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PROVINCIAL-LEVEL DETERMINANTS OF ENERGY INTENSITY: THE INTERPLAY OF ENVIRONMENT GOVERNANCE INDEX, FIRM CHARACTERISTICS, AND REGIONAL DEVELOPMENT

Nguyen Hoang Long[1], Chu Thi Mai Anh[2], Phan Huong Giang[3]

[1,2,3] Foreign Trade University, Hanoi, Vietnam

*Corresponding Author

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ABSTRACT

Vietnam's rapid economic growth has raised concerns about energy consumption. This study investigates factors influencing enterprise energy use by analyzing data from 2018 to 2020. It examines how provincial environmental policies, economic factors, and business characteristics affect energy intensity. The research reveals that strong environmental regulations decrease energy use, but effectiveness varies regionally. Surprisingly, economic activity and a larger workforce are linked to lower energy intensity, potentially reflecting Vietnam's green initiatives and service sector development. Additionally, larger firms and those less reliant on machinery use less energy, while businesses with a bigger labor force consume more. These findings suggest that Vietnam's path to energy efficiency requires a nuanced approach considering both regional policy implementation and the country's unique development trajectory.

Keywords: *Environmental Governance Index, Energy Consumption, Energy Intensity, Provincial governance, Sustainable Development*

1. INTRODUCTION

To meet the goals of the Paris Agreement 2015, global greenhouse gas emissions need to be reduced considerably. This can only be achieved if today's developing countries participate in this overall effort (Jakob and Steckel, 2014; Paltsev *et al.*, 2015).

The Vietnamese Government ratified the Paris Agreement on November 3rd, 2016, officially setting the goal to achieve Net-zero in 2050. One of the key objectives following this ambitious goal is reducing the GHG emissions at each field level, focusing on the 5 most GHG-intensive industries, including energy, agriculture, land use and forestry, waste management, and industrial processes. Within those 5 industries, the field of energy plays an important role. Most other industries of the economy currently rely on specific energy sources, and their energy consumption, in turn, contributes to the national GHG emissions.

From the business perspective, energy consumption management, which was already crucial for minimizing production costs, now is turning even more important due to its contribution to GHG emissions. According to *Decree No. 06/2022/ND-CP* dated January 07, 2022 on mitigation of greenhouse gas (GHG) emissions and protection of ozone layer, a regulatory framework for monitoring, reporting, and verifying GHG emissions is established. It requires businesses and industries to measure and disclose their emissions, enabling better tracking of progress towards emission reduction goals. As businesses engage in production, distribution, and trade, their energy usage becomes intertwined with broader economic dynamics, shaping and responding to changes in the economic environment. From the government perspective, effectively managing energy consumption at the business level is now also such a compulsory requirement in order to achieve the GHG reduction goal.

For government policies to have a tangible impact on business operations, effective spillover effect throughout the local governments, who are directly responsible for policy implementation as well as those providing management and business support, is crucial. In the Vietnamese context, where competition among provinces to enhance the quality of public administration is a longstanding concern, evaluating policy implementation effectiveness at the provincial level becomes even more critical. This heightened importance extends to policies aimed at reducing greenhouse gas emissions through energy management practices.

Acknowledging the urgency, governments and policy makers from all over the world have intensified their efforts to address climate change and reduce greenhouse gas emissions. Studies have been carried out through major sectors in the economy namely manùacturing, agriculture, services, ... in order to recommend comprehensive strategies aimed at mitigating the impacts of climate change and transitioning towards sustainable, low-carbon economies. However, it is notable that current research shows little recognition of the imperative to incorporate provincial-level perspectives into climate change mitigation and adaptation strategies, especially in developing countries where local contexts and challenges can significantly influence the effectiveness of climate action efforts.

This study will evaluate the relationship between the enterprises' energy consumption, which is measured by the term of energy intensity, and groups of both business-level and provincial level factors. The study employs a quantitative approach with data collected by the United Nations Development Programme (UNDP) and the General Statistics Office (GSO) in Vietnam. Initially, a comprehensive literature review is conducted to synthesize existing knowledge and identify research gaps. Subsequently, empirical analysis is undertaken using regression models to explore the dynamic interactions between business energy intensity and selected businesses' internal and external indicators.

