to evaluate the scope of the underground activities. Therefore, the scope of the underground economy will be measured by two methods, including the scope of the underground economy estimated based on the dynamic general equilibrium (DGE) model (*undecon_DGE)* and the scope of the underground economy estimated based on the multiple indicators multiple causes (MIMIC) model (*undecon_MIMIC*).

Natural resources (*ln_natures*), our main variable, are considered an independent variable since we aim to explore the relationship between natural resources and the scope of the underground economy. We employ data on natural resources rents from the World Governance Indicators (WDI) dataset of the World Bank. The data comprises oil, coal (hard and soft), natural gas, forest, and mineral rents. Following Blanton and Peksen (2023), we use the natural log of the natural resources rents to adjust the skewness of the data.

Three types of control variables are used to separate the effect of the main variable

Tab. 1: Definitions and sources of variables

Variables	Legend	Measurement	Source
Dependent variable			
Underground economy 1	*undecon_DGE*	DGE estimates of underground output (% of official GDP)	Elgin et al. (2021)
Underground economy 2	*undecon_MIMIC*	MIMIC estimates of underground output (% of official GDP)	Elgin et al. (2021)
Interest variable			
Natural resources	*ln_natures*	Whole natural resources rents (% of official GDP)	WDI database
Control variable			
GDP growth	*GDPgr*	GDP growth rate (annual %)	WDI database
Tax burden	*tax*	Total tax burden (% of official GDP)	Heritage Foundation
Urbanization	*urban*	Urbanization level (urban population/ total population)	WDI database
Political stability	*polistab*	Ranges from −2.5 (least stability) to 2.5 (most stability)	WGI database
Size of government	*gov*	General government final consumption expenditure (% of official GDP)	WDI database
Trade openness	*ln_open*	Volume of imports plus exports (% of official GDP)	WDI database
Corruption	*corrup*	Rescaled CPI from 0 (least corrupt) to 100 (most corrupt)	Transparency International
Global financial crisis	*GFC*	GFC is 1 for the global financial crisis, and 0 otherwise	Blanton and Peksen (2021), Siddik et al. (2022)

Source: own

(*ln_natures*). The first type includes macroeconomic variables, such as the GDP annual growth rate (*GDPgr*), tax burden (*tax*), and the global financial crisis (*GFC*). The second involves institutional factors, such as political stability (*polistab*), corruption (*corrup*), and the size of the government (*gov*). The third type focuses on variables such as commercial openness (*ln_open*), and urbanization (*urban*). *GDPgr*, *ln_open*, *gov*, and *urban* are collected from the WDI database. The *polistab* data is collected from the World Governance Indicators (WGI) dataset of the World Bank. The corruption perceptions index (CPI) provided by Transparency International will be used to measure corruption (*corrup*). For consistency between the data, the data from 1995 to 2011 is multiplied by ten so that they can equate to the range currently used by Transparency International from 0 to 100. Thereby, for simplicity and ease of presentation, the CPI is converted to a scale from 0 (least corrupt) to 100 (most corrupt). Tax burden (*tax*) data is obtained from the Heritage Foundation. Finally, the *GFC* is a dummy variable whose value is 1 if it denotes the financial crisis of 2007–2008, and 0 otherwise.

Detailed information about the variables is presented in Tab. 1. Whole variables are treated in percentages. The exceptions are *ln_natures* and *ln_open*, which appear in their natural logarithm form, and *polistab* and *corrup*, expressed as an index.

2.2 The models

Because the aim of this study is to delve into whether abundant natural resources impact the scope of the unofficial economy in ASEAN, by using the study conducted by Blanton and Peksen (2023), we assign a base model as follows:

$$undecon_{it} = \beta_0 + \beta_{it}\, ln\_natures + \\ + \beta_{it} X_{it} + \varepsilon_{it} \quad (1)$$

where: the dependent variable is the scope of the underground economy (*undecon*); interest variable is natural resources (*ln_natures*); β is the corresponding coefficient to measure its influence on the scope of the underground economy; *X* is the matrix of eight control variables, that is, the GDP annual percentage growth rate (*GDPgr*), tax burden (*tax*), global financial crisis (*GFC*), size of government (*gov*), political stability (*polistab*), corruption (*corrup*), trade openness (*ln_open*), urbanization (*urban*); and ε is the error term.

