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Analysis of multi-factors affecting resource consumption efficiency in Vietnam

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Abstract:

The primary objective of this study is to delve into the factors potentially influencing resource utilisation efficiency at the provincial level in Vietnam. We leverage 185 data points gathered from 63 Vietnamese cities and provinces in the period 2020-2022, obtained from two key sources: the General Statistics Office of Vietnam and the Ministry of Information and Communications of Vietnam. The collected data was subjected to analysis using an empirical econometric model that incorporates time-series characteristics to explore the connections between these potential determinants of resource consumption efficiency. The analysis revealed a strong correlation between resource utilisation efficiency and the quality of digital transformation, logistics performance, and various aspects of public governance, including accountability to higher authorities, control of corruption, administrative procedures, and public service delivery. Additionally, the provincial competitiveness index, encompassing factors like entry costs, policy bias, and labour policy, also demonstrated a significant association. These findings highlight a clear link between effective public governance and efficient resource utilisation in Vietnamese provinces. This suggests that robust public governance systems, combined with advancements in digitalisation and logistics, can play a crucial role in optimising resource utilisation within Vietnamese provinces.

Keywords: **digital transformation, logistics, provincial competitiveness, public governance, resource consumption efficiency.**

Classification number: ***2.2***

1. Introduction

Human well-being relies heavily on renewable resources such as fish stocks, forests, groundwater, and rangelands. However, the unequal distribution of these resources often perpetuates socioeconomic disparities, particularly in developing regions [1]. Addressing these disparities requires not only conservation efforts but also equitable access to resource benefits and opportunities for local communities. Implementing inclusive policies and fostering international cooperation are vital steps towards achieving sustainable resource utilisation and promoting global well-being [2].

The interconnectedness between natural resource extraction and biodiversity has profound implications in the contemporary world [3], shaping strategies for income augmentation in nations [4]. Many renewable resources have undergone periods of unsustainable utilisation and degradation followed by recovery efforts. These resources serve as primary inputs for economic and social material production, pivotal in wealth accumulation and economic development [5]. Natural resource abundance plays a pivotal role in fostering industrial development [6], serving as a cornerstone for economic growth strategies. However, the renewed emphasis on economic expansion following the global COVID-19 pandemic has intensified pressures on natural resource reserves worldwide [7], raising concerns about sustainable resource management and environmental conservation.

The exploitation and development of mineral and oil resources have traditionally served as key drivers of economic strength. However, growing concerns over their environmental impact and sustainability

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have prompted scrutiny. As resource-rich economies continue to pursue growth, the efficient utilisation of natural resources becomes increasingly imperative. Achieving sustainable development poses a significant challenge for these economies, as they navigate the balance between economic advancement and environmental preservation [8]. Simultaneously, digital technologies play a crucial role in enhancing energy efficiency, facilitating the adoption of green production methods, and thereby mitigating resource and environmental pressures. This technological advancement contributes to the realisation of green, low-carbon development in both the economy and society [9]. Significant technological innovation, coupled with economic growth and financial transformations, holds the potential to redirect economies away from resource-centric growth models [10, 11]. This shift aligns with global growth strategies such as the Sustainable Development Goals, signalling a broader commitment to sustainable development.

S.A. Bawazir (2006) [12] defines sustainable growth as encompassing "the periods of 'e' hardware, software, service, and people". In the digital age, authorities in both developed and emerging nations are leveraging Information and Communication Technologies (ICTs) to promote coordinated policies, enhance public services, and establish transparent institutions that contribute to a sustainable future [13]. Through the implementation of digital government initiatives, effective management of natural resources can be facilitated. Therefore, it is crucial to assess the role of digital technology in fostering the sustainability of natural resources.

The adoption of a circular economy framework and the pursuit of resource efficiency necessitates certain prerequisites, with logistics playing a central role among them. A. Zhang, et al. (2022) [14] characterise logistics as the wings of the circular economy, enhancing circular supply chains and environmental sustainability. P.K. Mallick, et al. (2023) [15] highlight the significance of efficient logistics within the circular economy, enabling faster circulation between producers and consumers, thus establishing a closed-loop economic mechanism with minimal waste and reduced environmental impacts. Digitising logistics or supply chains introduces a more innovative model that harnesses the potential of information and communication technologies to create more efficient and accessible channels for logistics management.