Several studies have examined energy consumption practices across various countries, analyzing both external and internal approaches adopted by enterprises. Regarding external factors, economic growth, a macroeconomic factor, has been a subject of investigation since early research. Kuznets (1955) and Cleveland *et al.* (1984) observed that economies heavily reliant on energy are significantly affected by fluctuations in energy consumption. Subsequent research has further solidified this relationship, with studies by Zaharia *et al.* (2019) demonstrating a strong positive correlation and Zhao *et al.* (2016) even identifying a bi-directional causal relationship between GDP and energy consumption at both national and provincial levels across diverse contexts. More recent studies have revealed a strong impact from population and labor force changes on energy use. Zaharia *et al.* (2019) found a significant positive correlation between labor force participation rate and final energy consumption, but Wahyudi & Palupi (2023) indicated this relationship is only significant in the long term, with no short-term effect. However, unlike GDP, the impact of labor force has primarily been studied in developed regions, such as the EU28 (Zaharia *et al.*, 2019) and OECD countries (Wahyudi & Palupi, 2023).

Energy-related policies are another factor likely to influence energy consumption. Due to the critical role energy plays in the economy and national security, coupled with unique market characteristics like inelastic short-term demand, price volatility, and unsuitable market rules, the energy sector is less likely to achieve an efficient state without continuous regulatory adjustments (Gencer *et al.*, 2020). In the global context of addressing climate change risks arising from greenhouse gas (GHG) emissions and other pollutants from excessive fossil fuel combustion, governments play a pivotal role in developing renewable energy sources and implementing energy

efficiency measures (Abdmouleh *et al.*, 2015). While studies have evaluated policy impacts on various sectors, few recent investigations have assessed how energy policies have affected overall energy consumption trends. Among those that have, Zhao *et al.* (2020) indicated that economic incentive tools had the most significant impact on energy consumption among implemented policies in China, while Tsemekidi Tzeiranaki *et al.* (2023) suggested that more ambitious policies could support reduced energy consumption in the EU service sector. However, to the best of the authors' knowledge, no research has yet evaluated the overall effectiveness of energy-related policies on enterprise energy consumption, as opposed to the impact of specific regulations or groups of regulations.

Furthermore, most studies primarily assess factors influencing energy use efficiency at the national level, neglecting research at the provincial and sectoral levels. In this area, only one study by Wei *et al.* (2013) has been conducted in China, investigating how different economic sectors relate to energy conservation efforts across 31 provinces. This research analyzed the energy intensity of each major economic sector, revealing the amount of energy each sector consumes relative to its economic output. By doing so, the study provided valuable insights into which sectors require more focus and effort in terms of energy conservation. This analysis stands out as one of the few that considers the diverse economic conditions across China's provinces, recognizing that each region may have different priorities and challenges when it comes to conserving energy and promoting sustainable development.

With regard to Vietnam, in 2022, it has been considered as one of the countries most heavily impacted by climate change, therefore, the government has consistently taken proactive and vigorous measures with an aim to mitigate the effects of climate change in the upcoming years. To be specific, in 2022, the Ministry of Industry and Trade has approved the "Action Plan for Climate Change Adaptation and Green Growth of the Industry and Trade Sector until 2030, with a vision to 2050", which marks an important initial step in the long-term process contributing to the goal of achieving net-zero emissions in Vietnam. To achieve this, the Ministry sets the target to contribute to Vietnam's commitment at COP26: By 2025, striving to reduce from 25% to 30% of total greenhouse gas emissions compared to the emissions scenario under normal energy sector development conditions (excluding transportation) and 30% to 40% in the 2026-2030 period. Most importantly, there has been an emphasis on the compliance of GHG inventory by enterprises, in which all facilities listed in the greenhouse gas emission inventory must conduct inventories and develop plans to reduce greenhouse gas emissions in alignment with the Prime Minister's decision, commencing from 2025.

Under these policies, with a host of research exploring the broader connections between energy usage, economic factors, and global trade patterns, particularly within specific sectors (Nguyen, 2021) or household consumption (Phan & Duong, 2022), the goals to a more sustainable economy for Vietnam is no longer far-reaching. However, with such a complex geography as Vietnam, characterized by diverse topography, climate zones, and socio-economic conditions in different areas, we recognise the need for comprehensive research that delves deeper into the provincial level and business-level, which shows a lack of recognition in the context of developing countries in general.