Control variables were chosen based on previous studies by Acosta-González et al. (2014), Arsić et al. (2015), Blanton and Peksen (2021, 2023), Duong et al. (2021), Ghosh and Paul (2008), Luong et al. (2020), Lyulyov et al. (2021), My et al. (2022), My et al. (2024), Razmi and Jamalmanesh (2014), Sahnoun and Abdennadher (2019), Siddik et al. (2022), and Thach et al. (2022). In this research, we use Stata version 17.0 to perform Bayesian regression estimates and related analyses.

2.3 Estimation strategies

Unlike previous studies that used frequentist approach, this study applies the Bayesian approach. Bayesian statistics has many advantages over the frequency approach. The first benefit of Bayesian statistics is that evidence can be continuously computed and updated as data becomes available (Oanh et al., 2023; Van De Schoot & Depaoli, 2014; Wagenmakers et al., 2017). This process is possible because all inferences in Bayesian statistics are based on actual observed data. This is a major advantage of Bayesian over frequentist methods because inference does not depend on data that has never been observed. Second, Wagenmakers et al. (2017) note that in contrast to frequentist statistics, Bayesian inference is logically coherent and internally consistent. Specifically, the Bayesian approach enables testers to explicitly report the probability of a system obtaining the desired outcome by using posterior probability. This interpretability is in direct contrast to the frequentist view which results in indirect measures of system performance with more esoteric definitions, such as *p*-values or confidence intervals. Third, Bayesian regression demonstrates superior performance compared to frequency school regression models in scenarios with limited sample sizes (Kruschke et al., 2012, Oanh et al., 2023). This approach offers accurate and evidence-based conditional conclusions that are not influenced by asymptotic approximations. The process of small sample inference follows a similar procedure as that of large sample inference. Therefore, the availability of trustworthy priors enables the attainment of meaningful Bayesian estimates (Miočević et al., 2017). Moreover, Van De Schoot and Depaoli (2014) state that another important advantage of Bayesian statistics is that they

give a probability distribution of the hypotheses. Bayesian inference lets you figure out whole probability distributions over a range of parameter values. This is done by using Bayes' theorem to set prior distributions over the parameters and then changing them based on new data. This results in posterior distributions that mirror the updated beliefs about the parameters given the data. These posterior distributions can then be used for inference, prediction, and uncertain quantification. Lastly, standard statistics models cannot be used to predict some complex models (Kruschke et al., 2012). When models are pretty complicated, numerical integration is often needed to get numbers based on maximum likelihood estimation. This method is impossible to use because it requires estimating the maximum likelihood over a lot of dimensions. Therefore, alternative estimation tools are needed. Bayesian estimation can also handle some commonly encountered problems in orthodox statistics.

Bayesian analysis is based on the Bayes rule (Bayes, 1991), which underpins Bayesian statistical inferences:

$$p(\theta \mid X) = p(X \mid \theta)p(\theta)/p(X) \quad (2)$$

where: $p(\theta \mid X)$ is desired posterior distribution; $p(X \mid \theta)$ is likelihood; $p(\theta)$ is prior information; and $p(X)$ is normalization constant.

The Bayesian linear regression model for the underground economy (y) is given in the following form:

$$y_i \sim N(\mu_i, \tau) \quad (3)$$

where: $\mu_i = X_i^{'} \beta$ ($i = 1, \ldots, n$) and $\tau = 1/\sigma^2$.