Efficient resource management practices facilitate sustainable service delivery by aligning with community objectives and carefully weighing the trade-offs between desired services and available resources. Nevertheless, numerous factors such as policy frameworks, financial constraints, and legislative requirements often present challenges in adopting management approaches that ensure the long-term sustainability of services [16, 17]. Several policy challenges persist in the renewable energy sector, including the absence of incentives, substantial subsidies allocated to fossil fuel consumption, inadequate environmental regulations, elevated costs, complex tariff structures, limited technological know-how, and numerous others. Additionally, it's essential to recognise that various policy-related factors can either positively or negatively impact industrial and economic transitions. However, energy policymaking, particularly in determining a country's energy mix to mitigate emissions, often becomes embroiled in politics, influenced by factors such as the rule of law, corruption, governance, and economic growth. Provincial Governance and Public Administration Performance Index (PAPI) is a tool used to monitor and evaluate the capacity of the government to manage and implement policies, as well as to provide public services in Vietnam. The PAPI covers all 63 provinces and cities in Vietnam, and the data and evidence it provides reflect eight key dimensions of government performance [18].

In addition to the aforementioned policy challenges, the Provincial Competitiveness Index (PCI) also plays a crucial role in shaping the landscape of efficient resource management. The PCI, which measures the ease of doing business and the investment environment at the provincial level, influences the allocation and utilisation of resources within a country [19]. However, despite its significance, there is a notable scarcity of research examining the relationship between the PCI and efficient resource management practices in Vietnam. Recognising this gap, our team aims to contribute to the existing literature by investigating the implications of the PCI on resource management efficiency within the Vietnamese context.

The objective of this study is to investigate the influence of various factors, including the PAPI, the PCI, the Digital Technology Index (DTI), and logistics, on the efficiency of natural resource consumption. Vietnam serves as the focal point for this research,

providing a pertinent case study due to its dynamic economic landscape and significant reliance on natural resources for industrial and economic growth. Moreover, due to the lack of research within this sector in Vietnam, the research team decides to fill this gap. By examining these factors within the Vietnamese context, this research aims to shed light on the intricate relationship between governance, technological advancement, and logistical efficiency in shaping sustainable resource management practices.

The rest of this document is organised as follows: the subsequent section will conduct a literature review and establish the hypothesis. Following that, the research methodology will be outlined, and the analysis results will be discussed in the fourth section. Subsequently, the discussion section will present the study's findings and outline its limitations. Afterwards, the recommendation section will offer suggestions and proposals based on the research results. Lastly, the conclusions section will summarise the main findings of this study.

2. Literature review

The issue of resource consumption in the post-COVID era has become a contentious topic among businesses and countries. Y. Matiiuk, et al. (2023) [20] asserted that the COVID-19 pandemic altered people's perceptions of climate change and human responsibility, contributing to resource-consuming behaviour. Nations should focus on comprehensive multifaceted policies while addressing climate change issues. These strategies include protecting biodiversity, using natural resources sustainably, and investing in R&D on low-carbon technologies [21]. These will encourage sustainability and reduce countries' reliance on the production and use of natural resources.