2. RESEARCH METHOD

The empirical model

In this study, the authors considered enterprise's energy intensity as the dependent variable, which is influenced by a group of province-level factors and a group of business-level factors. The following empirical model is constructed from 2 sets of factors identified through a comprehensive review of prior literature. The first set, 114abelled Business_level_Var, comprises 3 variables representing key performance indicators of a business. This set was suggested by Papadogonas et al. (2007) to have an impact on business's energy consumption and further supported by Hassen et al. (2018), Alam et al., (2016) and Azam et al. (2015). The second set of Provincial_level_Var includes 3 variables reflecting macro-economic indicators. These were originally suggested by Zaharia et al. (2019) for national level, but have been adapted to align with the provincial research focus of this study. The research model is presented as follows:

$$EGI_i = \sum \beta_{i1} \times Business - level\_Var_i + \sum \beta_{i2} \times Provincial\ level_{Var_i} + \varepsilon_i$$

in which:

EGI: Variable related to the term of *energy intensity*. At the macro level, *energy intensity* is usually used as a proxy to measure and compare the energy efficiency of different countries, energy intensity refers to total primary energy supply per thousand US dollars of GDP (OECD, 2015). At the micro level, *energy intensity* is calculated by dividing energy expenditures to sales (Papadogonas *et al.*, 2007). Generally speaking, lower energy intensity indicates that a business consumes less energy per unit of output.

Energy Intensity = Energy Expenditure / Sales Revenue

Provincial level_Var*:* Variables related to *Province level socio-economic* factors, including: Environmental Governance Index, Gross Regional Domestic Product and Labor Force Participation Rate.

Environmental Governance Index (EGI): Environmental governance refers to a nation's implementation of environmental policies. The derivation of the EGI involves the quantification and normalization of a range of indicators that capture various aspects of environmental governance. These indicators may encompass the number of enacted environmental regulations, the degree of enforcement of these regulations, and the overall commitment of the province to sustainable practices (Zhang et al., 2021). Each indicator is normalized on a scale from 0 to 1, with 1 denoting the highest level of environmental governance. There are, however, times when a policy cannot achieve its initial objective. Tsemekidi Tzeiranaki *et al.* (2023), studying the evolution of the European Union (EU) tertiary sector, indicated that policies regulating effective energy efficiency had a major impact on energy trends. In this study, the authors also anticipate a positive influence of EGI on business energy intensity, signifying that effective provincial environmental policies could incentivize businesses to adopt more efficient practices.

Gross Regional Domestic Product (GRDP): Prior researches suggested a positive association between national GDP and national energy consumption (Zaharia et al., 2019). At regional level, the authors expected that the GRDP, or the regional GDP, could play the same role. In other words, higher regional economic activity might lead to higher energy intensity.

Labor Force Participation Rate (LFPR): The same as GDP, studies have also shown a positive correlation between national labor force participation rate. In this study, the authors hypothesize a similar relationship at the provincial level, where a higher labor force participation rate might negatively impact business energy efficiency within the province, showing through a positive relationship with businesses' energy intensity.

Business-level_Var: Variables related to business-level economic factors, including: Firm Size, Captial Intensity, Labor and Ownership Structure.

Firm Size: A positive correlation was found existed between enterprise size and the implementation of energy-efficient practices. This correlation can be attributed to the diminished constraints faced by larger enterprises in terms of both capital resources and technical expertise (Hassen et al., 2018). This previous finding implied that bigger companies are more likely to use energy more effectively and therefore, their consumption per unit of revenue could also be lower. Therefore, this study hypothesizes a negative association between firm size, measured by sales revenue, and energy intensity

Capital intensity: Capital intensity refers to the accumulated depreciation value of fixed assets per unit of sales revenue. Capital-intensive industries, with their reliance on plants and equipment, might require more energy for operation and maintenance. Conversely, low capital intensity could indicate lower energy consumption. Based on this reasoning, the authors hypothesize a positive relationship between capital intensity and energy intensity (Papadogonas *et al.*, 2007).

Labor: The impact of labor on energy efficiency differs in developing economies like Vietnam. Firms may rely more on labor due to lower wages, potentially increasing energy consumption and leading to inefficiencies (Alam *et al.*, 2016; Azam *et al.*, 2015). The authors therefore hypothesize that the size of the enterprise's labor force will positively influence energy intensity.

The focusing independent variable, Environmental Governance Index (EGI), is employed from the Vietnam Provincial Governance and Public Administration Performance Index (PAPI). Initiated by the United Nations Development Programme in Vietnam in 2009, PAPI annually assesses citizen experiences and perceptions regarding policy implementation and service delivery across all 63 Vietnamese provinces. The EGI, therefore, serves as a proxy for citizen perception of local environmental management effectiveness.