The prior distribution is determined as follows:

$$p(\beta, \tau) = \prod_{j=0}^{k} p(\beta_j) p(\tau) \quad (4)$$

where: $\beta_j \sim N(\mu_{\beta_j}, C_j^2)$ and $\tau \sim gamma(a, b)$; y_i is the underground economy; $X_i^{'}$ represents the vector of explanatory variables; β denotes the coefficient of the parameter estimates; μ_i is the mean of the estimated regression coefficients, and $1/\sigma^2$ is the precision (τ).

Using a normal distribution with substantial variance, we apply a non-informative prior for each unknown parameter in the model (Kosheleva et al., 2021). The prior mean for τ is 1, and the variance is 100, so a = b = 0.01.

For the likelihood functions of the coefficients, we assume that the parameters have parameters of normal distributions derived from Equation (1). Finally, we apply the Markov Chain Monte Carlo (MCMC) technique and Gibbs sampling algorithm to approach the corresponding posterior distributions of the parameters.

For the simulated scenarios, we used two chains with an adapt phase of 12,500 iterations, followed by a burn-in period of 2,500 iterations, and finally, the posterior distribution was drawn from the next 10,000 iterations.

In Bayesian analysis, the convergence of MCMC is one of the most important steps. Under certain conditions, MCMC algorithms will take a sample from the desired posterior distribution after it has converged to the balanced state. That is, at an equilibrium state, the distribution of samples from the chains must be the same regardless of the initial value of the chain. To test the convergence of MCMC, we calculate the R_c value of Gelman and Rubin (1992); if the diagnostic R_c value is greater than 1.2 for any model parameter, no convergence is recorded. Besides, effective sample size (ESS) is also considered when determining whether MCMC converges or not. ESS measures the degree of autocorrelation in samples that increase uncertainty compared to an independent sample. Kruschke (2015) argues that the closer the sampling efficiency is to 1, the better it is.

3. Results and discussion

3.1 Descriptive statistics

The statistical summary is presented in Tab. 2, while Tab. 3 summarizes descriptive statistics of whole variables for ten nations in the sample. For the dependent variable (*undecon*), the mean of the underground economy scope is 31.91 (*undecon_DGE*) or 33.06 (*undecon_MIMIC*), indicating that ASEAN countries have a significant scope of the underground economy. Besides, the standard deviation is 13.77 (*undecon_DGE*) or 13.73 (*undecon_MIMIC*), which explains a huge difference in the scope of the underground economy between these Southeast Asian countries. Singapore has the lowest scope of the underground economy of 12.46 (*undecon_DGE*) or 12.62 (*undecon_MIMIC*); the country with the highest scope of the underground economy

is Thailand (*undecon_DGE* is 48.70) or Myanmar (*undecon_MIMIC* is 50.74). For the main independent variable of interest, we find that natural resources (*ln_natures*) have an average of 7.25 by standard deviations of 7.08, which alludes to a large difference in natural resources in ten countries in the study sample. Brunei has the most abundant natural resources (23.14) in ASEAN countries, while Singapore has almost no natural resources, most of which have to be imported. We observe an average annual GDP growth of 5.49 by standard deviations of 4.29. Myanmar ranks first in terms of the average annual GDP growth rate (8.73), while Brunei achieves the lowest average value of 1.25. For the tax burden (*tax*), Cambodia has the highest level of the tax burden (91.12), and Vietnam has the lowest tax burden (67.14). Singapore is a country with a rapid urbanization rate, while Cambodia has the lowest urbanization rate in the region (19.41). For government size (*gov*), we find a mean of 11.53, by standard

Tab. 2: Descriptive statistics brief

Variable	Obs.	Mean	Std. dev.	Min	Max
Undecon_DGE	278	31.91	13.77	11.29	65.75
Undecon_MIMIC	260	33.06	13.73	11.89	53.78
Ln_natures	269	7.25	7.08	0.00	35.27
GDPgr	277	5.49	4.29	−34.81	14.53
Tax	217	79.20	10.58	32.20	91.70
Urban	280	46.70	24.72	15.78	100.00
Gov	248	11.53	5.57	3.46	29.87
Polistab	200	−0.17	0.94	−2.09	1.62
Ln_open	267	125.31	90.89	0.17	437.33
Corrup	194	61.17	22.04	6.00	87.00