A group of scholars has examined the relationship between digital transformation and the efficiency of natural resource deployment. W.U.H. Shah, et al. (2024) [22] underlined the significance of natural resources in developing prosperous economies, which can foster continued industrialisation, develop more export industries, and attract FDI. At a business level, F. Liao, et al. (2024) [23] demonstrated a significant and favourable association between the digitalisation of businesses and the enhancement of green supply chain efficiency, primarily involving the enhancement of green technology capacity, easing financial constraints, and thereby promoting greater efficiency in their supply chains. Additionally, J. Wang, et al. (2024) [24] found that digitalisation contributes to the improvement of enterprises' energy efficiency. Digital transformation has heterogeneous characteristics in different strategies, groups, and growth stages. Further discussion reveals that digital inclusive finance, government subsidies, intellectual property protection, and the opening of the service industry have positive regulatory effects on the energy efficiency improvements brought about by digital transformation. On a broader scale, digital transformation positively influences resource consumption effectiveness. Z. Wang, et al. (2024) [25] provided evidence that digital transformation significantly raises the efficiency of regional coal consumption. Furthermore, a thorough analysis of spatial effects reveals that the benefits of digital transformation extend beyond borders, enhancing the efficiency of coal consumption in neighbouring regions and promoting the sustainable growth of the region's coal resources as a whole. The moderating impact study emphasises how significantly the policy level of digital development contributes to the positive link between coal consumption efficiency and digital transformation. N.T. Hieu, et al. (2023) [26] state that there is a considerably positive connection between digitalisation and the development of environmental innovation, which contributes to resource utilisation in Vietnam. By offering a deeper explanation for the phenomenon, B. Lin, et al. (2024) [27] showed how digital transformation increases a company's green innovative output by improving the conversion efficiency of innovation resources. To foster green innovation efficiency, it is suggested that government support for a company's innovation initiatives can effectively amplify the positive influence of digital transformation on the efficient allocation of enterprise innovation resources. A few scholars have proposed that digital transformation will help increase emerging markets' performance. Specifically, N. Liu, et al. (2023) [28] concluded that digitalisation indicators such as the digital economy index, e-government, and ICT diffusion index would help increase fossil fuel resource efficiency in both the long and short term. The development of the green financing market and its promotion on the digital platform is an operational policy for emerging markets that will attract private sector capital to projects related to the efficiency of natural resources.

Public administration and governance need further improvement in Vietnam to promote the development of the economy, society, resources, environment, and ecology. M. Swilling, et al. (2017) [29] showed that the entrepreneurial role of state institutions would result in city-wide urban governance coalitions between government policymakers, knowledge networks, social entrepreneurs, innovators, investors, and civil society formations committed to innovations that result in greater resource efficiency. Similarly, N. Liu, et al. (2023) [28] proved a nonlinear relationship between government transparency and eco-efficiency performance. This will help prevent corruption, improve public participation, and enhance efficiency performance. D. Fadly (2020) [30] states that adopting environmental regulations and standards among SMEs is essential to gaining competitiveness and environmental sustainability in the context of Vietnam. According to K. Chen, et al. (2024) [31], the government's digital governance capacity significantly contributes to the improvement of natural resource management in urban areas. Rather than quantity, it is mainly green technology innovation, intellectual property protection, and the quality of green technology innovation that helps governance promote natural resource management. While examining the resource curse [32] - a well-known proposition that refers to the restriction of resources to economic growth and the economic growth rate of a resource-rich economy tending to be slower than that of a resource-poor economy, M. Tatar, et al. (2024) [33] and X. Li, et al. (2024) [34] reveal the association between good governance and natural resource management. Additionally, good governance indicators and green growth are identified as efficient tools to combat the resource curse phenomenon in developing Asian economies.

Another strand of literature has concentrated on logistics and its contribution to resource utilisation effectiveness. F.O. Tavares, et al. (2024) [35] proved the critical role of logistics in waste management, material recovery, energy efficiency, and resource sharing. Logistics is an important part of the transition to the circular economy, making business processes more sustainable and environmentally friendly. C. Ju, et al. (2023) [36] supports the above statement by revealing the participation of e-commerce, green logistics, green electricity generation, good governance, and ICT diffusion in advancing the sustainable development goals of developing and emerging Asian countries. For example, O. Ostapenko, et al. (2020) [37] illustrated the application of principles and goals of the concept of green logistics to raise the level of energy-economic efficiency in the energy sector of Ukraine. According to P.T. An, et al. (2023) [38], within Vietnamese enterprises, green logistics activities play a significantly important role in utilising natural resources. However, J. Wehner (2018) [39] offers an overview of the problem of low energy efficiency in logistics, which needs a holistic approach. S. Rossi, et al. (2013) [40] suggest that we lack the capabilities and tools to deploy a strategy for eco-efficiency, despite the many opportunities for LSPs to improve their approach to eco-efficiency as a source of competitive advantage.

