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From resource curse to financial opportunity: A quantile-based frontier analysis of resources conversion efficiency in Southeast Asia

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ABSTRACT

Southeast Asian economies are richly endowed with natural resources, yet the link between resource abundance and financial development remains complex and contested. This study explores the heterogeneous impact of different types of natural resource rents on financial development across five Southeast Asian countries, Indonesia, Malaysia, the Philippines, Thailand, and Vietnam, over the period 1995 to 2021. Using a multi-method empirical strategy that integrates Stochastic Frontier Analysis (SFA), threshold regression, and quantile-based techniques, the analysis captures nonlinearities, distributional shifts, and institutional moderating effects within the resource-finance nexus. The results reveal that forest rents exert a positive and statistically significant effect on financial development, particularly at the median quantile and in economies with higher renewable energy adoption. In contrast, mineral and natural gas rents are negatively associated with credit expansion, especially in countries with weaker financial systems, suggesting the presence of a financial resource curse. Institutional quality and renewable energy consumption play crucial moderating roles by attenuating the adverse effects of rent dependency while enhancing financial sector efficiency. Efficiency estimates highlight Indonesia and the Philippines as regional frontrunners in transforming resource wealth into productive credit allocation. The study recommends integrating forest rents into green finance frameworks, strengthening governance mechanisms, and designing resource-sensitive financial deepening strategies. Overall, the findings offer timely insights to inform policy frameworks aligned with Sustainable Development Goals 8 and 9.

1. Introduction

Over the past several decades, policymakers and scholars have grappled with a persistent paradox confronting resource-rich economies: how to leverage natural resource wealth for sustained economic growth while safeguarding environmental and financial sustainability. This challenge is central to what is often termed the "resource curse", wherein the abundance of natural resources such as oil, minerals, and timber paradoxically correlate with economic volatility, institutional degradation, and underperformance in long-term development metrics [1,2]. Despite their potential to catalyze growth, natural resources frequently engender fiscal instability, corruption, and rent-seeking behaviors, which hinder broader financial development [3].[1]

Addressing this paradox requires an economic restructuring away from overdependence on resource rents toward diversified and sustainable economic models. Such models hinge on innovation, inclusive governance, and resilient institutions capable of channeling natural resource rents into long-term financial development and environmental stewardship [4]. Consequently, financial systems become both beneficiaries and enablers of sustainable development, facilitating credit allocation, resource mobilization, and productive investment.

Extensive literature has explored the economic implications of natural resource abundance, focusing primarily on its impact on growth and governance [5–7]. However, a growing body of research has shifted the

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[1] Financial development and credit expansion are use interchangeably throughout the study because the latter is a proxy of the former.

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analytical lens toward the implications for financial development, a crucial intermediary in the development process [8]. The financial resource curse (FRC) hypothesis posits that resource-dependent economies often experience sluggish financial sector growth due to institutional inefficiencies, policy inertia, and volatility in resource rents [9,10].

The FRC hypothesis further suggests that natural resource rents may distort financial systems through crowding out productive investment, dampening credit intermediation, and promoting unproductive lending patterns [11]. While natural resource revenues increase liquidity, the absence of robust legal frameworks and governance mechanisms often prevents this capital from being efficiently deployed in the financial sector. In many resource-rich economies, weak integration of financial services with the real economy impairs inclusive development [12]. Conversely, when aligned with sound governance and institutional quality, natural resource rents can serve as catalysts for financial sector development [13].

Moreover, many studies overlook the heterogeneity in resource rent types and their conversion efficiency across countries [14]. Traditional empirical models tend to aggregate natural resource rents without evaluating the distinct effects of mineral, forest, or oil rents, or accounting for conversion inefficiencies in resource utilization [15]. This is a significant oversight, as the manner in which resource rents are transformed into financial capital is central to understanding both the opportunities and limitations of resource-driven development [16].

In light of these gaps, this study explores the heterogeneous impact of different types of natural resource rents (such as mineral, forest, and natural gas rents) on financial development across five Southeast Asian countries—Indonesia, Malaysia, the Philippines, Thailand, and Vietnam. Going beyond the conventional use of credit-to-GDP ratios, we incorporate institutional quality and renewable energy adoption as critical moderators that condition this resource–finance linkage. Drawing inspiration from foundational work on the resource curse [17], financial development [18], and rent–institutions interactions [19], our study integrates threshold regression, quantile analysis, and stochastic frontier methods to better account for heterogeneity and inefficiency in rent conversion. Specifically, we seek to answer: **(1)** How do different natural resource rents affect financial development across varying quantiles of credit-to-GDP? (2) To what extent do institutional quality and renewable energy transition moderate these effects? (3) Which Southeast Asian countries exhibit greater efficiency in transforming resource rents into credit expansion? These questions allow us to probe the financial resource curse hypothesis in a more differentiated and policy-relevant way. Hence, the research hypothesis on FRC is that natural resources do not promote financial development.

The focus on Southeast Asia's emerging economies, particularly ASEAN member states offers a compelling empirical setting for this investigation. ASEAN, comprising ten resource-rich nations, accounts for substantial global production of crude rubber, tin, petroleum, and natural gas. Despite robust macroeconomic performance and a collective GDP exceeding USD 2.6 trillion [4], many ASEAN countries continue to face difficulties integrating resource wealth with sustainable financial sector growth [1,2]. This makes the region a pertinent case for assessing the FRC hypothesis in resource-rich yet financially heterogeneous contexts, especially given sparse literature on the subject focusing on ASEAN countries.

The methodological innovation of this study lies in its combined use of Stochastic Frontier Analysis (SFA), threshold regression, and quantile regression approaches. These techniques enable the analysis to capture inefficiencies in resource conversion, model non-linearities, and assess conditional effects based on governance and environmental factors [20,21]. While Ordinary Least Squares (OLS) models assume homogeneity in responses and are sensitive to distributional assumptions, the proposed multi-method framework offers a more robust estimation strategy [22]. Further, the use of explainable tools such as plots allows for the interpretation of individual-level contributions to model predictions [23], thereby enhancing the practical relevance of the findings for policymakers.

The contribution of this study is threefold. First, it extends the literature by incorporating previously underexplored resource rent types into financial development models. Second, it highlights the moderating role of governance and green transition in shaping the efficiency of rent-to-finance conversion. It is important to clarify that moderating variables are policy variables in interactive regressions because they articulate what levels of the moderating or policy variables are needed to influence how the channels or mechanisms affect the outcome variables [24,25]. Hence, employing renewable energy adoption as a policy variable has direct policy relevance on renewable energy deployment. Third, it introduces methodological rigor through advanced econometric and machine learning techniques to provide more nuanced insights into the FRC hypothesis.

This research addresses critical gaps in understanding the financial development implications of natural resource dependency, with a focus on the ASEAN bloc. By identifying the conditions under which resource rents contribute positively to financial development, the findings aim to guide policymakers in resource-rich economies toward more effective, inclusive, and environmentally aligned economic strategies.

The remainder of this paper is organized as follows. Section 2 reviews the literature on the relationship between natural resource rents and financial development. Section 3 details the methodology and model specification. Section 4 presents the empirical findings and discusses their implications. Section 5 concludes with key recommendations for policy and future research.

2. Literature review

2.1. Theoretical foundations

The paradoxical relationship between natural resource abundance and long-term economic development has given rise to what is widely known in development economics as the "resource curse" or the "paradox of plenty." Conventional economic theory posits that countries endowed with abundant natural resources possess a form of natural capital that can be strategically transformed into other forms of productive capital, such as infrastructure, education, and technological advancement. The expected outcome, based on neoclassical growth theory, is enhanced welfare through increased consumption and investment [26]. However, decades of empirical research have documented a contrary pattern: resource-rich countries often exhibit slower economic growth, weaker institutions, higher inequality, and greater macroeconomic volatility than their resource-poor counterparts [27–29].

2.1.1. Theories of the resource curse

Several theoretical frameworks have been developed to explain this paradox. The earliest explanation stems from the "Dutch Disease" hypothesis. This theory describes how a boom in natural resource exports can lead to an appreciation of the real exchange rate, thereby undermining the competitiveness of the non-resource tradable sectors such as manufacturing and agriculture. This structural shift can induce deindustrialization and increased dependence on volatile resource revenues, rendering the broader economy vulnerable when commodity prices fall [28,29].

Another significant theoretical strand emphasizes macroeconomic volatility. Natural resources, particularly oil and minerals, are subject to substantial price fluctuations in global markets. This revenue instability complicates fiscal planning, induces procyclical spending behaviors, and exacerbates debt cycles [28]. Such volatility can hinder both short- and long-term investment in human capital and public infrastructure, impeding sustainable development.

Beyond macroeconomic explanations, a more institutionally grounded perspective has emerged. The institutional quality hypothesis posits

that the presence or absence of effective governance mediates the relationship between resource wealth and development outcomes. In weak institutional environments, resource windfalls can fuel rent-seeking, corruption, elite capture, and conflict over control of rents [12,30]. Conversely, in countries with robust institutions, characterized by transparency, rule of law, and democratic accountability, natural resources can be leveraged for inclusive growth. Case studies of Botswana, Chile, and Norway exemplify how institutional strength can mitigate or even reverse the resource curse, transforming resource wealth into a foundation for economic resilience and diversification [29,31].

A growing body of literature has also questioned the statistical robustness of the resource curse hypothesis itself. Scholars such as [32,33] argue that earlier studies suffered from endogeneity and omitted variable biases, particularly by failing to account for the role of institutions as both cause and consequence of natural resource management. As a result, more recent models integrate political economy and historical-institutionalist perspectives to capture the dynamic interactions between natural resources, state capacity, and development trajectories [34,35]. Thus, theoretical critiques of the resource curse have evolved into a more constructive inquiry: under what conditions can natural resources be a catalyst for development? Recent scholarship underscores the need to examine the complex interdependencies between resource wealth, institutional quality, financial systems, and structural transformation [36]. Rather than framing the issue in binary terms, curse versus blessing, the focus has shifted toward identifying the institutional and policy configurations that enable countries to escape the trap of rentierism[2] and to pursue inclusive and diversified development paths [38,39]. This study draws from these theoretical insights to investigate how resource rents shape macroeconomic trajectories, particularly through the lens of financial sector responsiveness and institutional governance.

2.1.2. Financial sector development and sensitivity to resource flows

A less explored but increasingly important dimension of the resource curse relates to the development and behavior of the financial sector in resource-rich economies. Theoretically, the financial sector plays a pivotal role in capital allocation, risk management, and long-run economic growth. However, natural resource windfalls can distort financial intermediation through several mechanisms [40]. First, large and volatile resource revenues may induce governments to engage in off-budget spending or overreliance on sovereign wealth funds, thereby bypassing domestic capital markets and reducing the demand for financial sector development [41]. Second, resource abundance often reduces the incentives for governments to establish efficient tax systems and fiscal institutions, which are crucial for fostering broader financial inclusion and stability [42]. This "fiscal laziness" weakens the social contract and may erode the foundations of modern financial institutions [43].

Further, the financial sector in resource-rich countries may become overly exposed to commodity price cycles, leading to procyclicality in credit flows, asset prices, and exchange rate movements.[3] In the presence of underdeveloped regulatory frameworks, such cycles can contribute to financial fragility and crisis-proneness [44]. Nevertheless, some studies suggest that resource rents can positively affect financial development when properly harnessed [45]. Resource revenues can provide governments with the fiscal space to invest in financial infrastructure, expand access to credit, and support financial deepening. The experience of countries like Malaysia and Chile illustrates how resource-based wealth can be leveraged to foster robust banking systems and capital markets when accompanied by sound macroeconomic and institutional governance [46,47].

Thus, the relationship between natural resources and financial sector development is not deterministic but conditional, shaped by political, institutional, and macroeconomic variables. Integrating financial development into the broader discussion of the resource curse allows for a more nuanced understanding of how resource rents interact with state structures, investment patterns, and long-run growth dynamics.