Source: own

Tab. 3: Nation average value for variables in the model

Countries	*Undecon_ DGE*	*Undecon_ MIMIC*	*Ln_natures*	*GDPgr*	*Tax*	*Urban*	*Gov*	*Polistab*	*Ln_open*	*Corrup*
Brunei	30.70	31.04	23.14	1.25	87.08	72.65	23.76	1.18	102.71	42.49
Cambodia	47.17	48.58	3.49	6.01	91.12	19.41	5.34	−0.37	110.80	79.28
Indonesia	18.37	19.31	6.72	4.86	80.17	44.80	8.36	−1.08	54.79	73.69
Laos	30.20	30.16	8.22	6.87	68.88	25.56	10.60	−0.05	73.33	74.56
Malaysia	30.52	31.45	11.09	5.73	81.67	65.14	12.24	0.22	173.71	50.49
Myanmar	46.49	50.74	9.06	8.73	82.29	27.89	17.14	−1.15	19.68	80.88
Philippines	38.35	41.09	1.07	4.58	76.77	46.12	10.66	−1.24	80.89	70.48
Singapore	12.46	12.62	0.00	5.87	87.49	100.00	9.74	1.24	354.19	10.13
Thailand	48.70	50.41	1.84	4.22	76.29	37.98	13.87	−0.71	114.52	65.85
Vietnam	16.06	15.18	8.14	6.84	67.14	27.43	6.58	0.25	129.80	71.98
Total	31.91	33.06	7.25	5.49	79.20	46.70	11.53	−0.17	125.31	61.17

Source: own

deviations of 5.57. Brunei has the highest average value for government size, while Cambodia has the lowest median value of 5.34. Singapore has the highest average political stability, while the Philippines has the lowest.

Furthermore, we observe that the mean of trade openness (*ln_open*) is 125.31 with a standard deviation of 90.89, which shows a huge difference in the trade openness of ASEAN countries. Singapore achieves the highest value, while Myanmar achieves the lowest. In general, ASEAN countries have a relatively high level of corruption (61.17), Singapore has the lowest level of corruption (10.13), and Myanmar has the highest level of corruption among these Southeast Asia nations (80.88).

3.2 Baseline estimations

To report preliminary estimates, we exhibit the posterior mean of the parameters and a 95%-credible interval, which contains the parameter of interest with a certain probability, in Tab. 4. If a particular parameter has a positive (negative) posterior mean and the probability of its positive (negative) effect in the 95%-credible interval is greater than 50%, it is rated to cause a strongly positive (strongly negative) impact.

First of all, we evaluate the degree of convergence of MCMCs when performing Bayesian regression. The degree of convergence is considered through R_c and ESS values. In Tab. 4, our results reveal that the maximum R_c value of Gelman-Rubin diagnostics is 1.00034, less

Tab. 4: Bayesian estimation of natural resources on the underground economy (dependent variable: *undecon_DGE*)

Independent variables	Posterior mean	Probability of mean (%)	ESS min	R_c max
Ln_natures	−0.75050	95.9	1.00000	1.00002
	[−1.59378; 0.09589]			
GDPgr	−0.31934	91.9	1.00000	0.99998
	[−0.78962; 0.15264]			
Ln_open	1.36011	96.6	0.96000	1.00006
	[−0.08979; 2.80957]			
Tax	0.22749	98.4	0.99360	1.00000
	[0.02453; 0.43009]			
Urban	−0.27644	100.0	0.97690	1.00009
	[−0.41846; −0.13434]			
Gov	1.17990	100.0	1.00000	1.00007
	[0.77755; 1.58590]			
Polistab	−1.77860	98.5	0.96570	1.00005
	[−3.37112; −0.19537]			
Corrup	0.09457	86.8	0.98260	0.99999
	[−0.07544; 0.26606]			
GFC	0.40241	66.6	0.98770	0.99998
	[−1.41455; 2.24339]			
Constant	0.01638	50.8	0.99670	1.00002
	[−1.95807; 1.96093]			
Variance	94.27232	–	0.85710	1.00034
	[74.7164; 118.8254]			