The relationship between competitiveness and effective resource consumption has been examined by several scholars. For example, M. Alsaleh, et al. (2020) [41] and K. Tatić, et al. (2006) [42] reveal that the bioenergy industry is in direct proportion to the global competitiveness index. However, there is no study on the correlation between these two factors on a smaller scale. Therefore, in this paper, we will further explore the relationship between the PCI and resource efficiency.

3. Methodology

3.1. Research methodology flowchart

In this research, secondary data sources are collected from the General Statistics Office of Vietnam and the Ministry of Information and Communications. Data is gathered from 63 cities and provinces over the past three years (2020, 2021, and 2022), resulting in a dataset comprising 189 records. However, due to missing information from 3 cities (totalling 4 records), the final analysis is conducted using a refined dataset of 185 records. The analysis focuses on how the key components: PAPI, PCI, DTI, Logistics total factor productivity (LTFP), and GDP per capita impact resource consumption efficiency (RCE). The research employs an empirical econometric model to analyse the data and determine the coefficients of each variable. The results section delves into descriptive statistics, correlation analysis, and regression analysis, and outlines recommendations based on the findings. The procedure of the research methodology is described in the following Fig. 1.

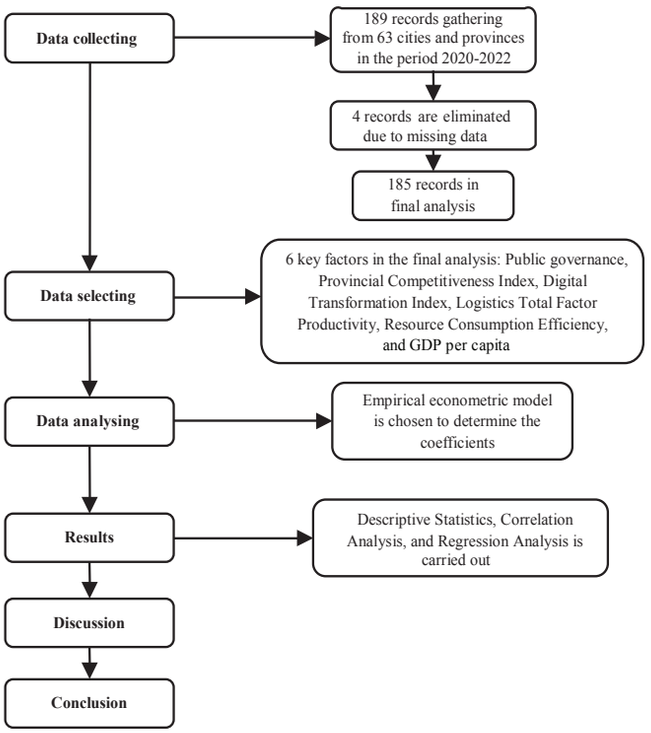

Fig. 1. Research methodology flowchart. Source: Authors' research.

3.2. Research model

In this paper, we measure the impacts of various factors (provincial competitiveness, digital transformation, public governance, logistics performance) on the efficiency of natural resource deployment and depletion in Vietnam. To this end, natural resource consumption efficiency is selected as the dependent variable. Furthermore, the digital transformation index, provincial competitiveness index, public governance index, and total factor productivity of logistics are determined as explanatory variables. In addition, GDP per capita is added to the model as the control variable. Lastly, to determine the coefficients, we examine the empirical econometric model incorporating time series features.

The research model below is developed based on the study by L. Zhao, et al. (2023) [43] on the components affecting resource consumption efficiency. This study differs by including the influencing factors of the PAPI and DTI indices. In the study by L. Zhao, et al. (2023) [43], they refer to the effects of the green growth index, natural resources activity coefficient, inflation rate, employment rate, and foreign direct investment.

$$RCE_t = \beta_0 + \beta_1 PAPI_i + \beta_2 PCI_i + \beta_3 DTI_i + \beta_4 LTFP_i + \beta_5 GDPPC_i + \varepsilon_t \quad (1)$$

where β_0, β_1, β_2, β_3, β_4, β_5 are six unknown constants that represent the regression slope; ε_t (epsilon) is the error term; i is region of the variable.