Regarding the independent variables, this study utilizes data from Vietnam's General Statistics Office (GSO). Provincial social and economic data are sourced from the annually published Statistical Yearbook. Business-level data, including firm size, capital intensity, labor force, and ownership structure, are obtained from the Enterprise Investigation results, another GSO publication.

Data availability restricts the study period to 2018-2020. While observations span multiple years, the energy consumption data, a critical variable, is derived from independent, year-specific random samples within the Enterprise Investigation. This renders the dataset unsuitable for time-series analysis and necessitates a cross-sectional approach.

Table 1

Variable	Variable description	Source	Empirical studies	Expected impact
EGI	Environmental Governance Index	Provincial Governance and Public Administration Performance Index (PAPI)	Tsemekidi Tzeiranaki *et al.* (2023)	-
GRDP	Logarithm of Gross Regional Domestic Product	Statistical Yearbook by GSO	Wang *et al.*, 2019	+
LFPR	Labor Force Participation Rate		Zaharia *et al.,* 2019	+
SIZE	Logarithm of sales revenue	Enterprise Investigation by GSO	Hassen *et al.*, 2018	-
CAPINT	Logarithm of Capital intensity		Papadogonas *et al.*, 2007	+
LABOR	Logarithm of Enterprise's labor		Alam *et al.* (2016) and Azam *et al.* (2015)	+

3. RESULTS AND DISCUSSIONS

Descriptive statistics

A sample of 137,388 observations were utilized for further analysis after removing missing values for all variables and outliners for the dependent variable. The statistical analysis result is as follows:

Table 2

Variable	Mean	Std. dev.	Min	Max
ENEINT	0	3.048	-7.519	8.851
EGI	3.113	0.407	2.710	5.200
GRDP	4.666	0.415	3.395	5.526
LFPR	55.300	4.809	45.700	66.500
SIZE	8.495	1.967	-2.303	19.789
CAPINT	-2.527	2.097	-13.937	12.748
LABOR	1.881	1.110	0.000	10.324

While most variables seem to be distributed homogeneously, the standard deviation of EGI is low (0.407) compared to its range (2.71;5.20). This suggests a relatively heterogeneous distribution with a mean value closer to the minimum, implying that only a few provinces significantly outperform the average on the environmental management variable (EGI). A similar trend is observed for the LABOR variable. The high difference between most labor-owned enterprises and the rest indicates a skewed distribution, suggesting that the majority of the sampled enterprises are likely small or medium-sized in terms of labor force.

Determinants of businesses's energy intensity

Table 3 reports Pearson pairwise correlations among the models' variables. Generally, the low correlation among the explanatory variables indicate that multicollinearity is not a concern.

Table 3

	ENEINT	EGI	GRDP	LFPR	SIZE	CAPINT	LABOR
ENEINT	1						
EGI	-0.149	1					
GRDP	0.172	-0.598	1				
LFPR	-0.285	0.098	-0.196	1			
SIZE	-0.431	-0.034	0.051	0.003	1		
CAPINT	0.279	0.073	-0.084	0.015	-0.535	1	
LABOR	-0.144	0.087	-0.109	0.085	0.574	-0.115	1

The ordinary least squares regression with correction for heteroskedasticity was used to estimate the above model, firstly for the total sample. Futher analysis is then took for six samples of firms which depend on their based region. Numbering from 1-6, those regions are respectively (1) Northern midland and mountainous regions, (2) Red river delta region, (3) Central coastal region, (4) Central highland region, (5) Southeast region and (6) Mekong river delta region. The results of the analysis are presented in Table 4 and Table 5.

Table 4. regression result for the total sample

	Coefficient	**Std. err.**	**P>t**
EGI	-0.358	0.019	0.000
GRDP	-0.166	0.031	0.000
LFPR	-0.072	0.002	0.000
SIZE	-0.876	0.005	0.000
CAPINT	0.046	0.004	0.000
LABOR	0.635	0.008	0.000
Dummy_region			
2	-0.015	0.036	0.671
3	-0.292	0.031	0.000
4	-0.681	0.045	0.000
5	1.849	0.041	0.000
6	-0.666	0.035	0.000
_cons	9.577	0.202	0.000
N		137,953	

The p-value of 5 dummy variables lower than 1% indicate that there are significant differences between the energy consumption of enterprises in most of those regions (except for the insignificance between (1) & (2) regions). Further analysis is then conducted to investigate the differences in term of independent variables' impact.