Note: 95% credible interval in brackets; ESS for effective sample size and R_c is Gelman-Rubin statistic.

Source: own

than 1.1, and the smallest ESS is 0.8571, so MCMC has converged.

Next, we investigate whether the wealth of natural resources (*ln_natures*) is a blessing (i.e., reducing illegal economic activities) or a curse (i.e., increasing illicit economic activities) for ASEAN countries. Tab. 4 details the result, with the dependent variable being the underground economy's scope estimated based on the DGE model (*undecon_DGE*). The result indicates that abundant natural resources reduce the scope of the informal economy. The posterior mean of *ln_natures* is $\beta = -0.7505$, and the probability that the *ln_natures* variable has a negative effect of 95.9%. Therefore, we find strong negative evidence of the linkage between abundant natural resources and the scope of the unofficial economy. This finding implies that ASEAN countries with more abundant natural resources have a smaller scope of the underground economy. Our result contradicts hypothesis *H1* and the study of Blanton and Peksen (2023) but supports the view that natural resources wealth is a blessing. Thus, the poor economic performance of many ASEAN countries is not due to the wealth of resources but implies that certain social and political factors may shape such results.

One potential mechanism for the adverse impact of natural resource wealth on the underground economy can be through an increase in formal sector employment. That is, the efficient resources exploitation can help reduce the unemployment rate in the formal economy, which creates opportunities and motivation for individuals to leave the informal economy. For instance, Ali and Zulfiqar (2018) indicate that the agglomeration of natural resources can be a vital driver for decreasing unemployment. The authors, therefore, posit that the authorities should consider measures to promote the exploration, appropriate use and functioning of such resources. Here arises another question: what helps a country use natural resources efficiently and thereby escape the resource curse?

In this regard, Sovacool (2010) suggests three factors that could explain why Southeast Asia had avoided the resource curse. Firstly, it is due to the spread of natural resources in Southeast Asia. Normally, financiers and elites tend to easily dominate natural resources, such as oil fields. Still, oil and gas reserves in Southeast Asia are more dispersed over a wider geographical region than others. For example, the oil and gas fields in Indonesia are broad. Secondly, it is political institutions. In particular, countries with a political regime that enforces property rights, parliamentary democracies, and a strong tax system are inclined to escape the resource curse (Andersen & Aslaksen, 2008; Bulte et al., 2005; Sandbu, 2006). In addition, the lack of transparency and accountability regarding rent-seeking opportunities from natural resources is the root of the growth of the informal sector (Robinson et al., 2006). Except for Myanmar, the major oil and gas-producing ASEAN countries have relatively transparent and democratic political systems, respect for strong property rights and the rule of law, and are at average and above civil society groups. Most of these countries tend to economic diversification, such as encouraging exports and industrialization for import substitution in the 1980s and 1990s (Sovacool, 2010). Thus, political institutions in Southeast Asian countries equitably distribute benefits from natural resources. Finally, the role of collaboration in production, where resource exploitation is a partnership, ensures that revenue is distributed to more participants. Foreign-owned multinationals can react as buffers against export volatility. ASEAN nations adhere to the oil and gas cooperation model. These Southeast Asian countries have established active cooperation with biggish oil and gas firms to support probing, production, and distribution processes. For example, over 40 foreign oil companies are investing in Vietnam. Among them, many major oil companies are cooperating with Vietnam, such as Chevron (USA), Gazprom (Russia), KNOC (Korea), Petronas (Malaysia), Talisman and Repsol (Spain), ExxonMobil (USA), Total and Neon Energy (France), and PTTEP (Thailand).