2.1.3. Threshold effects and conditional resource-finance linkages

While the bulk of resource curse theories posit linear effects of rents on growth or institutional degradation, recent advancements underscore that such relationships are often nonlinear and conditional. The Threshold Hypothesis, originally formalized by Ref. [48], suggests that the influence of an explanatory variable (such as natural resource rents) on an outcome (like financial development) may depend on whether a third variable—like institutional quality—crosses a critical value. This approach aligns with theories of "institutional tipping points," wherein governance systems must surpass a certain threshold to effectively absorb resource shocks and channel rents into productive financial activity [19].

In the context of Southeast Asia, the role of renewable energy adoption and institutional capacity becomes especially pertinent. These dimensions not only mitigate environmental degradation but also serve as threshold-enablers that enhance rent transformation efficiency. This paper, to the best of knowledge, is among the first to formally test these threshold effects in a financial development setting, thus extending the theoretical frontier from "resource curse or blessing" to "resource conditionality under threshold regimes." Moreover, integrating threshold logic into financial sector analysis allows us to identify whether policy efforts should target financial systems broadly or prioritize context-specific enablers like regulatory stringency or green transition readiness.

2.2. Empirical review

2.2.1. Resource rents, institutional quality, and the green transition

The relationship between natural resource rents, financial development, institutional quality, and the green transition has gained significant empirical attention in recent decades. As the world increasingly turns towards renewable energy and environmentally sustainable models of development, understanding how traditional forms of wealth, especially from extractive sectors, interact with finance and governance becomes imperative. This empirical review synthesizes existing evidence on three major themes: (1) resource rents and financial development, (2) the mediating role of institutional quality, and (3) the evolving role of green transition and renewable energy in shaping the value of resource wealth.

2.2.1.1. Resource rents and financial sector development. The link between natural resource rents and financial development has yielded mixed findings in empirical literature [49]. While resource endowments can potentially catalyze investment and economic growth, numerous studies suggest that without effective financial intermediation, these windfalls may generate rent-seeking behavior and macroeconomic instability [50]. Notably, the focus of much of this literature has been on oil and gas rents [52], with forest and mineral rents receiving limited empirical scrutiny.

[12] examine the moderating effects of governance and infrastructure on the relationship between natural resource rents and economic growth, based on a sample of 110 countries from 2000 to 2018. The empirical basis consists of panel smooth transition regressions (PSTR). The relationship between economic growth and natural resources is not straightforward; its underlying non-linearity depends on the current levels of infrastructure and governance. In countries where governance

[2] Rentierism is an economic system where a significant portion of income is derived from ownership of assets, rather than from productive activity like creating goods or services [37].

[3] Procyclicality is the tendency of economic or financial variables to move in the same direction as the business cycle, amplifying economic fluctuations rather than moderating them [91].

and infrastructure development are at extremely low levels, evidence of a "natural resource curse" is evident. The positive impact of natural resources on economic growth necessitates governance thresholds. The nations listed below the set thresholds are primarily from Africa.

[53] show that resource windfalls could bolster banking sector development and stock market performance, but only in environments characterized by sound institutional governance and contract enforcement. In countries lacking robust institutions, resource rents were more likely to entrench the financial resource curse, marked by inefficiencies, under-regulated financial growth, and corruption. This highlights the need to distinguish between types of rents: while oil and gas dominate, the underexplored forest and mineral rents may yield unique financial patterns due to their distinct governance and extraction characteristics.

Moreover, empirical analyses suggest that natural resource dependence can distort credit allocation. Resource booms often lead to procyclical credit expansion, which increases systemic risk in the financial sector. The lack of diversification due to over-reliance on extractive industries further compounds the fragility of banking systems, especially in developing economies [54].

Despite these insights, the literature remains sparse on how forest and mineral rents, especially in biodiversity-rich regions like Southeast Asian countries, translate into financial intermediation outcomes. Given the socio-environmental externalities and the potential for green finance integration, this remains a critical gap.

2.2.1.2. Institutional quality, governance, and financial stability. Institutional quality plays a vital moderating role in determining whether resource abundance yields positive developmental outcomes or perpetuates the resource curse. Several empirical studies have shown that countries with strong governance frameworks are better positioned to translate resource revenues into inclusive and sustainable financial development [55]. [56] examined cross-country panel data and found that resource wealth is more likely to increase corruption in countries with authoritarian regimes or poor governance histories. Conversely, democracies or nations with strong institutional checks and balances showed a weaker link between resource rents and rent-seeking behaviors. [57] provided further insight into how oil price shocks influenced growth in resource-dependent economies. He found that shocks had significant negative impacts only in countries with low governance quality, suggesting that institutional resilience is key to buffering macroeconomic volatility stemming from commodity cycles.

A panel study across African countries (1996–2018) employed quantile regression to analyze the effects of institutional components such as regulatory quality, political stability, and rule of law on financial development. Results indicated that institutions matter more in countries that already exhibit higher levels of financial maturity. This underscores the compounding benefits of institutional strength, which reinforces financial infrastructure, credit security, and investment climates [58].

The Middle East and North Africa (MENA) region provides another compelling case. According to empirical findings by Ref. [59], robust institutional structures significantly bolster banking resilience in resource-dependent economies. Regulatory enforcement, transparency, and accountability were found to mitigate the risks of credit bubbles and sectoral misallocation of resource wealth. [60] show that control of corruption, an important institutional quality indicator, moderates the unfavorable effects of illicit financial flows. Similarly [61,62], both noted that corruption imposes indirect costs on growth through its negative effect on public investment and human capital accumulation.

Therefore, institutional quality not only determines how resource rents impact growth but also critically shapes the structure, depth, and stability of financial systems. This offers an important policy implication: reforms that enhance governance quality, judicial independence, and policy consistency are necessary to leverage resource wealth effectively.

2.2.1.3. Renewable energy, green transition, and resource rent utilization. With global momentum towards decarbonization and sustainable development, a key empirical question is how the rise of renewable energy alters the value and impact of traditional resource rents. The literature on the intersection of green transition and resource economics is growing but remains relatively limited.

A recent study on South Africa by Ref. [63] used ARDL and quantile ARDL models to examine the long-run effects of renewable energy consumption and resource rents on environmental sustainability, measured by CO_2 emissions and the ecological footprint. The findings revealed that while renewable energy consumption significantly enhanced environmental sustainability, resource rents exerted only a weak and sometimes negative impact. This suggests that transitioning to renewables offers better developmental and environmental returns compared to dependence on extractive rents.

Another study by Ref. [64] builds on the premise higher wealth disparity is associated with reduced carbon dioxide (CO_2) emissions in low- and middle-income nations. The study examines the relationship between rising inequality and renewable energy consumption using a sample of 39 lower- and middle-income sub-Saharan nations. Quadratic Tobit regressions serve as the foundation for the empirical data. Given that only one of the three income inequality factors employed in the study shows a net positive influence, the explored assumption is only partially valid. Policy makers should maintain the Atkinson index below a threshold of 0.6180 in order to achieve equitable redistribution of income and, consequently, to discourage measures that favor income disparity for renewable energy usage.

In forest-rich economies, the opportunity exists to reframe forest resource rents through the lens of ecosystem services, carbon markets, and biodiversity credits. These mechanisms could alter the structure of financial incentives and create new avenues for green finance and environmental fiscal reforms. However, empirical studies quantifying these transitions remain scarce.

The link between resource rents and green finance instruments such as green bonds, carbon pricing, and sustainable investment indices has yet to be empirically established at scale. In the context of the climate crisis, this remains a pressing research priority.

2.3. Research gaps

Empirical literature strongly supports the proposition that resource rents can stimulate financial development, particularly credit growth [45]. However, the extent and direction of these effects are highly contingent on institutional quality. Effective governance, policy stability, and corruption control are indispensable for ensuring that resource revenues strengthen rather than destabilize financial systems. At the same time, renewable energy adoption appears to offer more sustainable and environmentally beneficial returns than traditional resource exploitation [65]. This shift has implications for the economic utility of resource rents and calls for a rethinking of their management and allocation, especially in forest- and mineral-rich contexts.

Despite these insights, some research gaps persist. First, the underrepresentation of forest and mineral rents [66]. Most studies focus on oil and gas. The impact of forest and mineral rents on financial development remains underexplored, particularly in the context of ecosystem service valuation and biodiversity financing. Further, institutional threshold effects have largely been unexplored [67]. More empirical work is needed to identify the precise institutional conditions under which resource rents begin to act as a blessing rather than a curse.

In addition, empirical evidence on how renewable energy transitions reshape the value and use of traditional resource rents is limited. This is especially pertinent as countries adopt net-zero targets and climate-aligned fiscal strategies. Research is needed to understand how green financial instruments interact with resource rent utilization and influence long-term sustainability outcomes.

While empirical studies on the natural resource-financial

development nexus are abundant, we observe they are heavily concentrated on conventional econometric frameworks such as Ordinary Least Squares (OLS), Fixed Effects (FE), Random Effects (RE), and Generalized Method of Moments (GMM) and ARDL. This methodological concentration presents a gap in the literature: current models often assume uniform relationships across countries and time, potentially obscuring critical heterogeneity in the resource–finance–energy nexus. These approaches, although robust for certain inferential purposes, may inadequately capture structural heterogeneity, non-linear effects, and efficiency differentials across economies.

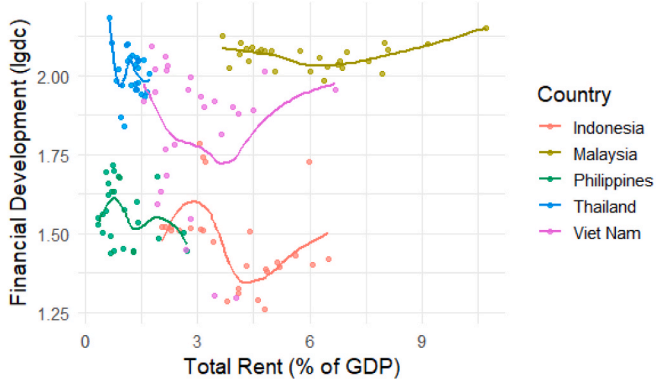
Very few studies have employed Stochastic Frontier Analysis (SFA) to measure efficiency in resource rent utilization [22,23]. There are also few studies that have employed threshold regression models to detect institutional tipping points, or quantile regression techniques to uncover heterogeneous effects across different levels in the resource-finance nexus. Even fewer studies have considered these methods in the context of Southeast Asian countries. Therefore, addressing these gaps with multi-country data from resource-rich contexts will provide a more holistic understanding of how natural capital, institutional ecosystems, and renewable transitions converge to shape the developmental trajectory of resource-rich nations.

To visually probe the relationship between natural resource rents and financial development across countries, Fig. 1 plots domestic credit (lgdc) against total rent as a share of GDP. The observed nonlinear and country-variant patterns motivate the use of flexible modelling strategies, including stochastic frontiers and threshold regressions.

2.4. Data and variable construction

This study utilizes an unbalanced panel dataset comprising five Southeast Asian economies—Indonesia, Malaysia, the Philippines, Thailand, and Vietnam—spanning the period from 1995 to 2021. The dataset is compiled from authoritative global sources, including the World Bank's World Development Indicators (WDI), and Worldwide Governance Indicators (WGI), among others (see Table 1). All variables are annual in frequency and were transformed into logarithmic form, where appropriate, to stabilize variance and ensure linear comparability in elasticities. To maintain consistency across models and facilitate interpretation, monetary variables are expressed in constant US dollars and adjusted for purchasing power parity.

The dependent variable is domestic credit to the private sector by banks (lgdc), a standard proxy for financial development that reflects the capacity of financial institutions to support private sector activity. The central explanatory variables are disaggregated natural resource rents expressed as a percentage of GDP, namely forest rent (fornt), mineral rent (minrnt), natural gas rent (ngrnt), and coal rent (coalrnt). These variables capture the sectoral composition of resource wealth and



Source: Authors' work.

Fig. 1. Is there a Financial Curse? Natural Rent vs. Credit in Southeast Asia (1995–2021). Source: Authors' work.

Table 1
Description of the variables.