Table 5. regression results for 06 regions

	Total	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
EGI	-0.358***	0.242**	0.112***	1.285***	1.393**	-4.502***	-0.119***
	0.019	0.104	0.022	0.068	0.599	0.182	0.036

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GRDP	-0.166***	0.081	-0.219***	1.930***	2.541**	-2.135***	2.320***
	0.031	0.097	0.039	0.077	1.286	0.131	0.098
LFPR	-0.072***	0.084***	-0.005	0.054***	-0.145	-0.211***	-0.022***
	0.002	0.008	0.003	0.003	0.121	0.012	0.005
SIZE	-0.876***	-0.844***	-0.884***	-0.804***	-0.822***	-0.912***	-1.010***
	0.005	0.020	0.006	0.010	0.025	0.011	0.014
CAPINT	0.046***	0.048***	0.092***	0.092***	0.034*	-0.025***	0.011
	0.004	0.015	0.005	0.008	0.020	0.008	0.011
LABOR	0.635***	0.755***	0.941***	0.735***	0.984***	0.300***	1.291***
	0.008	0.030	0.009	0.015	0.042	0.016	0.022
_cons	9.577	-2.979***	3.989***	-12.496***	-4.110	40.968***	-4.863***
		0.718	0.257	0.566	2.755	0.873	0.525
N	137,953	5,215	58,076	18,428	2,672	46,190	7,372

**, **, ***denote statistical significance at 10%, 5%, and 1%, respectively*

Group 1: Social-economic variables at provincial level

Environmental Governance Index

As expected, environmental governance of provinces shows a negative influence on energy intensity, which reveals that stronger environmental governance frameworks tend to exhibit lower levels of energy intensity, indicating a more sustainable and efficient use of energy resources in that area. This inverse relationship can be attributed to several key factors. It likely results from stricter regulations and a focus on renewables that reduce reliance on fossil fuels. Additionally, effective governance can foster innovation in energy efficiency and further drive down consumption. This finding is also consistent with the results of a cross-country study by Tsemekidi Tzeiranaki *et al*. (2023) in Europe.

However, interestingly, this impact is reversed in provinces in the northern and middle region. The coefficient of EGI in region (1), (2) and (3) are positive, highlighting that the environmental governance in those provinces has a negative impact on enterprises' energy consumption. This phenomenon might be an alert that the implementation of environment management policies in these 3 areas is currently not effective and requires further research.

Gross regional domestic product (GRDP)

According to the results, a negative relationship is observed between gross regional domestic product (GRDP) and energy intensity. This suggests that as regional economic activities continue to expand, there is a corresponding decrease in enterprises' energy consumption within the region. The findings of this part in our research is somewhat opposed with the result of Zaharia *et al.* (2019), in which the authors stated that at the national level, an increase in gross domestic product (GDP) was associated with a rise in energy intensity. This result likely reflects the efficiency of environmental policies at national level. Vietnam's transition towards a green economy, driven by policies like the National Green Growth Strategy (2023), incentivizes cleaner production and energy-saving technologies. Additionally, the growing services sector within its economic structure diversifies energy use, reducing overall intensity. Furthermore, foreign direct investment, attracted by Vietnam's labor force and infrastructure, may contribute to technology transfer and further efficiency gains.

However, the region-specific analysis again raises an interest. Although the analysis for the total sample indicates a negative relationship, the same trend can only be observed in the Red river delta region and Mekong river delta region, while the rest of the nation observed the contrary. This may imply that the effect of GDP growth on energy consumption at national level can only spillover to

the 2 most developed economic centers, surrounding Ha Noi City and Ho Chi Minh City - 2 largest cities in Vietnam.

Labor Force Participation Rate (LFPR)
The same as GRDP, there is a negative correlation between regional labor participation rate and energy intensity, which was also indicated by Zaharia *et al.,* (2019). The negative relation suggests that as more people join the labor market, there is a corresponding increase in energy use within the region's enterprises. The recent higher participation rate likely signifies a shift towards service and knowledge-based industries. These sectors require significant labor but have lower energy consumption per unit of output compared to traditional manufacturing. Additionally, a larger workforce fosters innovation in resource utilization, including energy. This, coupled with potential technology transfer from foreign investment attracted by the abundant labor pool, can further contribute to energy-efficient practices. This trend highlights the potential for Vietnam's workforce to be a catalyst for a more sustainable future.

Applying the above argument to the region-specific analysis, some regional variations emerge. The southeast aligns with the national trend, exhibiting a shift towards less energy-intensive sectors with increasing labor. Conversely, northern and central regions show a positive association between labor and energy intensity, which likely suggest a prevalence of energy-intensive industries.