In the case of the control variables, similar to Blanton and Peksen (2001, 2023), Luong et al.(2020), Lyulyov et al. (2021), My et al. (2022, 2024), Sahnoun and Abdennadher (2019), Siddik et al. (2022) and Thach et al. (2022), we find that economic growth (*GDPgr*) has an adverse and strong effect on the scope of the underground economy. The above results suggest that the association between economic growth and the underground economy is always negative. Higher-income countries have lower shadow economies. By contrast, countries with lower GDP per capita have high

poverty and unemployment rates, along with endemic income inequality, which imposes financial difficulties on low-income individuals who turn to the shadow economy for their livelihood. Another finding suggests that trade openness (*ln_open*) amplifies the scope of the underground economy, which is concordant with the result of Blanton and Peksen (2023), and Ghosh and Paul (2008). Our results can be explained as follows: international trade is sometimes seen as a catalyst for increased competitiveness among domestic manufacturers, which in turn contributes to the proliferation of informal employment. This occurs when workers in the formal market are laid off in order to reduce costs and are subsequently replaced by informal workers. Furthermore, we uncover that there are positive and strong effects of the burden of tax (*tax*) on the scope of the underground economy, which is similar to the result of Arsić et al. (2015), Duong et al. (2021), Lyulyov et al. (2021), My et al. (2022) and Sahnoun and Abdennadher (2019). The study also shows that higher urbanization (*urban*) is connected with a lower scope of the underground economy. Our observations are similar to those of Acosta-González et al. (2014). Another finding indicates that government size (*gov*) positively and strongly affects the underground economy. The above results suggest that the larger governments are proxying for an increase in government overreach that could incentivize individuals and firms to migrate to the underground economy. This result is consistent with Ghosh and Paul (2008), My et al. (2022), and Sahnoun and Abdennadher (2019) when considering developed countries. Consistent with the conclusions of Razmi and Jamalmanesh (2014), Sahnoun and Abdennadher (2019), and Siddik et al. (2022), we find the adverse impact of the extent of political stability (*polistab*) on the scope of the underground economy. That is, the higher the political stability of a country is, the smaller the scope of the underground economy is. A country with a stable political situation will have little internal conflict and violence. The smaller risk of internal conflict and violence ensures a healthy political environment, and thus political stability reduces the size of the shadow economy. Specifically, a politically stable business environment will create motivation for the growth and survival of businesses. Concerning corruption (*corrup*), our research results support the view that corruption and illicit activities are complementary, which is compatible with the conclusions of Acosta-González et al. (2014), Blanton and Peksen, (2021), Blanton and Peksen (2023), Duong et al. (2021), Luong et al. (2020), My et al. (2022), Razmi and Jamalmanesh (2014), Sahnoun and Abdennadher (2019) and Thach et al. (2022). Finally, we discover positive and strong effects of the 2007–2008 financial crisis (*GFC*) on the scope of the underground economy of ASEAN countries (Blanton & Peksen, 2023; Siddik et al., 2022). This result implies that the GFC will cause businesses to downsize or go bankrupt, while workers' income will decrease and the unemployment rate will increase. It is almost certainly true that some businesses and workers move underground when profits or incomes take a hit.