Variables	Descriptions	Sources
Lgdc	Log of Domestic Credit to Private Sector by Banks (% of GDP)	World Bank [68]
front	Forest Rent (% of GDP)	World Bank [68]
Minrnt	Mineral Rent (% of GDP)	World Bank [68]
Ngrnt	Natural Gas Rent (% of GDP)	World Bank [68]
Coalrnt	Coal Rent (% of GDP)	World Bank [68]
Ren	Renewable Energy Consumption (% of Total Final Energy Consumption)	World Bank [68]
Lgppp	Log of GDP per capita (constant 2015 US$)	World Bank [68]
Lgge	Log of re-scaled Government Effectiveness (Index)	Worldwide Governance Indicators [69]
Lggdp	Log of Gross Domestic Product (constant 2015 US$)	World Bank [68]
Lggi	Log of re-scaled Composite Governance Index	Worldwide Governance Indicators [69]
Fdi	Foreign Direct Investment, net inflows (% of GDP)	World Bank [68]

Source: Authors' work.

its potential heterogeneity in financial outcomes.

To explore the conditional impact of rent on financial development, two sets of moderators were introduced. The first involves governance quality, captured through government effectiveness (lgge) and institutional governance index (lggi), both sourced from the Worldwide Governance Indicators database. Since WGI indicators range between −2.5 and + 2.5, a direct logarithmic transformation would yield undefined values for negative observations. To ensure variance stabilization and comparability with other log-scaled variables, these governance indices were first re-scaled to a strictly positive range using a linear shift before applying the natural log transformation. This approach preserves their relative distribution and interpretability while ensuring mathematical validity. The second moderator focuses on the green transition, measured by renewable energy consumption (ren), defined as the share of renewables in total final energy consumption.

Control variables include per capita income (lgppp) and total GDP (lggdp), both in logarithmic form, to account for income effects and macroeconomic scale. Foreign direct investment inflows (fdi) as a percentage of GDP were also included in auxiliary models for robustness checks, though not all specifications retained them.

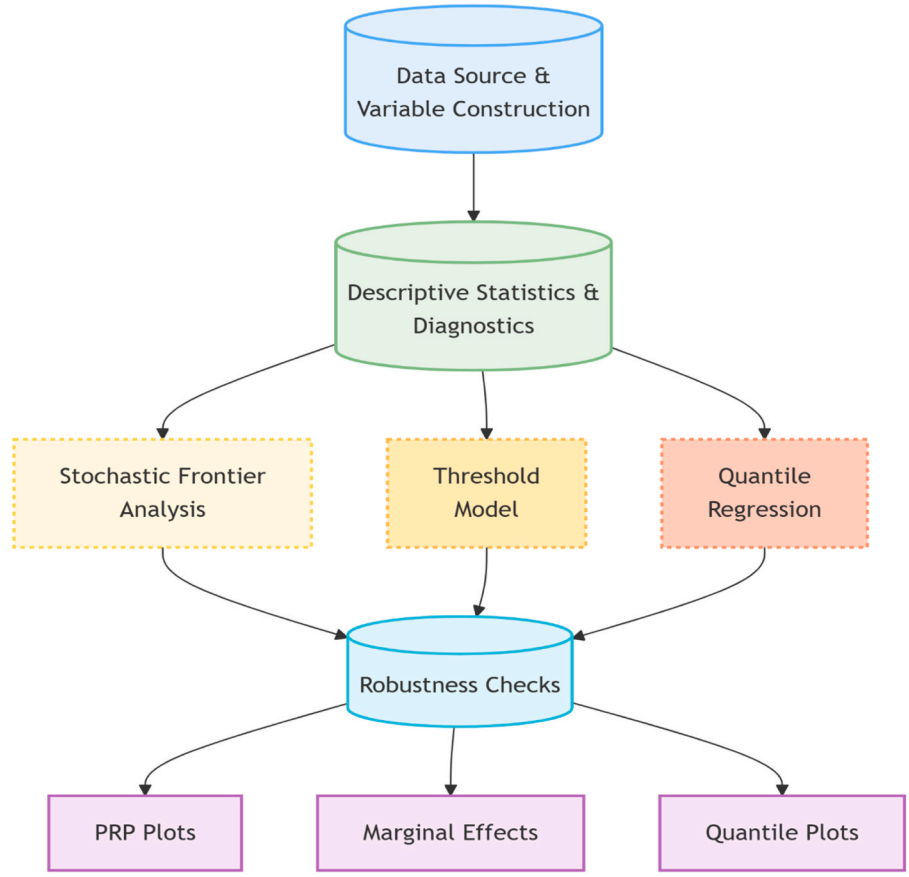
A detailed description of the variables, along with their definitions and sources, is provided in Table 1 below:

2.5. Empirical strategy

To rigorously examine the heterogeneous and nonlinear effects of natural resource rents on financial development across Southeast Asian economies, the study adopts a multi-stage empirical strategy. This progression of methods (see Fig. 2) allows us to sequentially uncover patterns, validate econometric assumptions, and estimate nuanced relationships that conventional linear regressions might overlook. Beginning with descriptive and diagnostic assessments, the analysis advances toward more complex econometric models, including stochastic frontier analysis, threshold regressions, and quantile regressions. Each methodological layer is chosen deliberately to align with the study's core research questions on the conditionality, distributional dynamics, and institutional moderators within the resource–finance nexus.

2.5.1. Descriptive and diagnostic analysis

The first step in the empirical process involves examining the statistical properties and relationships among the variables through descriptive statistics and correlation matrices. This provides an initial understanding of the data's central tendencies, dispersion, and distributional characteristics. The descriptive statistics revealed a broad variation across the natural rent indicators—forest rent, mineral rent,



Source: Authors' work.

Fig. 2. Methodological framework. Source: Authors' work.

coal rent, and natural gas rent—highlighting substantial heterogeneity across countries and time. Notably, the standard deviations of mineral and forest rents are comparatively high, suggesting fluctuations in resource dependence across the sample.

The correlation matrix was then constructed to evaluate the pairwise associations among all variables. While most correlations were moderate and within acceptable thresholds, some notable associations were detected. For instance, renewable energy shares exhibited a negative correlation with mineral rent and natural gas rent, signaling potential structural trade-offs in the resource-energy-finance triad. However, no collinearity appeared strong enough to threaten regression reliability.

To further assess the possibility of multicollinearity—a common concern in panel regressions—Variance Inflation Factor (VIF) analysis was conducted. Together, these preliminary analyses establish a solid empirical foundation for the advanced estimation techniques employed in the following subsections. They ensure that the model assumptions are adequately satisfied and help in identifying patterns that guide the choice of more appropriate, nuanced estimation methods.

2.5.2. *Stochastic frontier analysis (SFA)*

To examine how efficiently Southeast Asian economies transform natural resource rents into financial development, this study applies the Stochastic Frontier Analysis (SFA) framework. SFA is particularly appropriate because it not only captures the average link between resource rents and financial development but also measures the efficiency of this transformation. Unlike standard regression models, which treat all unexplained variation as random, SFA separates the error term into two parts—one reflecting random noise and the other representing inefficiency.

SFA was preferred over non-parametric approaches such as Data Envelopment Analysis (DEA) because it accounts for random shocks and allows for formal statistical testing. This makes it more suitable for cross-country macro-panel data, where measurement errors and unobserved country-specific factors are common [70]. The method aligns closely with the study's central objective: to determine how effectively different types of resource rents (forest, mineral, and natural gas) contribute to financial development, measured by domestic credit to the private sector (% of GDP). By estimating an efficiency frontier, SFA helps identify how far each country operates from its potential, providing insight into the "financial resource curse" mechanism [71].

We employ two widely accepted SFA models to ensure robustness and capture time-varying dynamics:

(a) Time-Invariant Model

This specification assumes that inefficiency effects are country-specific and time-invariant. The model is expressed as:

$$lgdc_{it} = \beta_0 + \beta_1 \text{fornt}_{it} + \beta_2 \text{minrnt}_{it} + \beta_3 \text{ngrnt}_{it} + \beta_4 \text{coalrnt}_{it} + \beta_5 \text{ren}_{it} + \beta_6 \text{lgppp}_{it} + \beta_7 \text{lgge}_{it} + \beta_8 \text{lggdp}_{it} + v_{it} - u_i \quad (1)$$

where, ln (lg dc_{it}) denotes the natural log of domestic credit to the private sector, $v_{it} \sim N(0, \sigma_v^2)$ captures the symmetric random error, $u_i \sim N^+(0, \sigma_u^2)$ captures non-negative inefficiency, β_k are parameters to be estimated.

This model allows benchmarking of each country's financial development performance against the estimated efficient frontier over the full period [72] (i.e., Battese & Coelli, 1995).

(b) Time-Varying Inefficiency Model

To account for potential changes in efficiency over time—especially relevant for countries undergoing policy reforms or experiencing shocks—we implement the [73] (i.e., Kumbhakar et al., 2014) model, where inefficiency varies with time:

$$lgdc_{it} = \beta_0 + \beta_1 \text{fornt}_{it} + \beta_2 \text{minrnt}_{it} + \beta_3 \text{ngrnt}_{it} + \beta_4 \text{coalrnt}_{it} + \beta_5 \text{ren}_{it} + \beta_6 \text{lgppp}_{it} + \beta_7 \text{lgge}_{it} + \beta_8 \text{lggdp}_{it} + v_{it} - u_{it} \quad (2)$$

where, the inefficiency term u_{it} is time-varying, capturing fluctuations in efficiency across the years of observation. The model provides richer insights into dynamic improvements or deteriorations in financial development performance [73,74].

Both models are estimated using Maximum Likelihood Estimation (MLE), which ensures asymptotically efficient and unbiased parameter estimates. The MLE procedure simultaneously estimates the frontier function parameters and the inefficiency distribution, making it suitable for small to medium-sized panel datasets such as ours [75]. By leveraging both static and dynamic SFA models, we ensure a comprehensive efficiency assessment, capturing both persistent and evolving inefficiency patterns across Southeast Asian economies.

2.5.3. Threshold regression model

To explore potential non-linearities in the relationship between natural resource rents and financial development, we employ a threshold regression framework. This method allows us to identify whether the effects of resource rents vary significantly across different regimes of rent intensity, thereby uncovering structural asymmetries in the resource-finance nexus. Unlike linear models that impose constant marginal effects, threshold regressions permit parameter shifts once a specified threshold variable exceeds a certain cut-off value.

In our case, the threshold is constructed based on the median value of total natural resource rents (sum of forest, mineral, natural gas, and coal rents, expressed as a percentage of GDP). This approach splits the sample into "low rent" and "high rent" regimes, facilitating regime-wise coefficient estimation. The underlying model takes the following form:

$$\text{lgdc}_{it} = \beta_0 + \beta_1 \cdot \text{X}_{it} + \beta_2 \cdot \text{HighRent}_{it} + \varepsilon_{it} \quad (3)$$

where lg dc_{it} denotes the log of domestic credit to the private sector (as a proxy for financial development) for country i in year t, X_{it} represents a vector of explanatory variables including disaggregated resource rents and control variables, and HighRent_{it} is a dummy variable that takes the value 1 if total rent exceeds the median threshold, and 0 otherwise.

To further enrich the analysis, we incorporate interaction terms involving institutional quality (measured by the log of the Worldwide Governance Indicator, lggi). This specification tests whether good governance can mitigate the adverse effects of high resource rents on financial development. The extended model is expressed as:

$$\text{lgdc}_{it} = \beta_0 + \beta_1 \cdot \text{X}_{it} + \beta_2 \cdot \text{HighRent}_{it} + \beta_3 (\text{HighRent}_{it} \times \text{lggi}_{it}) + \varepsilon_{it} \quad (4)$$

The model is estimated using Ordinary Least Squares (OLS) with robust standard errors to account for heteroskedasticity, ensuring the reliability of inference. The use of threshold modeling is inspired by the seminal work of [48], which formalizes regression models with regime shifts, and is well-suited for analyzing non-linearities in cross-country resource–finance relationships. Moreover, the interaction term between institutional quality and rent variables aligns with frameworks developed by scholars exploring moderation effects in macro-financial linkages [76].