By incorporating the three main dimensions of the PCI and four main dimensions of PAPI in Equation (1), the final version of the estimation equation is as follows:

$$RCE_t = \beta_0 + \beta_1 PAPIVA_i + \beta_2 PAPICoC_i + \beta_3 PAPIAP_i + \beta_4 PAPIPSD_i + \beta_5 PCIEC_i + \beta_6 PCIPB_i + \beta_7 PCILP_i + \beta_8 DTI_i + \beta_9 LTFP_i + \beta_{10} GDPPC_i + \varepsilon_t \quad (2)$$

where β_0, β_1, β_2, β_3, β_4, β_5, β_6, β_7, β_8, β_9, β_{10} are eleven unknown constants that represent the regression slope; ε_t (epsilon) is the error term; i is region of the variable.

In Equation (2), RCE indicates resource consumption efficiency; PAPIVA, PAPICoC, PAPIAP, PAPIPSD indicate vertical accountability, control of corruption, administrative procedures, public service delivery, respectively. In addition, PCIEC, PCIPB, PCILP indicate entry costs, policy bias, and labour policy. Moreover, DTI indicates the digital transformation index, LTFP indicates logistics total factor productivity, and GDPPC as a control variable indicates GDP per capita. Table 1 describes the abbreviations, units, and sources of selected variables.

Table 1. List of variables to construct an empirical model (2020-2022).

Variable	Abbreviation	Unit	Source
Vertical accountability	PAPIVA	Index	Provincial Governance and Public Administration Performance Index
Control of corruption	PAPICoC	Index	
Administrative procedures	PAPIAP	Index	
Public service delivery	PAPIPSD	Index	
Entry costs	PCIEC	Index	Provincial Competitiveness Index
Policy bias	PCIPB	Index	
Labour policy	PCILP	Index	
Digital transformation index	DTI	Index	Ministry of Information and Communications, Vietnam
Logistics total factor productivity	LTFP	Index	Author's calculation
Resource consumption efficiency	RCE	Index	Calculated based on L. Zhao, et al. (2023) [43]
GDP per capita	GDPPC	Current thousand Vietnam Dong	General Statistics Office of Vietnam

4. Results and discussion

Table 2 shows the descriptive statistics of the research variables for all 185 records. Firstly, let's examine the parameters describing the RCE of 63 Vietnamese provinces and cities over a period of three years. The average score is 1.01, indicating that Vietnamese provinces have a low average risk of natural resource utilisation, with the lowest score being 0.94 and the highest 1.15, which demonstrates that resource consumption efficiency can operate more effectively.

Table 2. Descriptive statistics.

Variables	N	Minimum	Maximum	Mean	Std. Deviation
PAPIVA	185	3.84	5.82	4.50	0.38
PAPICoC	185	0.00	8.29	6.78	0.69
PAPIAP	185	0.00	7.84	7.22	0.58
PAPIPSD	185	6.34	8.46	7.42	0.48
PCIEC	185	5.17	9.14	7.19	0.66
PCIPB	185	3.72	8.81	6.24	0.85
PCILP	185	3.73	8.41	5.98	0.84
DTI	185	0.21	0.80	0.43	0.13
LTFP	185	0.96	1.09	1.00	0.02
GDPPC	185	1.74	8.08	3.78	1.14
RCE	185	0.94	1.15	1.01	0.06

Source: Authors' research.

Table 3 reveals that the correlation coefficients among independent variables are generally weak, and variance inflation factors remain below 0.5. This suggests a minimal risk of multicollinearity significantly impacting the results [44]. Furthermore, the correlation matrix between inputs and outputs indicates a strong positive association between resource consumption efficiency and all input variables.