Group 2: Economic variables at business level

Firm size
This study reveals a negative correlation between enterprise size and energy intensity. This finding is also consistent with the results of a cross-country study by Hassen *et al.* (2018) in Europe. This relationship can be attributed to several factors. Firstly, economies of scale allow larger enterprises to spread fixed costs, including those related to energy-intensive processes, over a larger production volume, resulting in lower energy intensity per unit of output. Secondly, larger firms are more likely to adopt advanced technologies for automation and energy-efficient machinery, further reducing energy consumption. Finally, stricter regulations and sustainability goals may incentivize larger companies to implement energy-saving measures and report consumption data. This trend holds true across regions, likely due to the prevalence of smaller, labor-intensive firms that lack access to modernization (Papadogonas *et al.*, 2007). These smaller, less modern businesses benefit more from cost savings through economies of scale in energy use, explaining the significant coefficient of the SIZE variable.

Capital intensity
As expected, capital intensity shows a positive relationship with energy intensity. According to Papadogonas *et al.* (2007), high capital intensity of a firm results in an increase in the firm's energy consumption levels. On the contrary, low capital intensity would be an indication of a firm that consumes less energy. This relationship can be understood through several key reasons. Firstly, industries and firms that rely heavily on capital-intensive processes, such as manufacturing, mining, and heavy industries, often require significant energy inputs to operate machinery, equipment, and infrastructure smoothly. These capital-intensive operations may involve high-energy consumption such as production, transportation, and heating/cooling, leading to higher energy intensity. Secondly, these firms invest in technologies and equipment that are energy-intensive. While these technologies may make considerable contributions in productivity and output, they often require substantial energy inputs to function efficiently. Thirdly, capital-intensive assets such as

machinery, equipment, and infrastructure require regular maintenance, repair, and upkeep to ensure operational efficiency and productivity, so the maintenance activity often involves energy-intensive processes, which add to the overall energy consumption of capital-intensive firms, thereby increasing energy intensity. The contrasting regional findings – a positive correlation in the Southeast and an insignificant one in the Mekong Delta likely suggests a prevalence of non-capital-intensive industries in these southern areas.

Labor

A positive relationship between labor and energy intensity is witnessed, which shows that as labor input increases, energy intensity tends to rise as well, equivalent to a lower energy use. In developing economies like Vietnam, the impact of labor on energy consumption often differs from that in more developed countries due to various factors such as wage levels, technological adoption, and industrial structure. In many cases, firms in developing economies may rely more heavily on labor-intensive production methods, particularly in sectors where wages are relatively low compared to energy costs. Several factors contribute to the positive relationship between labor and energy intensity in developing economies. It is obvious that many firms tend to opt for labor-intensive production methods to minimize costs. This can result in lower energy efficiency as firms allocate more resources to labor rather than investing in energy-efficient technologies or processes. Furthermore, in many developing countries, a significant portion of economic activities occurs in the informal sector, where businesses operate outside formal regulations. This informal sector plays a significant role in economic activities, often comprising a substantial portion of the workforce and contributing to overall GDP. These informal enterprises often have limited access to modern technologies and energy-efficient equipment, and make use of outdated or inefficient machinery and production methods, relying instead on labor-intensive methods that contribute to higher energy intensity. This conclusion aligns with previous studies by Alam et al. (2016) and Azam et al. (2015) and is applicable to each region-specific analysis. However, the contrasting coefficient of the LFPR (labor variable at provincial level) warrants further investigation.

4. CONCLUSIONS AND SUGGESTIONS

This study examined the impact of the Energy Governance Index (EGI) on enterprise energy intensity at the provincial level in Vietnam. While a stronger EGI correlated with lower national energy intensity, regional variations emerged, highlighting the need for further investigation into policy effectiveness in specific areas. Beyond EGI, firm size displayed a negative association with energy intensity, indicating increased efficiency with larger enterprises. Conversely, capital-intensive industries exhibited higher energy use. Interestingly, labor input within firms surprisingly showed a positive association with energy intensity. This discrepancy between regional labor participation and firm-level labor findings warrants further research.

In the context of Vietnam's early-stage renewable energy sector, where access for all enterprises remains limited, policies encouraging energy saving become even more critical. This study suggests that for energy-use policies to be most effective, local government agencies must conduct comprehensive evaluations of the natural environment, economic conditions, and social context within their jurisdictions prior to policy implementation. National-level policies should be applied with flexibility to accommodate the specific circumstances of each province. A one-size-fits-all approach and short-term goals should be avoided.

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