In addition, to examine whether renewable energy conditions the impact of resource rents on financial development, supplementary interaction specifications were estimated of the form:

$$\text{lgdc}_{it} = \alpha + \beta_1 \text{fornt}_{it} + \beta_2 \text{ren}_{it} + \beta_3 (\text{fornt}_{it} \times \text{ren}_{it}) + \gamma Z_{it} + \mu_i + \varepsilon_{it} \quad (5)$$

and analogous terms for other rent types (minrnt × ren, ngrnt × ren). Fig. 4 illustrates the marginal effects of forest rent on financial development derived from this interaction model, evaluated at the mean and ±1 SD of renewable energy consumption, with the predicted *lgdc* rising from approximately 1.6 to over 3.0 as forest rent increases from 0 % to 8 % of GDP.

2.5.4. Quantile regression

To account for distributional heterogeneity in the impact of resource rents on financial development, we utilize quantile regression (QR). Traditional mean regression techniques (e.g., OLS) provide only an average estimate of the relationship between variables. However, such estimates may obscure important differences across the conditional distribution of the dependent variable.

Quantile regression addresses this limitation by estimating separate coefficients at different points (quantiles) of the financial development distribution. Specifically, we estimate the effects at the 25th (Q1), 50th (median), and 75th (Q3) percentiles of lg dc_{it}. This allows us to assess whether countries with low, median, or high levels of financial development are differently affected by natural resource rents.

The QR specification is as follows:

$$Q_\tau(\text{lgdc}_{it}|X) = \beta_{0\tau} + \sum_{k=1}^{K} \beta_{k\tau} X_{kit} \quad (6)$$

where $Q_\tau(\cdot)$ denotes the conditional quantile function at quantile τ, and X_{kit} includes the vector of explanatory variables. Estimates are obtained for $\tau = 0.25, 0.50$, and 0.75.

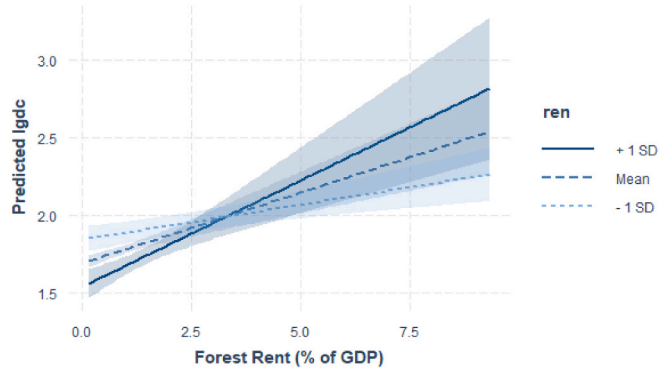
To ensure robustness, we employ bootstrapped standard errors with 1000 replications. This mitigates the impact of outliers and provides more reliable inference for quantile-specific estimates. The use of quantile regression enhances the granularity of our analysis, revealing how the effects of natural resource rents are not uniform but vary significantly across different financial development strata.

2.5.5. Robustness and simulation

To validate the stability and robustness of the estimated coefficients, the study employs a Monte Carlo Simulation framework grounded in lagged fixed-effects dynamic panel models. This approach involves generating 1000 resampled models where the lag of the dependent variable is included to account for potential state dependence in financial development. The Monte Carlo simulation with 1000 repetitions was conducted using a dynamic fixed-effects framework to test the robustness of the baseline results. The model incorporated lagged financial development to capture persistence and retained country-

Source: Authors' work.

Fig. 3. Partial residual plot for mineral rent. Source: Authors' work.



Source: Authors' work.

Fig. 4. Marginal effect of forest rent on financial development across renewable-energy levels. Source: Authors' work.

specific fixed effects to control for unobserved heterogeneity. Each repetition drew parameter values from the empirical distribution of the data, allowing for both serial and cross-sectional dependence. The procedure confirms that the main estimates are stable across repeated samples and not sensitive to dynamic feedback or data dependence.

The Monte Carlo simulation serves two primary objectives. First, it evaluates the distributional consistency of key coefficient estimates—particularly for forest and mineral rents—by analyzing the spread, central tendency, and bounds across simulated iterations. Second, it helps detect any undue sensitivity to sampling variation or model specification, particularly in smaller panels like the one used in this Southeast Asian context. As shown in the results section, the coefficients of interest (e.g., for forest and mineral rents) display relatively stable means and medians across simulations, thereby enhancing confidence in the underlying econometric estimates. This method of bootstrapped repetition mirrors practices in prior work emphasizing simulation-based validation in small-N panel studies [77,78].

3. Empirical Results

3.1. Presentation of results

The descriptive statistics of the study variables in Table 2 offer a snapshot of data behavior across the 135 observations drawn from five Southeast Asian economies. The dependent variable, financial development (lgdc), has a mean of 1.788 and a standard deviation of 0.269, reflecting moderate variation. Among independent variables, forest rent (fornt) and renewable energy consumption (ren) exhibit high dispersion, with standard deviations of 1.527 and 15.396, respectively. The distribution of institutional quality (lggi) is notably skewed (−9.666) with extremely high kurtosis (105.075), indicating significant outliers and non-normality. These patterns underscore the importance of employing flexible and robust estimation techniques in the empirical analysis.

To further examine the marginal effect of resource variables on financial development, Fig. 3 presents a partial residual plot focused on minrnt. The graph reveals a visibly negative slope, suggesting that mineral rents may be inversely associated with domestic credit levels after controlling for other covariates. While the relationship appears consistent, variability across countries remains visible, supporting our subsequent model decisions.

Although the governance index (*lggi*) exhibits extreme skewness (−9.666) and kurtosis (105.075), these arise from the bounded nature of the rescaled WGI data and not from measurement errors. Similarly, *ren* and *fornt* display high variability typical of heterogeneous Southeast Asian contexts. Robustness checks using 1–99 percentile winsorization and inverse-hyperbolic-sine (IHS) transformations confirmed that the main results remain stable, validating the resilience of the models to distributional irregularities.

Table 3 presents the Pearson correlation coefficients among the key variables used in the analysis. Notably, financial development (lgdc) exhibits a strong negative correlation with renewable energy consumption (ren) (−0.665) and mineral rent (minrnt) (−0.593), while showing positive associations with governance indicators (lgge: 0.487; lggi: 0.309) and forest rent (fornt: 0.393). Interestingly, total GDP (lggdp) is highly correlated with both lgdc (0.741) and ren (−0.869), suggesting potential structural overlaps between development levels and resource dependencies. The moderate to high correlations among some independent variables warrant multicollinearity diagnostics, which are addressed in subsequent sections using VIF analysis.

The strong negative correlation between *lgdc* and *ren* (−0.665) should be viewed as descriptive rather than causal. This inverse relationship likely reflects cross-country differences in economic and financial maturity, as economies with less developed financial systems tend to have higher shares of traditional or biomass-based renewables within total energy use. The correlation therefore captures structural contrasts in development stages rather than a direct effect of renewable energy on finance.

Following the initial exploration of relationships among variables, multicollinearity diagnostics were conducted to ensure the reliability of regression estimates. As reported in Table 4, the Variance Inflation Factor (VIF) values for most explanatory variables fall well below the conventional threshold of 10, indicating no serious multicollinearity issues. While lggdp exhibits the highest VIF at 8.76, this still remains within acceptable bounds for macroeconomic panel data. Variables like ren (4.90) and lgge (4.24) also reflect moderate collinearity, yet their corresponding 1/VIF values—0.204 and 0.236, respectively—confirm that the estimates remain interpretable and statistically stable. Overall, these diagnostics validate the suitability of the selected variables for subsequent econometric modeling.

The relatively higher VIF values for *lggdp* (8.76) and *ren* (4.90) reflect the structural overlap between economic scale and energy composition rather than problematic multicollinearity, as both remain within acceptable diagnostic limits.

Table 2
Summary statistics of key variables.

Variable	*Lgppp*	*ren*	*fornt*	*lgge*	*lggi*	*minrnt*	*ngrnt*	*coalrnt*	*lgdc*	*lggdp*
Mean	8.784	27.209	1.378	10.908	10.817	0.359	0.962	0.345	1.788	4.021
Standard Error	0.056	1.325	0.131	0.033	0.086	0.045	0.077	0.055	0.023	0.022
Median	8.919	27.800	0.621	10.924	10.894	0.102	0.651	0.063	1.890	4.005
Standard Deviation	0.650	15.396	1.527	0.384	0.997	0.519	0.900	0.638	0.269	0.251
Kurtosis	0.515	−0.392	6.935	−0.500	105.075	4.134	0.160	8.897	−1.383	−0.960
Skewness	−0.141	0.104	2.341	−0.551	−9.666	2.025	1.081	2.781	−0.351	0.074
Range	4.083	62.900	9.169	1.666	11.503	2.655	3.452	3.716	0.927	1.103
Minimum	7.090	2.000	0.165	9.861	0.000	0.000	0.000	0.000	1.259	3.392
Maximum	11.173	64.900	9.333	11.526	11.503	2.655	3.453	3.716	2.186	4.496
Sum	1185.778	3673.200	186.090	1472.522	1460.230	48.497	129.908	46.565	241.374	542.889
Count	135.000	135.000	135.000	135.000	135.000	135.000	135.000	135.000	135.000	135.000

Source: Authors' work.

Table 3
Pearson correlation matrix of key variables.

	lgppp	ren	fornt	lgge	lggi	minrnt	ngrnt	coalrnt	fdi	lgdc	lggdp
lgppp	1.000										
ren	−0.084	1.000									
fornt	−0.098	−0.361	1.000								
lgge	0.222	−0.633	0.046	1.000							
lggi	0.111	−0.413	−0.146	0.361	1.000						
minrnt	−0.033	0.327	−0.268	−0.046	0.035	1.000					
ngrnt	−0.118	−0.535	0.513	0.390	0.155	−0.036	1.000				
coalrnt	0.040	0.270	−0.131	0.150	0.073	0.496	−0.089	1.000			
fdi	−0.150	−0.092	0.094	−0.168	0.011	−0.091	0.225	−0.360	1.000		
lgdc	0.085	−0.665	0.393	0.487	0.309	−0.593	0.303	−0.309	0.111	1.000	
lggdp	0.084	−0.869	0.350	0.763	0.379	−0.359	0.588	−0.176	0.118	0.741	1.000

Source: Authors' work.

Table 4
Multicollinearity assessment (variance inflation factors).

Variable	VIF	1/VIF
lgppp	1.1238	0.8898
ren	4.8957	0.2043
fornt	1.8798	0.5320
minrnt	1.8398	0.5435
ngrnt	2.2055	0.4534
coalrnt	1.8143	0.5512
fdi	1.3985	0.7150
lggdp	8.7641	0.1141
lgge	4.2435	0.2357
lggi	1.4665	0.6819

Source: Authors' work.

Table 5 presents a comparative overview of coefficient estimates across the Battese-Coelli SFA, Kumbhakar SFA, and Threshold Regression models, thereby capturing both frontier-based efficiency estimations and non-linear effects of rent dependence.

In the Battese-Coelli SFA model, fornt exhibits a statistically significant positive association with domestic credit (lgdc), with a coefficient of 0.0290 (standard error = 0.0112, $p < 0.05$). This positive relationship strengthens in the Kumbhakar SFA to 0.0338 (0.0106, $p < 0.01$), suggesting that foreign rents may play a supportive role in credit provision. On the contrary, minrnt shows a robust and negative influence in both models: −0.1414 (0.0354, $p < 0.001$) under Battese-Coelli and −0.1535 (0.0314, $p < 0.001$) in the Kumbhakar specification. A similar negative pattern is observed for ngrnt, with estimates of −0.0620 (0.0203, $p < 0.01$) and −0.0615 (0.0200, $p < 0.01$), respectively.

Table 5
Comparison of core estimation results across SFA and threshold regression models.