Tab. 5: **Bayesian estimation, using *undecon_MIMIC* (dependent variable: *undecon_MIMIC*) – Part 1**

Independent variables	Posterior mean	Probability of mean (%)	ESS min	R_c max
Ln_natures	−1.04162	99.6	1.00000	1.00005
	[−1.80647; −0.26545]			
GDPgr	−0.22700	85.3	1.00000	1.00003
	[−0.65072; 0.20097]			
Ln_open	0.43923	73.8	1.00000	0.99998
	[−0.91474; 1.79619]			
Tax	0.41931	100.0	0.98880	0.99995
	[0.23428; 0.60519]			

Tab. 5: **Bayesian estimation, using *undecon_MIMIC* (dependent variable: *undecon_MIMIC*) – Part 2**

Independent variables	Posterior mean	Probability of mean (%)	ESS min	R_c max
Urban	−0.46393	100.0	1.00000	1.00004
	[−0.59615; −0.33102]			
Gov	1.79628	100.0	1.00000	1.00010
	[1.42946; 2.15506]			
Polistab	−2.30423	99.8	0.95400	1.00005
	[−3.82051; −0.78275]			
Corrup	0.00266	51.5	0.98100	1.00003
	[−0.15145; 0.15702]			
GFC	0.37917	66.1	1.00000	1.00020
	[−1.41000; 2.17974]			
Constant	−0.06727	52.7	0.99760	1.00003
	[−2.04049; 1.92936]			
Variance	76.11839	—	0.81790	1.00004
	[60.2358; 96.2142]			

Note: 95% credible interval in brackets; ESS for effective sample size; R_c is Gelman-Rubin statistic.

Source: own

3.3 Robustness checks

We perform a robustness check to inquire about the stability of the results disclosed in Tab. 4. Specifically, we use an alternative to the underground economy proposed by Elgin et al. (2021). Tab. 5 shows the results of Bayesian regression with *undecon_MIMIC* (the estimate of the underground economy's scope is derived from the MIMIC model). The results related to the effects of natural resources are consistent with previous results. Specifically, the posterior mean of *ln_natures* is β = −1.04162, and the probability that the *ln_natures* variable has a negative effect of 99.6%, which means that a country with abundant natural resources has a smaller underground economy scope. For the control variables, similar to the results in Tab. 4, we detect a positive effect of trade openness, government size, corruption, and the 2007–2008 financial crisis on the scope of the underground economy. Meanwhile, annual growth in GDP, urbanization, and degree of political stability reduce illegal economic activities in ASEAN countries. At the same time, the R_c and ESS values in Tab. 5 also provide evidence that MCMC is convergent, so the Bayesian estimation is robust.

Conclusions

Is the wealth of natural resources a curse or a blessing? To contribute to the answer of this question, we examine the linkage between abundant natural resources and the informal economy's scope using a dataset of ten Southeast Asian countries during the period 1991–2018. Applying the Bayesian linear regression, our results uncover that the wealth of resources significantly negatively affects the underground economic sector. The negative effect of abundant natural resources on the informal sector remains steady and strong when we employ a different metric for the underground economy. Our findings show that resource-rich nations incline to have a smaller scope of the underground economy.

These findings suggest some interesting information that the governments should consider when designing policy. First, the authorities can influence the underground economy through the management of natural resources. Second, abundant natural resources are an advantage of a country. However, if the government does not control resource exploitation well, it can lead to undesirable effects, such as an increase in the informal economy. A potential mechanism

for this consequence is through unsustainable spending and investment patterns related to resource windfalls (Blanton & Peksen, 2023). By contrast, if a country uses natural resources efficiently, it may escape the resource curse. Notably, the efficient exploitation of natural resources can help create jobs in the formal economy and thus motivate individuals to join this sector. Hence, in countries that aim to curtail underground activities, our findings suggest that they should more closely monitor and regulate the exploration, usage, and operation of the nation's resources.

Finally, the research is not free from limitations. The link between the underground economy and natural resources still has uncertain aspects that need to be explored. The paper examines this relationship in ASEAN countries between 1991 and 2018. Nevertheless, because natural resources' characteristics and management vary across regions, further studies can compare among regions based on the natural resource management index. Moreover, further studies may also investigate different mechanisms by which natural resources can influence the underground economy. Such studies will help better clarify the picture of these two very common issues occurring in many countries worldwide.

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