The econometric analysis, conducted using SPSS software, explored the connection between the RCE and its potential influencing factors. The findings presented in Table 4 indicate a statistically significant positive association between RCE and both logistics performance and the degree of digital transformation at the provincial level. Furthermore, the t-statistics and p-values confirm that all ten variables considered - Vertical Accountability, Control of Corruption, Administrative Procedures, Public Service Delivery, Entry Costs, Policy Bias, Labour Policy, Digital Transformation Index, Logistics Total Factor Productivity, and GDP Per Capita - exert a statistically significant influence on resource consumption efficiency. As hypothesised, the analysis revealed a mix of positive and negative significant relationships between provincial performance in various sectors, encompassing competitiveness, digitalisation, governance, logistics, and resource consumption efficiency. Notably, the results suggest that the explanatory variables account for approximately 95.3% of the variation observed in resource consumption

Table 3. Correlation analysis.

	PAPIVA	PAPICoC	PAPIAP	PAPIPSD	PCIEC	PCIPB	PCILP	DTI	LTFP	GDPPC	RCE
PAPIVA	1										
PAPICoC		1									
PAPIAP	0.557	0.62	1								
PAPIPSD	-0.335			1							
PCIEC	0.358	0.16		-0.344	1						
PCIPB				-0.160	0.176	1					
PCILP	0.262				0.210	0.260	1				
DTI	-0.321		-0.25		-0.213	-0.147	-0.223	1			
LTFP	-0.451		-0.191	0.397	-0.348				1		
GDPPC				0.260			0.401	0.249	0.412	1	
RCE	-0.532	-0.166	-0.24	0.329	-0.424	-0.286	-0.384	0.887	0.837	0.203	1

Source: Authors' research.

efficiency. This implies a strong explanatory power of the chosen model. Additionally, Table 4 shows that all Tolerance coefficients are greater than 0.1 and all VIF values are less than 2. Therefore, it can be concluded that there is no multicollinearity in the model.

Our regression analysis, presented in Table 4, reveals that the Digital Transformation Index exerts a substantial positive influence on resource consumption efficiency with a path coefficient of 0.232. Similarly, Logistics Total Factor Productivity demonstrates a significant positive impact on resource consumption efficiency as reflected by a path coefficient of 0.636. Turning to public governance aspects, Vertical Accountability (PAPIVA) exhibits a significant negative association with resource consumption efficiency, indicated by a path coefficient of -0.197. Conversely, Control of Corruption (PAPICoC) and Public Service Delivery (PAPIPSD) show a significant positive effect, with path coefficients of 0.142 and 0.091, respectively. Administrative Procedures (PAPIAP) also have a significant negative impact, as evidenced by a path coefficient of -0.102. The remaining provincial competitiveness indices - Entry Costs (PCIEC), Policy Bias (PCIPB), and Labour Policy (PCILP) - indicate moderate negative associations with resource consumption efficiency, reflected by path coefficients of -0.079, -0.070, and -0.105, respectively. In this research, the impact of entry cost, policy bias, and labour policy are agreeable. The effect of the labour policy on resource consumption efficiency has a positive effect. The results showed that digital transformation and logistics productivity caused the highest impacts on resource consumption efficiency, much higher than factors of PAPI and PCI.

From the obtained results, digital transformation and logistics productivity are strongly correlated with resource consumption efficiency in Vietnam. Firstly, the transformation of information and communication technology improves and optimises the management of natural resources by promoting transparency and improving resource accumulation, utilisation, and allocation. The findings align with L. Agnusdei, et al. (2023) [45], W. Guan, et al. (2024) [46], and Y. Shao, et al. (2024) [47] who found the critical role of digitalisation in resource consumption efficiency and the circular economy. Also, the results show the positive and significant impact of logistics productivity on the effectiveness of natural resource consumption, similar to how A. Xu, et al. (2023) [48] express that total factor productivity of logistics accelerates the expansion of the circular economy. Nevertheless, all subcategories of PCI show a negative pattern of Provincial Competitiveness towards the effectiveness of natural resource consumption. It was found that in Vietnam, the two dimensions Vertical Accountability and Administrative Procedures of PAPI have a negative correlation with resource utilisation, while the two other dimensions Control of Corruption and

Table 4. Regression analysis.