Variable	Battese-Coelli SFA	Kumbhakar SFA	Threshold
(Intercept)	−1.4771 (0.6046)*	−1.3228 (0.6478)*	
Fornt	0.0290 (0.0112)*	0.0338 (0.0106)**	
Minrnt	−0.1414 (0.0354)***	−0.1535 (0.0314)***	
Ngrnt	−0.0620 (0.0203)**	−0.0615 (0.0200)**	
Coalrnt	−0.0353 (0.0270)	−0.02 (0.03)	
Ren	−0.0003 (0.0017)	−0.00 (0.00)	0.0004 (0.0061)
lgppp	0.0002 (0.02)	0.00 (0.02)	
lgge	0.0143 (0.0815)	0.06 (0.06)	0.100 (0.0690)*
lggdp	0.7621 (0.1829)***	0.63 (0.14)***	0.0225 (0.0246)
sigmaSq	0.0396 (0.0130)**	0.02 (0.00)***	
Gamma	0.7182 (0.2270)**	0.00 (0.03)	
high_rent			−0.1809 (0.0282)**
total_rent			−0.0810 (0.0276)*
lggi			0.046 (0.008)**

*, **, *** denote significance levels at 0.05, 0.01, and 0.001, respectively.
Source: Authors' work.

The coefficient on coalrnt is negative in both models but not statistically significant: −0.0353 (0.0270) and −0.0241 (0.0251). Renewable energy consumption (ren) appears insignificant across all specifications, while lgppp remains statistically non-influential, indicating limited explanatory power of income levels in isolation.

Importantly, lggdp shows a highly significant positive effect in both SFA frameworks — 0.7621 (0.1829, $p < 0.001$) in Battese-Coelli and 0.6278 (0.1440, $p < 0.001$) in Kumbhakar — emphasizing the role of macroeconomic size in driving credit. In contrast, governance variables (lgge and lggi) do not exhibit statistical significance in SFA models but gain relevance in the Threshold Regression.

Within the Threshold model, high_rent (an indicator for above-median rent dependence) demonstrates a significant negative effect of −0.1809 (0.0282, $p < 0.01$), while total_rent itself also has a negative and significant coefficient of −0.0810 (0.0276, $p < 0.05$). Notably, the interaction between rent levels and institutional quality is visible in the positive and statistically significant coefficient of lggi: 0.0460 (0.0080, $p < 0.01$). Additionally, lgge becomes marginally significant in this specification with an estimate of 0.1000 (0.0690, $p < 0.1$), suggesting that public governance plays a more nuanced role when accounting for regime-based heterogeneity.

Besides, inefficiency parameters such as gamma and sigmaSq in both SFA models are statistically significant, indicating the appropriateness of frontier techniques for capturing unobserved heterogeneity and efficiency differentials. For instance, the gamma in Battese-Coelli is 0.7182 (0.2270, $p < 0.01$), implying that over 70 % of the variance is due to inefficiency rather than noise.

The Battese–Coelli model reports a gamma (γ) of about 0.72, which means that most of the variation in financial development across countries stems from efficiency differences rather than random noise. This finding is consistent with the relatively high mean efficiency scores of around 0.90 shown in Table 8. In this study, efficiency refers to how effectively each country converts its natural resource rents into financial development, measured by domestic credit to the private sector. A gamma above 0.7 suggests that cross-country differences in rent-to-

Table 6
Quantile regression estimates at the 25th, 50th, and 75th percentiles of financial development.

Variables	Q25	Q50	Q75
Intercept	−1.6989 (0.8760)	−2.5887 (0.6657)***	−1.5323 (0.9461)
fornt	0.0256 (0.0135)*	0.0386 (0.0137)***	0.0302 (0.0161)*
minrnt	−0.1231 (0.0637)*	−0.1906 (0.0561)***	−0.1595 (0.0517)**
ngrnt	−0.0727 (0.0209)***	−0.0408 (0.0281)	−0.0280 (0.0248)
coalrnt	−0.0390 (0.0555)	−0.0677 (0.0754)	0.0139 (0.0602)
ren	0.0013 (0.0027)	0.0023 (0.0026)	0.0011 (0.0033)
lgppp	−0.0099 (0.0131)	0.0099 (0.0187)	0.0047 (0.0204)
lgge	−0.0797 (0.1599)	0.1825 (0.1075)*	0.1862 (0.0768)**
lggdp	1.0956 (0.2733)***	0.5750 (0.1881)***	0.3368 (0.2370)**

*, **, *** denote significance levels at 0.05, 0.01, and 0.001, respectively.
Source: Authors' work.

Table 7
Monte Carlo simulation results: Distribution of key coefficient estimates.

Variable	Mean	Median	Min	Max
lgdc_lag	0.697	0.7146	0.2911	0.9199
fornt	0.0006	0.0022	−0.0867	0.1852
minrnt	−0.0113	−0.0111	−0.1077	0.0291

Source: Authors' work.

Table 8
Country- average efficiency scores.

Country	Avg_Efficiency_BC	Avg_Efficiency_Kumbhakar
Indonesia	0.905	0.912
Malaysia	0.899	0.799
Philippines	0.897	0.819
Thailand	0.87	0.831
Vietnam	0.826	0.863

Source: Authors' work.

credit conversion are systematic rather than random, confirming that the frontier approach is appropriate. The average efficiency score of 0.9 indicates that, on average, Southeast Asian economies are operating close to the best-practice frontier, though there remains scope for improvement through stronger governance, better financial intermediation, and diversification policies. For policymakers, an efficiency level of 0.90 implies that roughly ten percent of potential rent-driven financial development is still unrealized.

Fig. 4 displays the marginal effect of forest rent on financial development (*lgdc*) across three levels of renewable energy use: one standard deviation below the mean, at the mean, and one standard deviation above the mean. The predicted values of *lgdc* increase monotonically with higher forest rent at all three renewable energy levels. The slope of the relationship steepens slightly at higher renewable levels (+1 SD), with the predicted *lgdc* rising from approximately 1.6 to over 3.0 as forest rent increases from 0 % to 8 % of GDP. The associated confidence intervals narrow around the central range and widen at the tails, suggesting greater precision in mid-range predictions.

Quantile coefficient estimates (see Table 6) are reported across the distribution of the dependent variable (*lgdc*) for each explanatory variable, ranging from the 10th to the 90th quantile ($\tau = 0.1$ to $\tau = 0.9$). Each subplot represents one explanatory variable, where the solid black line denotes the estimated coefficient at each quantile, and the shaded grey region corresponds to the bootstrapped 95 % confidence interval. Red dashed lines represent conventional 5 % significance bounds (see Fig. 5).

Across multiple variables, such as *minrnt*, *fornt*, and *lggdp*, the quantile estimates exhibit consistent patterns of statistical significance across various quantiles. Notably, the confidence bands of certain variables, including *minrnt* and *fornt*, remain entirely above or below the zero line at mid-to-upper quantiles, suggesting persistent directional influence over those quantile ranges. In contrast, variables such as *ren* and *coalrnt* show more volatility and wider intervals, with estimates closer to zero and largely overlapping with the null line, indicating

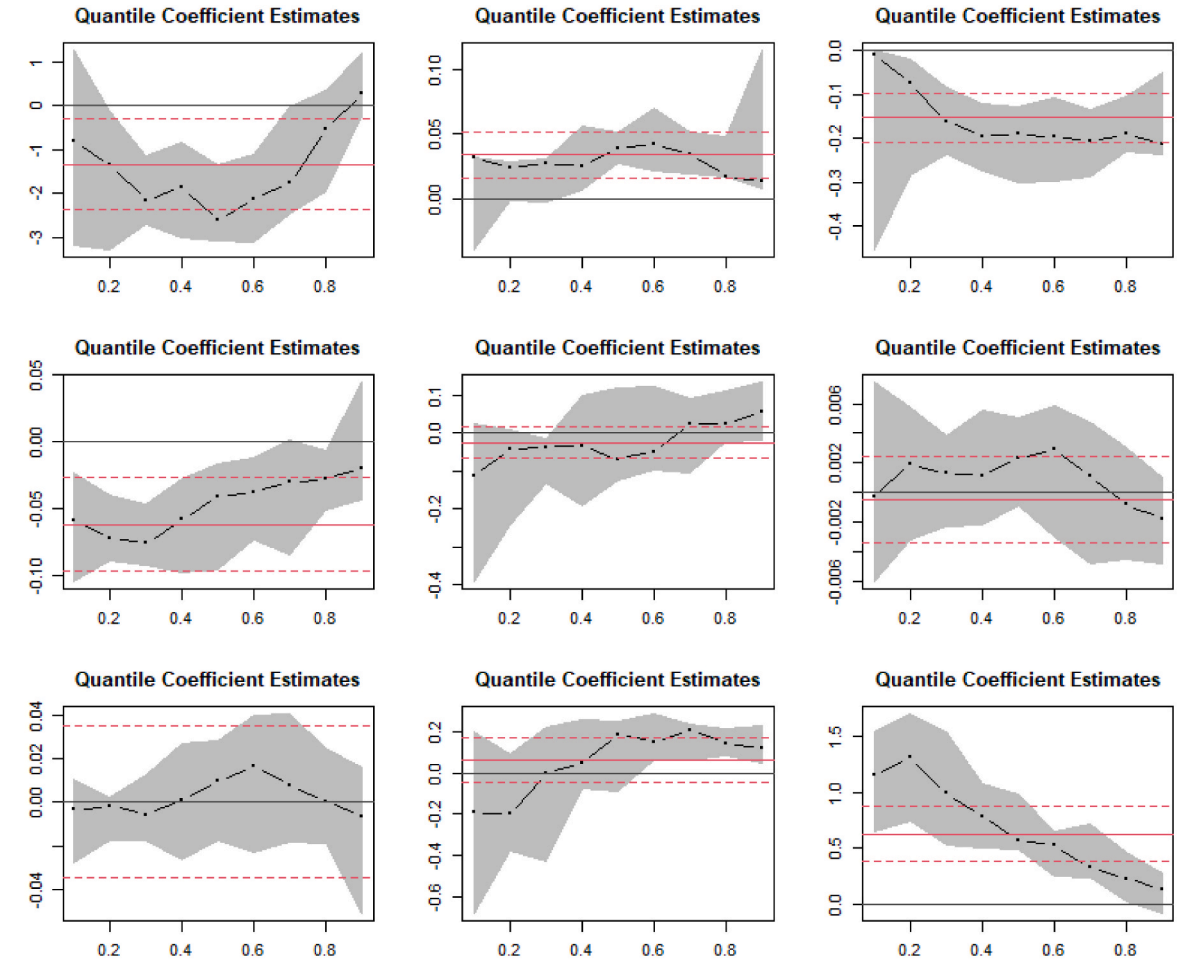


Fig. 5. Quantile Coefficient Estimates Across τ Levels (Line Plot with CI). Source: Authors' work.

weaker statistical precision at several quantiles.

Quantile regression estimates reveal important distributional heterogeneity in the relationship between natural resource rents and financial development across the 25th, 50th, and 75th percentiles. The coefficient of forest rent (*fornt*) is positive and statistically significant across all three quantiles, increasing from 0.0256 ($p < 0.10$) at the 25th percentile to 0.0386 ($p < 0.01$) at the median, before slightly moderating to 0.0302 ($p < 0.10$) at the upper quantile. Mineral rent (*minrnt*) exhibits a consistently negative and statistically significant effect, most pronounced at the median (−0.1906, $p < 0.01$).

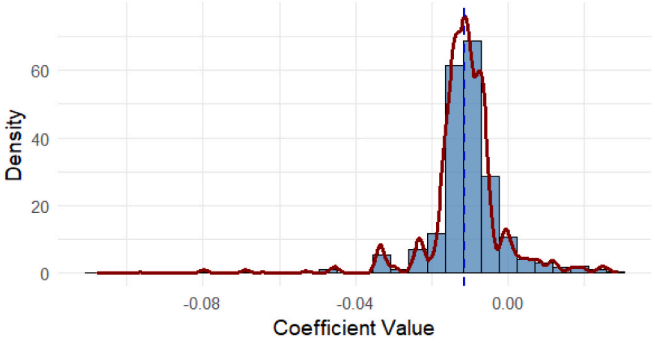
While the impact of natural gas rent (*ngrnt*) is significant only at the lower quantile (−0.0727, $p < 0.01$), the effects of coal rent (*coalrnt*) and renewable energy share (*ren*) remain statistically insignificant across the distribution. Among the controls, government effectiveness (*lgge*) becomes significant at higher quantiles, with coefficients of 0.1825 ($p < 0.10$) and 0.1862 ($p < 0.05$) at the 50th and 75th percentiles, respectively. The strongest and most consistent effect is observed for *lggdp*, which remains positive and significant across all quantiles, peaking at 1.0956 ($p < 0.01$) in the lower tail of the financial development distribution.

The statistical insignificance of *coalrnt* and *ren* across quantiles reflects the transitional nature of Southeast Asia's energy structure, where fossil-based generation still dominates and renewable deployment remains uneven. Consequently, these variables exhibit limited explanatory power for financial development in the short term, though their role may strengthen as regional energy diversification progresses. Coal rent (*coalrnt*) and renewable energy share (*ren*) remain statistically insignificant across all quantiles, indicating limited variation in their effects within the current sample.

Fig. 6 displays the distribution of log-transformed domestic credit across two regimes of total natural rent, categorized into low rent (0) and high rent (1). The x-axis plots total rent as a percentage of GDP, while the y-axis shows the corresponding values of domestic credit. The figure illustrates the threshold-based regime classification using the median value of total natural resource rents (3.87 % of GDP) as the dividing point. Observations below the threshold (Low Rent, $n = 68$) and above the threshold (High Rent, $n = 67$) are shown separately. The plot visualizes the change in domestic credit (log) across rent regimes, confirming a structural shift around the median threshold. Observations under each regime are color-coded, with a visible separation around the median rent threshold. Data points and lines are plotted for both regimes, illustrating their respective spread and variation.

3.2. Robustness check

To validate the reliability and stability of our core results, we conducted a series of robustness checks using Monte Carlo simulations (see Table 7 and Fig. 7) and efficiency estimations via stochastic frontier models. Specifically, we ran 1000 repetitions of the dynamic fixed effects model to assess the dispersion and stability of key coefficients. These simulations help evaluate whether the direction and magnitude of the resource rent coefficients—especially for forest and mineral rents—remain consistent under repeated sampling variability. Furthermore, we compare country-level efficiency scores derived from both the Battese-Coelli (see Fig. 8) and Kumbhakar specifications to ensure robustness in our SFA-based conclusions. These complementary checks strengthen confidence in the empirical validity of our financial resource curse hypothesis.



Note: mi Simulated from 1000 Dynamic FE Models
Source: Authors' work.

Fig. 7. Monte Carlo Distribution: Coefficient of Mineral Rent. Note: mi Simulated from 1000 Dynamic FE Models. Source: Authors' work.

Efficiency patterns across the five countries reveal minimal fluctuations over the study period (see Fig. 9), with all countries maintaining consistently high scores as estimated by the Kumbhakar model. The plotted trajectories show slight year-to-year variability but remain largely stable, suggesting persistent efficiency in credit allocation relative to natural rent utilization.

The accompanying country-level (see Table 8) averages from both the Battese-Coelli and Kumbhakar models further validate these trends. Under the Battese-Coelli specification, Indonesia emerges as the most efficient country with an average score of 0.905, followed by Malaysia (0.899) and the Philippines (0.897). The Kumbhakar model yields comparable but slightly adjusted rankings, with Indonesia again leading (0.912), while Vietnam (0.863) ranks notably higher compared to its position in the BC model. These consistent efficiency scores across models reinforce the reliability of the stochastic frontier approach in capturing the financial development implications of natural resource rents.

4. Discussion

This study set out to examine whether and how different types of natural resource rents influence financial development in Southeast

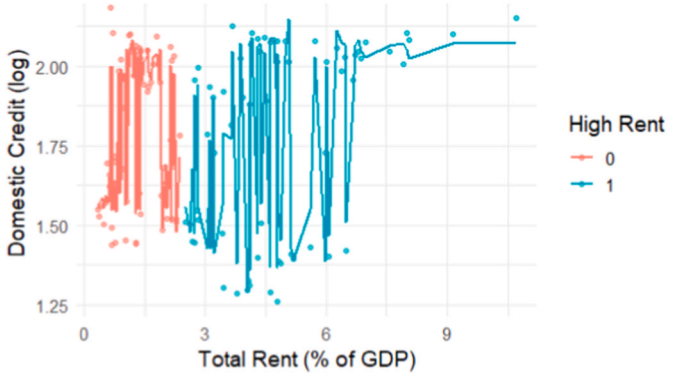
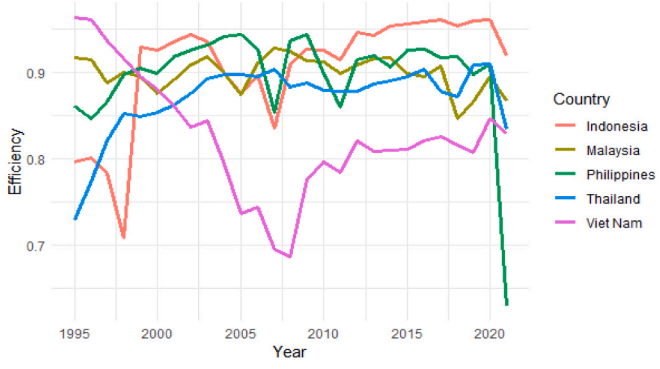
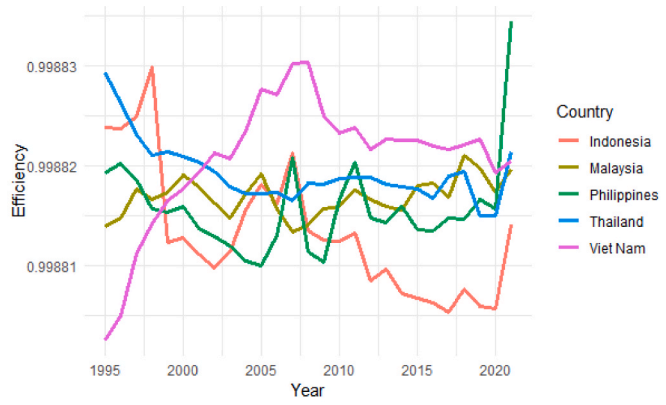


Fig. 6. Threshold effect of natural rent on financial development.



Source: Authors' work.

Fig. 8. Efficiency trends (Battese-Coelli). Source: Authors' work.



Source: Authors' work.

Fig. 9. Efficiency trends (Kumbhakar Model). Source: Authors' work.

Asia, a region characterized by both resource abundance and rising sustainability pressures. By incorporating stochastic frontier models, threshold regressions, interaction effects, and quantile-based methods, the analysis responded to three core research questions: (i) Do natural resource rents contribute to or inhibit domestic credit provision? (ii) Are these effects nonlinear or moderated by factors such as governance and renewable energy use? (iii) How efficient are Southeast Asian economies in converting resource wealth into financial sector growth? [79–81]. Our findings offer multi-layered insights that deepen the understanding of the "financial curse" hypothesis in a novel regional and methodological context. It is important to note that the research hypothesis on financial curse is that natural resources do not promote financial development.

The study advances the resource-finance literature in several ways. First, while much of the extant work focuses on aggregate resource dependence, we disaggregate rents into forest, mineral, gas, and coal categories, thus addressing heterogeneity in resource-finance dynamics. Our models consistently reveal that forest rent exerts a positive and statistically significant impact on domestic credit, a finding most pronounced under the Kumbhakar SFA specification.

The positive linkage between forest rents and credit provision likely reflects the increasing formalization of forestry-related finance in Southeast Asia. In Indonesia and the Philippines, two countries that later emerge as efficiency leaders, forest resources have become embedded within structured credit systems through land titling reforms, timber-backed value chains, and the proliferation of green finance initiatives. Programs such as Indonesia's *Forest Investment Program (FIP)* and *REDD + Payment for Ecosystem Services (PES)* schemes have expanded the flow of concessional and commercial finance to community forestry and plantation sectors. These mechanisms enable forest assets to serve as collateral or as sources of verifiable environmental revenue, reducing credit risk and attracting formal lending. Similarly, rural banking reforms in the Philippines have integrated agroforestry and ecotourism enterprises into microfinance and cooperative lending frameworks, reinforcing the observed positive elasticity of forest rent on domestic credit. Thus, the empirical association captures a deeper institutional transformation in which forest-linked rents are increasingly monetized through sustainable finance channels rather than informal or extractive circuits. This contrasts with mineral and natural gas rents, which show a robust negative influence, echoing concerns in prior literature about their volatility and enclave nature [82,83].

Second, the threshold regression and interaction models highlight conditional dynamics often neglected in conventional analyses. High rent regimes, as defined by the median split of total rent, are associated with significant declines in financial development, even after controlling for economic size and governance quality [51]. However, when institutional quality (lggi) is introduced as a moderating variable, it partly offsets the rent-induced drag on credit, underscoring the institutional enabler thesis in resource-finance linkages [76,84]. Similarly, our marginal effect plots demonstrate that the positive association between forest rent and financial development amplifies at higher levels of renewable energy usage, suggesting that greener energy regimes enhance the developmental returns to forest-based resources [85,86].

Third, the quantile regression results reveal distinct mechanisms underlying the resource–finance relationship across different levels of financial development. In lower quantiles, mineral rents exert significantly negative effects, likely reflecting weak institutional buffers, high rent-seeking, and shallow credit markets; as argued by Ref. [87]. At higher quantiles, the interaction between governance and resource rents turns more adverse, suggesting that even in relatively advanced financial systems, institutional complacency or elite capture may dilute financial discipline, as posited by Ref. [88]. Moreover, the contrasting effects of renewable versus non-renewable rents on credit provision point to structural differences: forest rents often benefit decentralized, agriculture-linked credit systems, while mineral and gas rents tend to concentrate in capital-intensive sectors with limited spillovers. These patterns underscore how financial frictions, institutional voids, and sectoral asymmetries condition the translation of resource wealth into broad-based credit growth. The insignificance of coal rent and renewable energy variables aligns with Southeast Asia's ongoing energy transition. Coal continues to dominate generation capacity, while renewable expansion remains gradual and concentrated in a few economies. Given that these sectors have not yet developed deep credit linkages, their limited effect on financial development is unsurprising. Over time, greater diversification of energy portfolios and financing mechanisms could strengthen the renewable-finance connection observed in higher-income contexts.

Beyond the observed statistical associations, these results can be understood through the evolving mechanisms that govern capital allocation in Southeast Asia's energy transition. As renewable energy (RE) penetration increases, the risk-return calculus for banks and investors begins to shift. Higher RE shares, supported by carbon pricing, feed-in tariffs, or Contracts for Difference (CfDs), stabilize expected returns from clean energy infrastructure by mitigating revenue volatility and policy uncertainty. Simultaneously, these mechanisms erode the relative attractiveness of fossil-linked lending by internalizing carbon costs and tightening balance-sheet exposures to stranded asset risks. Green-lending mandates and sustainability-linked bonds introduced in several ASEAN economies further reinforce this reallocation of credit by embedding environmental criteria into collateral valuation and loan pricing. In this sense, the moderating effect of renewable energy observed in our models is not merely statistical, it reflects a structural reorientation of credit systems toward grid modernization, storage investments, and electrification of transport and industry. These mechanisms collectively reduce financing costs for low-carbon technologies while increasing risk premia for fossil-based activities, thereby altering the composition of financial deepening itself. As Southeast Asian economies strengthen carbon disclosure frameworks and expand green taxonomies, these dynamics are likely to intensify, aligning domestic credit expansion with decarbonization imperatives rather than rent-seeking cycles.

Finally, our Monte Carlo simulations and efficiency analyses affirm the robustness of these patterns. Across 1000 simulations, the direction and dispersion of key coefficients, especially for mineral rent, remain stable. The efficiency scores derived from the Battese-Coelli and Kumbhakar models show that Indonesia and the Philippines consistently outperform others in converting rents into financial sector gains, suggesting model validity and policy relevance [89,90].

Taken together, the findings validate our central thesis that not all resource rents are equally detrimental to finance, and their effects are strongly shaped by moderating institutions, green transition indicators, and distributional positioning. These insights have important implications for Southeast Asian policymakers aiming to harmonize resource management with financial deepening goals under SDG 8 and SDG 9

frameworks.