	Unstandardised coefficients		Standardised coefficients	t	Sig.	Collinearity statistics	
	B	*Std. Error*	*Beta*			*Tolerance*	*VIF*
(Constant)	-.347	.066		-5.271	.000		
PAPIVA	-0.022	0.003	-0.197	-7.455	.000	0.33	1.96
PAPICoC	0.009	0.002	0.142	4.769	.000	0.26	1.85
PAPIAP	-0.01	0.002	-0.102	-4.389	.000	0.43	1.34
PAPIPSD	0.011	0.002	0.091	4.614	.000	0.58	1.71
PCIEC	-0.007	0.002	-0.079	-4.464	.000	0.74	1.35
PCIPB	-0.005	0.001	-0.07	-4.365	.000	0.89	1.13
PCILP	-0.007	0.001	-0.105	-5.221	.000	0.57	1.75
DTI	0.097	0.012	0.232	8.18	.000	0.60	1.68
LTFP	1.474	0.058	0.636	25.336	.000	0.29	1.50
GDP	-0.003	0.001	-0.055	-2.813	.005	0.36	1.75

Source: Authors' research.

Public Service Delivery show a positive impact on resource consumption efficiency. This finding aligns with M.C. Brisbois (2020) [49], who stated that effective multi-level electricity governance requires some decentralisation of responsibility, authority, and resources. Furthermore, J. Guo, et al. (2021) [50] and F. Teichmann, et al. (2023) [51] express that anti-corruption improves the allocation efficiency of resources.

5. Conclusions

In this study, we investigate the potential relationship between resource consumption efficiency and various determinants, including digital transformation, logistics performance, public governance mechanisms, and competitive advantages at the provincial level within the Vietnamese context. Our findings reveal that the quality of public governance has a notable correlation with the efficiency of resource consumption, exhibiting both favourable and unfavourable outcomes across specific categories. To address this, the Vietnamese government should enhance transparency, accountability, and the rule of law to ensure efficient resource use and mitigate negative outcomes. They should also consider developing smart city initiatives that integrate digital solutions for efficient urban planning and resource management.

Additionally, the adoption of digital transformation and the overall productivity of logistics significantly contribute to enhancing the quality of resource utilisation. Policymakers should focus on investment in digital infrastructure, provide training for digital skills, and encourage public-private partnerships to leverage technology in resource management and logistics at the provincial level in Vietnam. Moreover, the competitive performance among provinces in Vietnam demonstrates a considerable adverse effect on resource consumption efficiency. Therefore, engagement in cooperative initiatives is essential to share best practices and resources, thereby reducing redundancy and promoting more sustainable competition.

Thus, policymakers should prioritise the enhancement of public governance frameworks alongside fostering digital transformation initiatives to bolster resource utilisation quality. This necessitates the implementation of policies aimed at strengthening governance structures and promoting technological advancements in logistics. Furthermore, creating an environment that fosters healthy competition and promotes initiatives aimed at enhancing efficiency is crucial. Through these efforts, policymakers can drive Vietnam towards sustainable development and increased competitiveness on the global stage.

In future research, it is essential to investigate advanced manufacturing indices and cross-sectoral approaches to sustainable development that integrate environmental, social, and economic considerations. Research could focus on identifying synergies and trade-offs between different sectors (e.g., energy, agriculture, transportation) and developing integrated policy frameworks to address multiple sustainability challenges simultaneously. Moreover, conducting policy analysis and evaluation to assess the effectiveness of existing resource management policies and identifying opportunities for improvement can broaden the research scope. This could involve assessing the alignment of policies with sustainability objectives, evaluating their implementation and enforcement mechanisms, and identifying policy gaps or inconsistencies.

CRediT author statement

Nguyen Thi Xuan Hoa: Conceptualisation, Methodology, Validation, Writing; Nguyen Duc Anh: Data collection, Data analysis, Writing, Methodology; Ngo Huu Quang: Data collection, Data analysis; Nguyen Thi Huyen Trang: Data collection, Writing.

COMPETING INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this article.

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