5. Conclusion, policy recommendations, limitations and future studies

5.1. Conclusion

This study investigates the multifaceted relationship between disaggregated natural resource rents and financial development across five Southeast Asian economies from 1995 to 2021. By integrating stochastic frontier analysis, threshold regression, interaction models, and quantile-based techniques, the study provides a nuanced understanding of the "financial curse" hypothesis within a heterogeneous and transitional economic landscape.

The findings underscore that natural resource rents do not exert uniform effects on financial development. Specifically, forest rent is positively associated with domestic credit provision, particularly at the median quantile of the financial development distribution. In contrast, mineral and natural gas rents exhibit consistently negative impacts, highlighting their enclave nature and susceptibility to price volatility. Coal rents, while less statistically robust, also trend negative.

Crucially, the interaction models reveal that institutional quality and renewable energy usage can condition or even offset the adverse effects of resource dependence. Strong governance frameworks and greener energy transitions amplify the positive role of forest rents and mitigate the financial drag associated with extractive rents. Efficiency analyses further demonstrate that economies like Indonesia and the Philippines have shown relatively greater capacity to translate resource wealth into financial sector gains, emphasizing the role of institutional and policy context.

5.2. Policy recommendations

The empirical evidence from this study highlights the need for targeted policy actions that strengthen the link between natural resource rents, institutional quality, and sustainable financial development in Southeast Asia. While resource wealth provides a strong foundation for growth, its benefits can only be fully realized when governance, financial systems, and environmental mechanisms operate in harmony. The following recommendations translate these insights into practical and implementable strategies for policymakers and development partners in the region.

First, governments should develop forest-backed carbon credit markets and biodiversity bonds that assign measurable financial value to forest ecosystems. This would allow countries such as Indonesia, Malaysia, and the Philippines to generate new and sustainable sources of financing for reforestation, biodiversity conservation, and local livelihood programs. By integrating forest rents into formal green finance systems, policymakers can transform ecological assets into long-term economic opportunities.

Second, national treasuries should establish sovereign wealth or stabilization funds that reinvest excess resource rents into renewable energy infrastructure, technology innovation, and research. These funds can serve as fiscal buffers that cushion the economy against commodity price volatility while supporting long-term investments in clean energy transitions and industrial diversification.

Third, central banks and financial regulators should encourage commercial banks to dedicate a defined share of their lending portfolios—ideally between 10 and 15 percent—to certified green and low-carbon projects. This policy would mobilize private capital toward climate-aligned investments, enhance credit access for renewable energy firms, and accelerate the region's transition toward sustainable and inclusive finance.

Fourth, governance and institutional reforms should focus on digitalizing resource management systems. This includes the implementation of transparent fiscal dashboards and blockchain-based licensing systems that track natural resource flows, royalties, and tax revenues in real time. Such measures would significantly reduce corruption, strengthen accountability, and improve the efficiency of rent distribution to local communities and development programs.

Finally, ASEAN should establish a regional Green Finance Coordination Forum to harmonize sustainability standards, facilitate cross-border carbon trading, and support member states in developing national green finance taxonomies. This platform would foster knowledge sharing, technical cooperation, and policy alignment, thereby enhancing Southeast Asia's collective ability to attract climate finance and private investment for low-carbon growth.

Collectively, these measures provide a coherent policy roadmap for converting resource wealth into sustainable development outcomes. By combining financial innovation, institutional reform, and regional coordination, Southeast Asian economies can move beyond the traditional resource-dependent growth model and achieve a more resilient, equitable, and green financial future.

5.3. Limitations and future studies

Despite the novel contributions and robust empirical approach employed in this study, two key limitations merit consideration, and they provide fertile ground for future scholarly inquiry.

This study utilizes disaggregated resource rent data (forest, mineral, gas, and coal rents) at the national level, derived from authoritative international databases. However, due to data availability constraints, it does not capture the sub-sectoral characteristics, ownership structures (state-owned vs. private firms), or regional-level disparities in resource extraction and financial access. These unobserved heterogeneities may influence both the intensity and the quality of the resource-finance transmission mechanism, potentially masking localized patterns of development or exclusion, particularly in decentralized governance systems such as those in Indonesia or the Philippines.

Future research could address this limitation by employing subnational or firm-level panel data, enabling a more granular analysis of how different types of resource rents affect credit access, financial inclusion, and sustainability outcomes across provinces, districts, or economic zones.

Again, while the study integrates institutional quality (via LGGI and LGGE) and green transition indicators (renewable energy use), these proxies are derived from annual datasets that may not fully capture within-year policy shifts, governance reforms, or climate shocks that dynamically affect both natural resource management and financial flows. Additionally, the analysis assumes non-linear or threshold-based relationships, which may overlook complex feedback loops or temporal lags.

To overcome the underlying limitations, future studies should explore the use of dynamic institutional indicators, such as policy event data, governance reform indices, or real-time environmental stress variables (e.g., deforestation alerts or emission spikes). Coupling these with dynamic panel estimators or structural equation modelling could reveal causal mechanisms and adaptive policy responses in greater detail. Furthermore, future studies should adopt estimation techniques that are tailored to address more dimensions of endogeneity. For instance, in the present study, rents and credit can co-evolve and addressing reverse causality or omitted variables (such as commodity price shocks feeding both rents and credit) is essential.

Ethical approval

This article does not contain any studies with human participants or animals performed by the authors.

Credit author statement

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curation and Writing-Original Draft Preparation. Revision of manuscript.

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Declaration of competing interest

The authors have no conflict of interest to declare.

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Data availability

Data will be made available on request.

References

[1] Tang C, Irfan M, Razzaq A, Dagar V. Natural resources and financial development: role of business regulations in testing the resource-curse hypothesis in ASEAN countries. Res Pol 2022 Jun 1;76:102612.
[2] Pham TH, Lin CY, Moslehpour M, Van Vo TT, Nguyen HT, Nguyen TT. What role financial development and resource-curse situation play in inclusive growth of Asian countries. Res Pol 2024 Jan 1;88:104498.
[3] Wang Y, Duan Y, Dou J. Does resource-richness cause resources curse in financial market? A sustainable development overview for RCEP economies. Res Pol 2023 Jan 1;80:103193.
[4] Lai L, Li X. Resource curse, public crisis, and the road to sustainable development in emerging Asia. Res Pol 2024 Mar 1;90:104738.
[5] Haseeb M, Kot S, Hussain HI, Kamarudin F. The natural resources curse-economic growth hypotheses: quantile–on–quantile evidence from top Asian economies. J Clean Prod 2021 Jan 10;279:123596.
[6] Nawaz MA, Azam A, Bhatti MA. Natural resources depletion and economic growth: evidence from ASEAN countries. Pak J Econ Stud (PJES) 2019 Dec 31;2(2):155–72.
[7] Murshed M, Rahman AA. The importance of settling geopolitical disputes in neutralizing the carbon curse of natural resources: evidence from south and southeast Asia. Min Econ 2025 Mar;38(1):143–58.
[8] Benigno G, Fornaro L, Wolf M. The global financial resource curse. Am Econ Rev 2025 Jan 1;115(1):220–62.
[9] Hill H, Pasaribu DH. Avoiding the resource curse. J Southeast Asian Econ 2022 Dec 1;39(3):225–50.
[10] Zhang C, Liang Q. Natural resources and sustainable financial development: evidence from South Asian economies. Res Pol 2023 Jan 1;80:103282.
[11] Hu H, Li R, Zhang L. Financial development and resources curse hypothesis: China's COVID-19 perspective of natural resources extraction. Res Pol 2023 Aug 1;85:103965.
[12] Asongu SA, Diop S, Emeka ET, Ogbonna AO. The role of governance and infrastructure in moderating the effect of resource rents on economic growth. Polit Pol 2024 Oct;52(5):1059–80.
[13] Dwumfour RA, Ntow-Gyamfi M. Natural resources, financial development and institutional quality in Africa: is there a resource curse? Res Pol 2018 Dec 1;59:411–26.
[14] Mesagan EP, Vo XV. Does natural resource rent and consumption interplay worsen Africa's pollution? Heterogeneous panel approach with cross-sectional dependence. Res Pol 2023 May 1;82:103562.
[15] Li R, Hu S, Wang Q. Reexamining the impact of natural resource rent and corruption control on environmental quality: evidence from carbon emissions and ecological footprint in 152 countries. InNatural Resourc Forum 2024 May;48(2):636–60. Oxford, UK: Blackwell Publishing Ltd.
[16] Zhang Z, Xu X. Sustainable financial risk, resources abundance and technological innovation: evidence from resources abundance economies. Res Pol 2023 Jun 1;83:103559.
[17] Sachs J, Warner A. Natural reaource abundance and econmic growth. Nat Bureau Econ Res 1995;3:54.
[18] Beck T, Levine R. Legal institutions and financial development. In Handbook of new institutional economics 2005 (pp. 251-278). Boston, MA: Springer US.
[19] Mehlum H, Moene K, Torvik R. Institutions and the resource curse. Econ J 2006 Jan 1;116(508):1–20.
[20] Guo J, Wang Y, Xu H, Li B, Wang Y. The financial density and improvement of urban technological efficiency: an estimation based on the stochastic frontier approach. Land 2023 Aug 12;12(8):1592.
[21] Fusco E, Benedetti R, Vidoli F. Stochastic frontier estimation through parametric modelling of quantile regression coefficients. Empir Econ 2023 Feb;64(2):869–96.
[22] Coulibaly Y. The effects of climate change on public investment efficiency in resource-rich countries: evidence from stochastic frontier analysis. https://hal.science/hal-04072345v1/file/DR-LEO-2023-05.pdf; 2023.
[23] Sowu AK, Intapan C, Chaiboonsri C, Mensaklo E. Economic growth in Sub-Saharan Africa: an analysis of the technical efficiency of natural resource rent and institutions based on a copula stochastic frontier model. InApplications of optimal transport to economics and related topics 2024 Nov 10 (pp. 401-417). Cham: Springer Nature Switzerland.
[24] Emeka ET, Asongu SA. Research productivity and Africa's productive capacity: the moderating role of government education expenditure. High Educ Q 2025 Jul;79(3):e70039.
[25] Mete MC, Asongu S, Mignamissi D. Female economic inclusion, financial access and environmental degradation in Sub-Saharan Africa: policy synergies and thresholds. J Econ Adm Sci 2025 Aug 25:1–9. https://doi.org/10.1108/JEAS-03-2025-0169.
[26] Erdoğan S, Yıldırım DÇ, Gedikli A. Natural resource abundance, financial development and economic growth: an investigation on Next-11 countries. Res Pol 2020 Mar 1;65:101559.
[27] Barbier E. Natural resources and economic development. Cambridge University Press; 2019 Sep 19.
[28] Ross ML. The oil curse: how petroleum wealth shapes the development of nations. In The oil curse 2012 Mar 4. Princeton University Press.
[29] Frankel JA. The natural resource curse: a survey of diagnoses and some prescriptions. Commodity price volatility and inclusive growth in low-income countries. 2012 Apr. p. 7–34.
[30] Amare MZ, Demissie WM, Massa MM. The effect of natural resource rents on institutional quality in selected African countries. Sus Fut 2025 Jun 1;9:100506.
[31] Nathaniel SP. Environmental degradation in ASEAN: assessing the criticality of natural resources abundance, economic growth and human capital. Environ Sci Pollut Res 2021 May;28(17):21766–78.
[32] Aragón FM, Chuhan-Pole P, Land BC. The local economic impacts of resource abundance: what have we learned? World Bank Policy Research Working Paper; 2015 May 12. p. 7263.
[33] Brunnschweiler CN, Bulte EH. The resource curse revisited and revised: a tale of paradoxes and red herrings. J Environ Econ Manag 2008 May 1;55(3):248–64.
[34] Singh S, Sharma GD, Radulescu M, Balsalobre-Lorente D, Bansal P. Do natural resources impact economic growth: an investigation of P5+ 1 countries under sustainable management. Geosci Front 2024 May 1;15(3):101595.
[35] Tabash MI, Mesagan EP, Farooq U. Dynamic linkage between natural resources, economic complexity, and economic growth: empirical evidence from Africa. Res Pol 2022 Sep 1;78:102865.
[36] Abaidoo R, Agyapong EK. Financial development and institutional quality among emerging economies. J Econ Dev 2022 Aug 15;24(3):198–216.
[37] Karakilic E. Rentierism and the commons: a critical contribution to Brett Christophers' rentier capitalism. Environ Plan A Econ Space 2022 Mar;54(2):422–9.
[38] Xiang D, He X, Shi M. Deciphering the resource wealth enigma: unraveling the interplay of institutional quality, economic diversity, and R&D in mitigating the resource curse. Res Pol 2024 Apr 1;91:104935.
[39] Faisal F, Isiksal AZ, Ali A, Abu Mansor NN, Al Maktoumi IS. Natural resources to economic prosperity: evaluating the role of institutional quality, financial development, and human capital in the resource-rich economy: natural resources to economic prosperity: evaluating the role of institutional quality, financial development, and human capital in the resource-rich economy. Min Econ 2025 Jun;38(2):319–35.
[40] Beck T, Poelhekke S. Follow the money: does the financial sector intermediate natural resource windfalls? J Int Money Finance 2023 Feb 1;130:102769.
[41] Guizani M, Ajmi AN. Financial conditions, financial constraints and investment-cash flow sensitivity: evidence from Saudi Arabia. J Econ Adm Sci 2021 Oct 22;37(4):763–84.
[42] Boadway R, Flatters F. The taxation of natural resources: principles and policy issues. InTaxing choices for managing natural resources, the environment, and global climate change: fiscal systems reform perspectives. Cham: Springer International Publishing; 2023 Feb 22. p. 17–81.
[43] Azam W, Khan I, Ali SA. Alternative energy and natural resources in determining environmental sustainability: a look at the role of government final consumption expenditures in France. Environ Sci Pollut Res 2023 Jan;30(1):1949–65.
[44] Marioli FA, Vasishtha G. Fiscal policy procyclicality and volatility in commodity-exporting emerging and developing economies. World Bank; 2025 Jan.
[45] Wang Y, Wang R. Mineral resource rent and sustainable transition: the mediating role of financial development. Res Pol 2024 Feb 1;89:104527.
[46] Cherif R, Hasanov F. Oil exporters' dilemma: how much to save and how much to invest. World Dev 2013 Dec 1;52:120–31.
[47] Sayadi M, Khosroshahi MK. Assessing alternative investment policies in a resource-rich capital-scarce country: results from a DSGE analysis for Iran. Energy Policy 2020 Nov 1;146:111813.
[48] Hansen BE. Threshold effects in non-dynamic panels: estimation, testing, and inference. J Econ 1999 Dec 1;93(2):345–68.

[49] Yıldırım S, Gedikli A, Erdoğan S, Yıldırım DÇ. Natural resources rents-financial development nexus: evidence from sixteen developing countries. Res Pol 2020 Oct 1;68:101705.
[50] Wang Q, Li X, Li R. The impact of political, financial, and economic risks on energy transition: the role of natural resource rents. Humanit Soc Sci Commun 2025 Jan 22;12(1):1–6.
[51] Wang Z, Ali K, Ullah S. Revisiting natural resources and financial development nexus in China under the lens of time-frequency approach. InNatural Resourc Forum 2025 Feb;49(1):541–60. Oxford, UK: Blackwell Publishing Ltd.
[52] Brooks SM, Kurtz MJ. Oil "rents" and political development: what do we really know about the curse of natural resources? Comp Polit Stud 2022 Sep;55(10):1698–731.
[53] Ali A, Ramakrishnan S. Financial development and natural resources. Is there a stock market resource curse? Res Pol 2022 Mar 1;75:102457.
[54] Beck T. Finance and oil: is there a resource curse in financial development? European Banking Center Discussion Paper.; 2011. 2011-004).
[55] Huang Y, Shuaib M, Rahman MM, Rahman M, Hossain ME. Natural resources, digital financial inclusion, and good governance nexus with sustainable development: fuzzy optimization to econometric modeling. In: Nat res forum. Oxford, UK: Blackwell Publishing Ltd; 2024 Aug 19.
[56] Bhattacharyya S, Hodler R. Do natural resource revenues hinder financial development? The role of political institutions. World Dev 2014 May 1;57:101–13.
[57] Moshiri S. Asymmetric effects of oil price shocks in oil-exporting countries: the role of institutions. OPEC Energy Rev 2015 Jun;39(2):222–46.
[58] Adusei M. The finance–growth nexus: does risk premium matter? Int J Finance Econ 2019 Jan;24(1):588–603.
[59] Omri A, Saidi K. Factors influencing CO2 emissions in the MENA countries: the roles of renewable and non-renewable energy. Environ Sci Pollut Res 2022 Aug;29(37):55890–901.
[60] Asongu SA, Somé J. Corruption, terrorism and illicit financial flows related to extractive commodity trade in Africa. Res Pol 2025 Apr 1;103:105569.
[61] Dzhumashev R. Corruption and growth: the role of governance, public spending, and economic development. Econ Modell 2014 Feb 1;37:202–15.
[62] Khan MA, Gu L, Khan MA, Oláh J. Natural resources and financial development: the role of institutional quality. J Multi Fin Manag 2020 Sep 1;56:100641.
[63] Udeagha MC, Muchapondwa E. Investigating the moderating role of economic policy uncertainty in environmental Kuznets curve for South Africa: evidence from the novel dynamic ARDL simulations approach. Environ Sci Pollut Res 2022 Nov;29(51):77199–237.
[64] Asongu SA, Odhiambo NM. Inequality and renewable energy consumption in Sub-Saharan Africa: implication for high income countries. Innovat Eur J Soc Sci Res 2024 Apr 2;37(2):382–98.
[65] Agozie DQ, Afful-Dadzie A, Gyamfi BA, Bekun FV. Does psychological empowerment improve renewable energy technology acceptance and recommendation? Evidence from 17 rural communities. Renew Energy 2023 Dec 1;219:119449.
[66] Akram R, Ai F, Srivastava M, Sharma R. Considering natural gas rents, mineral rents, mineral depletion, and natural resources depletion as new determinants of sustainable development. Res Pol 2024 Sep 1;96:105200.
[67] Olaniyi CO, Al-Faryan MA, Ogbaro EO. Do institutional quality and its threshold matter in the sensitivity of the renewable energy transition to financial development? New empirical perspectives. Int J Finance Econ 2025 Jan;30(1):5–43.
[68] WDI. World bank development indicator. World Bank; 2024. https://databank.worldbank.org/source/world-development-indicators (open in a new window).
[69] Worldwide governance indicators. World Bank; 2024. Available: https://www.bing.com/ck/a?!&&p=1e71929095c2fd6371bc86418546bfa590ca7125bec23cd304e70c319b491f30JmltdHM9MTc2MTc4MjQwMA&ptn=3&ver=2&hsh=4&fclid=0ec9c603-b0e2-6ed4-276f.
[70] El Mehdi R, Hafner CM. Panel stochastic frontier analysis with positive skewness. Comput Econ 2025 May;65(5):2743–60.
[71] Karakaplan MU. Panel stochastic frontier models with endogeneity. STATA J 2022 Sep;22(3):643–63.
[72] Battese GE, Coelli TJ. A model for technical inefficiency effects in a stochastic frontier production function for panel data. Empir Econ 1995 Jun;20(2):325–32.
[73] Kumbhakar SC, Lien G, Hardaker JB. Technical efficiency in competing panel data models: a study of Norwegian grain farming. J Prod Anal 2014 Apr;41(2):321–37.
[74] Aliyev M, Kafouros M. Do firms earn rents from the intangible assets of their owners? institution-Based insights from the energy sector. Brit J Manag 2023 Oct;34(4):2354–73. https://doi.org/10.1111/1467-8551.12704.
[75] Haschka RE, Wied D. Skewness issues in quantifying efficiency: insights from stochastic frontier panel models based on closed skew normal approximations. Compt Econ 2025 Jan 22:1–36. https://doi.org/10.1007/s10614-025-10857-9.
[76] Khan MA, Khan MA, Khan MA, Alhumoudi H, Haddad H. Natural resource rents and access to finance. J Multi Fin Manag 2023 Dec 1;70:100821. https://doi.org/10.1016/j.mulfin.2023.100821.
[77] Koehler E, Brown E, Haneuse SJ. On the assessment of Monte Carlo error in simulation-based statistical analyses. Am Statistician 2009 May 1;63(2):155–62. https://doi.org/10.1198/tast.2009.0030.
[78] Pata UK, Kartal MT, Dam MM, Kaya F. Navigating the impact of renewable energy, trade openness, income, and globalization on load capacity factor: the case of Latin American and Caribbean (LAC) countries. Int J Energy Res 2023;2023(1):6828781. https://doi.org/10.1155/2023/6828781.
[79] Ali A, Ramakrishnan S, Faisal F, Bazhair AH, Sulimany HG, Rahman SU. Does escaping the natural resource curse complement evading the financial resource curse too? Empirical evidence from Indonesia. Int Rev Econ Finance 2024 Mar 1;91:539–55. https://doi.org/10.1016/j.iref.2024.01.023.
[80] Jamil N, Ahmed J. Natural resources—are they a blessing or curse? A systematic literature review of resource-finance nexus. Sustain Dev 2025 Mar 6. https://doi.org/10.1002/sd.3427.
[81] Raihan A. The influences of economic progress, natural resources, and capitalization on financial development in the United States. Innov Green Dev 2024 Jun 1;3(2):100146. https://doi.org/10.1016/j.igd.2024.100146.
[82] He J, Deng Z. Revisiting natural resources rents and sustainable financial development: evaluating the role of mineral and forest for global data. Res Pol 2023 Jan 1;80:103166. https://doi.org/10.1016/j.resourpol.2022.103166.
[83] He Y, Wang S, Chen N. Mineral rents, natural resources depletion, and ecological footprint nexus in high emitting countries: panel GLM analysis. Res Pol 2024 Feb 1;89:104472. https://doi.org/10.1016/j.resourpol.2023.104472.
[84] Adekoya OB, Ajayi GE, Suhrab M, Oliyide JA. How critical are resource rents, agriculture, growth, and renewable energy to environmental degradation in the resource-rich African countries? The role of institutional quality. Energy Policy 2022 May 1;164:112888. https://doi.org/10.1016/j.enpol.2022.112888.
[85] Lei X, Yu J. Striving for sustainable development: green financial policy, institutional investors, and corporate ESG performance. Corp Soc Resp Env Manag 2024 Mar;31(2):1177–202. https://doi.org/10.1002/csr.2630.
[86] Sun X, Meng Z, Zhang X, Wu J. The role of institutional quality in the nexus between green financing and sustainable development. Res Int Bus Finance 2025 Jan 1;73:102531. https://doi.org/10.1016/j.ribaf.2024.102531.
[87] Yadav A, Bekun FV, Ozturk I, Ferreira PJ, Karalinc T. Unravelling the role of financial development in shaping renewable energy consumption patterns: insights from BRICS countries. Energy Strategy Rev 2024 Jul 1;54:101434. https://doi.org/10.1016/j.esr.2024.101434.
[88] Yadav A, Gyamfi BA, Asongu SA, Behera DK. The role of green finance and governance effectiveness in the impact of renewable energy investment on CO2 emissions in BRICS economies. J Environ Manag 2024 May 1;358:120906. https://doi.org/10.1016/j.jenvman.2024.120906.
[89] Dar AH, Mathur SK, Mishra S. The efficiency of Indian banks: a DEA, Malmquist and SFA analysis with bad output. J Quant Econ 2021 Dec;19(4):653–701. https://doi.org/10.1007/s40953-021-00247-x.
[90] Wu X, Shen Y, Chen J, Chen Y. Social–financial approach for analyzing financial transitions. Financ Innov 2023 May 2;9(1):89. https://doi.org/10.1186/s40854-023-00503-4.
[91] Jiang H, Zhu Y, Yuan C, Zhang X. Interest rate liberalization and the procyclicality of the bank liquidity buffer: evidence from China. J Asian Econ 2025 Jun 1;98:101904. https://doi.org/10.1016/j.asieco.2025.101904.